Who Will Succeed in Dental School?

Predictors of dental school performance

By

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Submitted in accordance with the requirements for the degree of Doctor of Philosophy

The University of Leeds

Faculty of Medicine and Health

School of Dentistry

January 2023

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Intellectual Property Rights Statement

Acknowledgement

First, and foremost, all praise is to God, the Most Gracious, the Most Merciful, for his guidance, mercy and showers of blessings.

I would like to begin by expressing my heartfelt gratitude and appreciation to all my supervisors for their consistent support throughout my studies.

I would like to express my sincere gratitude to my primary supervisor, Jennifer Hallam, who always makes time to patiently answer my questions and urgent meeting requests; for her constant encouragement, uplifting assurance, and motivation, as well as for her consistent support to arrange and facilitate all that is needed for the research to advance and for all her guidance throughout the project. Thank you!

I am extremely grateful to my supervisor, Gail Nicholls, who has motivated me to undertake my research with zeal and perseverance ever since I met her in my transfer viva; her warm encouragement, huge expertise, comprehensive comments and invaluable guidance are greatly appreciated. I am fortunate to learn under her guidance.

My appreciation to my supervisor, Professor Michael Manogue, who gave me the opportunity for a new experience in my career by accepting me as a PhD student in the education field. It was an honour to learn under his guidance. His insightful feedback and kind support have been a great guide to me during my studies.

I sincerely acknowledge the assistance of numerous individuals at the School of Dentistry, special gratitude to Miss Jane Greenwood, Miss Rachel Mays, Miss Carrie van der Zee, the library team, the IT team and admissions team for generously helping me with different aspects of the project.

I am also grateful to the Saudi Arabian Ministry of Higher Education for giving me the opportunity to pursue my postgraduate studies. I gratefully acknowledge the generous support of my PhD scholarship by the Government of the Kingdom of Saudi Arabia, through Umm Al-Qura University.

I would also like to express my sincere gratitude for Dr Paula Lancaster and Professor Sally Curtis for their time and expertise in examining my PhD thesis. I truly appreciate the effort and dedication they have put into reading, analysing and critiquing my work. Their insightful comments have been invaluable in helping me improve my thesis. It has been an honour to have them as my examiners.

Another special heartfelt thanks to my dear supervisor Dr Jennifer Hallam to whom I am very grateful for the support and encouragement she has given throughout my academic journey, from the early stages of my research to the final moments of my PhD viva.

Finally, I would like to express my deepest appreciation to my family for their love and support throughout this journey. I am immensely grateful to my beloved mother, whose unwavering belief in me has been a constant source of inspiration. To my beloved father, I am grateful for his continuous encouragement and guidance. I extend my heartfelt thanks to my dear sister, who has been my pillar of strength and support. A special mention goes to my sweet nephew, whose encouraging words have uplifted me whenever I needed them. A heartfelt gratitude for my brother, his belief in me and willingness to lend a helping hand whenever needed have been invaluable. And lastly, I would also like to take a moment to acknowledge my “Cookie” for his beautiful companionship and unconditional love throughout my PhD journey. His presence provided a sense of calm and relaxation during the stressful periods of writing and research, and his playful antics never failed to bring a smile to my face. I am grateful for his company and will always cherish the memories of our time together during this important phase of my life!

I am beholden to you all with gratitude!

Abstract

Background: Selection of students with the highest potential of success is a very challenging process because selection is carried out among a highly academically qualified pool of applicants exceeding the number of places available. Additionally, evidence about the incremental and predictive validity of admission assessments and personal attributes assessed at admission is limited.

Objectives: To address this, a systematic review for evidence of the predictive validity of selection methods was completed, the incremental and predictive validity of admission assessments and whether any of the assessments are biased towards or against certain individuals were then investigated.

Methods: This was a retrospective cohort study using data of four cohorts at the University of Leeds, School of Dentistry. Data analysis included univariate and multivariate analysis. Outcome measures included academic and clinical performance. Predictor measures included personal statement, BMAT and MMI scores in addition to the socio-demographic characteristics of participants.

Results: Hierarchical regression models revealed that BMAT was the only admission assessment that contributed significantly in increasing the variance. Sections 3 and 2 were the most predictive. Additionally, MMI and BMAT significantly predicted on course 3rd to 5th year clinical practice and 2nd to 3rd year academic scores. Empathy, communication, insight and presentation stations were the most predictive of students' performance. None of the admission assessments showed evidence of bias against gender, widening participation or ethnic groups.

Conclusion: The findings demonstrated evidence of incremental and predictive validity of BMAT as an admission test. They also revealed the necessity to re-evaluate the MMI structure, particularly the skills assessed and the tasks used to assess them, to improve its validity. The research has also highlighted the need to identify and provide appropriate support to individuals at greater risk of low performance and the necessity for adequate admissions data management at the University to facilitate future studies.

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List of Abbreviations

A2L	Access to Leeds
A-Levels	Advanced level qualifications
BDS	Bachelor of Dental Surgery
BMAT	Biomedical admissions test
BSc	Bachelor of Science
CAS	Common assessment scale
CP (Number)	Clinical practice (Year in the course)
DREC	School of Dentistry Research Ethics Committee
Dental Surgery MChD/BChD	Master and Bachelor Dentistry Degree
GAMSAT	Graduate medical school admissions test
GCSE	General certificate of secondary education
IPE	Inter-professional engagement
MDT	Manual dexterity test
MMI	Multiple mini-interview
OFS	Office for Students
OSCE (3,4)	Objective structured clinical examination (3rd year, 4th year)
OSPE	Objective structured practical examination
PAS	Pre-admission academic score
PBL	Problem based learning
PQA	Post-qualification applications
PS	Personal statement
SJT	Situational judgement test
UCAS	Universities and colleges admission service
UCAT	University clinical aptitude test
WA	Widening access
WP	Widening participation
WPS	Widening participation scheme
Y	Year

Chapter 1
Introduction

"Admissions are the responsibility of universities and colleges themselves, and rightly so. Institutions should be able to set their own criteria, choose their own assessment methods, and select their own students. But it is important that everyone has confidence in the integrity of the admissions process. Access to higher education matters to many people, and so do fair admissions" (Schwartz, 2004).

The first step in achieving a fair admission process is to examine what is currently in place and then work step by step toward improvement and the ultimate goal of a fair admissions system for all. It has been found that that students' academic in-course performance can be influenced by multiple factors, which a recent systematic review classified as demographic factors, psychological factors, learning-related daily habits, learning environment, and admission criteria (Meepradit et al., 2022). However, the purpose of this thesis is to investigate part of the student performance predictors which are admissions-related and demographic-related factors. Setting the admission entry criteria and selection methods aim to ensure that the candidates selected will potentially show success as students as well as professionals in their future career, with the ultimate goal of anticipating which will be the best clinician (Cleland et al., 2012a, Rees et al., 2016b, Booth et al., 2022). However, focusing on predicting undergraduate school performance is a clearer criterion of the selection process, and the association between undergraduate performance and future performance as a clinician is complex and heavily influenced by factors taking place during undergraduate studies which requires further study. This is referred to as the "criterion problem", meaning that it is still uncertain as to whether undergraduate performance or later performance as a clinician should be used as a criterion for selection (Cleland et al., 2012a). Therefore, this research will focus on the undergraduate performance of students as the outcome criterion. The subsequent sections will provide a brief introduction of the admission process followed by a systematic review of the existing evidence regarding the predictive validity of admission assessments in the United Kingdom.

1.1 Dental undergraduate selection

The process of selecting applications for dentistry programmes is difficult for both the institution and the applicants. Institutions must choose from a highly qualified pool, and applicants must endure a challenging process, and it is important to ensure the correct decisions are made and can be defended. Additionally, Applicants for these programmes often considerably exceed the number of places available. In fact, number of applicants to dentistry in the 2018–2019 and 2019-2020 cohorts were 3,051 and 3,187, respectively (Booth et al., 2022). However, confirmed total intake of dental students at UK dental schools was 1101 and 1121 during the academic years of 2018-2019 and 2019-2020, respectively (Office for Students, 2022). Moreover, many of these candidates fulfil or exceed the academic entry requirements of the programmes for which they applied (Barbour and Sandy, 2014a). Furthermore, it is essential to find the balance between selecting those who will be successful in school and in the field and increasing the diversity of the enrolled students and, consequently, in the workforce. Besides ensuring that the dental workforce has the correct numbers, skills, values, and behaviours (Newton et al., 2003, Fielding et al., 2018, Gallagher, 2019). This suggestion seeks to establish a diversified health care workforce that is capable of meeting the demands of an increasingly diverse population, not just in terms of direct clinical treatment, but also in terms of leadership, health system design, and research (Betancourt, 2006). Each country has its own unique set of educationally disadvantaged populations. Socioeconomic status, or 'class' is the key concern in the United Kingdom, but ethnicity is the main issue in other nations (Fielding et al., 2018). Little is known about whether selection procedures contribute to diversity expansion and the evidence that is available is contradictory (Fielding et al., 2018). Another issue is that the qualified individuals from certain backgrounds do not apply in sufficient numbers to the most selective institutions (Schwartz, 2004). In recent years, student selection processes in Higher Education institutions have come under criticism as research findings indicate that there is prejudice in favour of white candidates, female applicants, and applicants from independent schools (Ferguson et al., 2002a). Given the current emphasis on widening access to promote fair access, it is essential that the biases are identified and changes made to reduce these within these selection tools (Cleland et al., 2012b, Curnow, 2018). In a review conducted by Gorard et al., three primary types of barriers were identified that could potentially hinder students in accessing higher education. These barriers include situational factors such as the cost, time, and distance from learning opportunity; institutional factors resulting from the availability and flexibility of opportunities offered by educational institutions; and dispositional factors that pertain to the individual's attitudes and motivation towards education. Dispositional barriers can stem from various factors, such as past educational experiences and achievements, family and social influences, as well as the level of support provided by schools and colleges to students transitioning into higher education (Curtis et al., 2014). It is evident that individuals from low socioeconomic backgrounds face obstacles when it comes to accessing higher education. However, the implementation of specifically tailored widening access programs can effectively address and overcome these barriers. Widening access (WA) is a part of the greater picture of equitable/fair access to specialised educational training, which is related to social mobility as education is a substantial predictor of later-life income and opportunity. Individuals have an equal opportunity of advancement in terms of finance or employment when a society is mobile. WA refers to the policy that under-represented groups (such as students from certain ethnic or cultural groups, mature students, disadvantaged backgrounds, and disabled students) should be supported to access higher education. This will help to provide equal opportunities and to end the transmission of disadvantage from a generation to the next, i.e. improving social mobility (Cleland et al., 2012b). This is reasonably justified on two bases. To begin, to address the challenges of society in terms of social justice and social mobility by supporting people from all backgrounds to pursue higher education, rather than having one's social and economic status determined by birth (Fielding et al., 2018). The establishment of the Office for Students (OFS) in 2018 as an independent regulator of Higher Education in England is one of the attempts to support students to access, succeed, and protect their interests in higher education. Second, it is deemed critical to train a diverse workforce in order to improve the quality of the provided healthcare by ensuring that clinicians are as representative of the community they serve as possible (Fielding et al., 2018). Therefore, universities and colleges should reassess their admissions procedures in order to provide equal opportunities to access higher education within the regulations imposed by the law and ensure racial and socioeconomic diversity among the class (Schwartz, 2004, Rees et al., 2016b).

Further to the possible biases in the admission process, concerns are highlighted in research that the currently used, admission processes may lack incremental validity and waste resources (Cleland et al., 2012b). Additionally, the fact that undergraduate dental surgery programmes are lengthy and expensive, and the evidence of a relation between possessing strong personal qualities and the quality of care provided, imposes an ethical and economic obligation to generate competent clinicians, given the high-stakes nature of the profession, its relationship to individual and societal health and well-being, and its financial cost (Papadakis et al., 2004, Wenghofer et al., 2009, Patterson et al., 2016, Mirghani et al., 2019b). Therefore, selecting the most suitable candidates for the career is necessary for both the student and the school, in addition to ensuring future patient care quality and safety (Mirghani et al., 2019b). In other words, student selection is a subject of substantial public interest among a diverse range of stakeholders. These include applicants and prospective applicants; selectors; students; members of the profession; school career guidance teachers; members of the general public and patients (Kelly et al., 2018).

Given the above, it is imperative for the admission committee to select the candidates who are highly likely to be successful future clinicians as well as successful students (Salvatori, 2001b).

1.2 Academic criteria, non-academic criteria or both?

There is a controversy about the admission procedures that best enable institutions to recognise individuals who are most suited to the profession (Eva et al., 2004c). However, there seems to be a general agreement about the necessity of assessing both the academic and the non-academic characteristics (Salvatori, 2001a). As for academic ability, it is typically assessed by the applicant's pre-admission academic achievement or by their performance on standardised admissions tests. It is believed that academic ability reflects the applicant's potential to endure the rigour of the programme (Salvatori, 2001b, Eva et al., 2004a, Barbour and Sandy, 2014a). However, it is questionable whether differences in pre-admission academic achievement are related to future clinical performance as observed that some high-performing students who succeed during the course of academic study may not be as successful in the clinical setting. Additionally, dental school failures by students with high predental academic records are a sign that the current admissions system needs to be changed or improved (Poole et al., 2007, Barbour and Sandy, 2014a). That said, non- academic qualities may be an important aspect to take into account when making dentistry school admissions decisions, along with other performance criteria (Chamberlain, 2004). In fact, Barkley suggested that instead of picking the highest performing applicants and endeavouring to instil a value for relationships with patients and staff, dental programmes should select applicants who already possess this value and teach them to become dentists. (Barkley, 1976). Additionally, Schwartz described a 'Holistic assessment' which refers to an evaluation that takes into account a wide range of information, such as skills and contextual factors in addition to academic performance of each candidate as an individual and employ an evidence-based approach to ensure that the holistic evaluation is fair (Schwartz, 2004). This is suggested to aid in identifying the potential of applicants whose grades may not represent their abilities, distinguishing between individuals who appear to be similarly qualified for courses with competitive admissions, encouraging applicants from diverse backgrounds to apply, identifying the applicants who will collectively create the finest potential group of students and evaluating skills that are specifically needed in the course applied for to assess the applicant’s fitness in a certain profession (Schwartz, 2004). Moreover, a review paper carried out in 2015, emphasised the importance of soft skills in a dental career and defined them as a group of personality attributes, social graces, personal habits, and facility with language that mark people to varying degrees. In other words, they are psychological, interpersonal, self-promoted and non-technical qualities. They also suggested that soft skills increase the individual’s professionalism, confidence, friendliness, coordination and optimism (Dalaya et al., 2015). Therefore, expanding the selection procedure to include the applicants' personal qualities may serve on two grounds. First, that it would result in the selection of those who will perform better as clinicians than those who are merely chosen on the basis of academic performance. Secondly, is to ensuring that the health care staff is representative, since this will contribute to better health care particularly for minority groups (Stegers-Jager, 2018).

Which non-academic attributes should be considered?

Several educationalists have listed the criteria required in prospective students to become competent practitioners. For instance, the American Dental Education Association (ADEA) has listed the following characteristics as important to be present in a dental student: critical thinking, communication and interpersonal skills, professionalism, practice management and informatics, health promotion, and patient care (ADEA, 2013). Likewise, Cowpe et al identified seven domains for the graduating European dentist approved by the Association for Dental Education in Europe (ADEE). Their list included the following domains: interpersonal, communication and social skills; professionalism; knowledge base, information and information literacy; diagnosis and treatment planning; clinical information gathering; therapy; establishing and maintaining oral health; and prevention and health promotion (Cowpe et al., 2010). Similarly, the General Dental Council of the UK (GDC) has developed learning outcomes which are classified in four domains: communication, clinical, professionalism, and management & leadership (GDC, 2015). According to the (student professionalism and fitness to practice) report developed by the GDC, student's professionalism was defined as "It is how you demonstrate the appropriate attitudes and behaviour with patients and your colleagues (staff on the training course, employers and other students)" They go on to say "These are behaviours or attributes a patient expects a dental professional to demonstrate" (GDC, 2016). Additionally, Emery et al suggested that admission staff must use a variety of information to envisage how an applicant's future performance is likely to be, including qualities such as self-motivation and excitement, which will mediate the link between what could and what will be accomplished by the student (Emery et al., 2011). Powis et al and Collins et al assessed other skills, motivation and certainty of career choice were of particular note as is becoming increasingly crucial in health professions as internalised student motivation has been positively linked in research to a variety of educational outcomes, including improved conceptual learning, creativity and deep study strategies (Powis et al., 1988, Collins et al., 1995, Orsini et al., 2018). Another study found a significant relationship between the number of in-course tests failed and poor interview results and low grades in intelligence, spatial abilities, and manual ability. Additionally, they found that spatial ability was significantly related to good performance in a pre-clinical course in cavity preparation (Heintze et al., 2004).

These different lists were made in an attempt to guide the admission processes in selecting students that are most likely to succeed in the profession (Mirghani et al., 2019a). However, it remains essential that these recommendations are assessed by each institution for local relevance (Albanese et al., 2003). Nonetheless, measuring these personal characteristics can be challenging for the following reasons. First, measuring a characteristic requires defining it in a measurable term. The second reason is whether these qualities are stable or not. Stability of a personal quality refers to the high probability of its occurrence in different situations (Albanese et al., 2003). The Big Factor theory of McCrae and Costa states that personality traits are biologically determined and that the development of traits occurs up until early adulthood (Chamberlain, 2004). According to this theory, slight or no change occurs on any personality dimension after early adulthood (Srivastava et al., 2003). Similarly, Bullimore claims that personality is established and set by the age of eighteen (Albanese et al., 2003). This notion suggests that personality is stable across time and situations (Hambrick et al., 2014). If personal characteristics of an individual are stable, the admissions staff will face the challenge of creating a reliable and valid assessments of these characteristics and then to assign them suitable weight for applicants' selection (Albanese et al., 2003). However, interviews are influenced by "context specificity," which implies that an individual's performance may be more determined by the context in which it is elicited than by their stable traits (Eva, 2003). In other words, context specificity highlights the importance of 'state' as opposed to 'trait'. That is, the 'state' is often a better indicator of an individual's behaviour rather than their personality. Consequently, provision of a generalised representation of the candidate's abilities may not be possible using a single interview. Even though several topics can be discussed with a candidate in a single interview, this may yet reveal only a sample of the possible several responses that can be given by the candidate (Eva, 2003, Eva et al., 2004c).

In contrast to the Big Five Factor theory, is the contextualist approach which implies that personal qualities are multi-determined and can be influenced by one's social environment (Srivastava et al., 2003). Contextualist views foresee a degree of change (plasticity), as personality characteristics can change over time due to a variety of reasons. It has been proposed that social roles, life experiences, and the social environments in which people live all have a significant impact on a person's traits. McCrae and Costa's prior theory about the stability of personality has been challenged by newer research. For instance, Srivastava et al used the Big Five Inventory to examine changes in personality. In particular, they looked at men and women between the ages of 21 to 30 and 31 to 60 years old. They found that 'conscientiousness' and 'agreeableness' rose at varied rates throughout early and middle adulthood. While men's neuroticism did not alter over this period, it decreased in woman. Even in late adulthood, all of the Big Five variables except for 'neuroticism' were shown to be changing. This shows that the Big Five qualities are complicated and vulnerable to a wide range of developmental factors (Srivastava et al., 2003). This issue that some personal characteristics may be adjustable while others may be stable by the time students apply for their undergraduate programme adds to the complexity of assessment (Albanese et al., 2003). Whether personal characteristics are stable or flexible and whether they are teachable or innate remains a contentious issue in the literature; however, it should be kept in mind when selecting which personal characteristics of applicants to assess and ensuring that there is sufficient evidence that it accurately predicts student performance. It may also influence our decision on whether to employ personality assessment or interviews as an assessment.

Motor skills are also essential for dental practice (Dalaya et al., 2015). However, there is a lot of controversy in literature about using motor skills tests for the purpose of selecting students. For instance, Cleghorn et al assessed the correlation between manual dexterity test (MDT) scores, which is a carving exercise, and preclinical psychomotor skills score. They found that tests identified students who had extremely weak psychomotor skills in the course and those scored 10 or less in the MDT. Therefore, they supported using the test as a cut-off in admission to reduce the number of students who will face difficulty in the psychomotor skill development (Cleghorn et al., 2018). On the other hand, Gansky et al found that only four of the twenty-three students who failed the MDT, which was a two-hour block-carving test, were in the lowest 10% of their class by five preclinical laboratory courses. However, it's worth noting that the test they used had no effect on the admission decision, therefore it is possible that students did not give their best effort on the exam (Gansky et al., 2004). Similarly, Giuliani et al found that basic manual dexterity test is not necessary for the selection of dental students and that students who follow training have significantly improved their manual ability. In other words, that manual dexterity skill is trainable. However, it’s worth noting that, similar to Gansky’s study, the test they used did not affect the admission decision. In addition, the tests used in their study were not specific to dentistry. They were meant to investigate basic skills, such as tactile discrimination and eye-hand coordination. All these skills were not specific to dentistry (Giuliani et al., 2007). Therefore, if motor skills test is to be used as a screening tool, it is necessary that the tests are relevant to the needs of the dental field and have shown evidence of good predictive validity.

1.3 Admission assessments

The admission assessments to dental schools differ between institutions and countries and the utilisation of these can be in isolation or in various combinations. Dental schools in the United Kingdom use a combination of methods for applicants’ selection. Each institution has the autonomy to decide the assessment tools used to evaluate their dental applicants. All request previous academic attainment as represented by level two and three qualifications such as GCSE and A level score or equivalent, or for graduate students this will also include post-school qualifications, along with a combination of aptitude tests, personal statements, references, and interviews (Booth et al., 2022). The University Clinical Aptitude Test (UCAT) is the aptitude test almost used by all dental schools in the UK except for the University of Leeds where the Biomedical Admission Test (BMAT) is used.

Many institutions apply a two-step process: shortlisting for an interview based on the previous academic achievement, aptitude test, the information provided in the UCAS form, the personal statement, supplementary questionnaires and/or referee’s letter, followed by an interviewing stage (Parry et al., 2006). However, an essential challenge remains: determining the predictive validity of various selection methods, which refers to the extent to which a predictor measure is correlated to a criterion measure (Cleland et al., 2012b). It is clear that there is a growing body of research around the selection of medical students, but few studies explore dental student selection in detail (Greatrix and McAndrew, 2022). Predictive validity studies are essential for establishing trust in the use of selection assessments to inform universities selection procedures. At the same time, candidates should be reassured of the legitimacy of selection methods that would otherwise be perceived as an additional barrier (Greatrix et al., 2021).

The following section will briefly explore the admission assessments and their predictability of a student's performance as outlined in figure 1 below. Further discussion about this will be presented in the chapter 2 in which the literature was systematically reviewed for the predictive validity of selection methods in the undergraduate dental programmes in the United Kingdom.

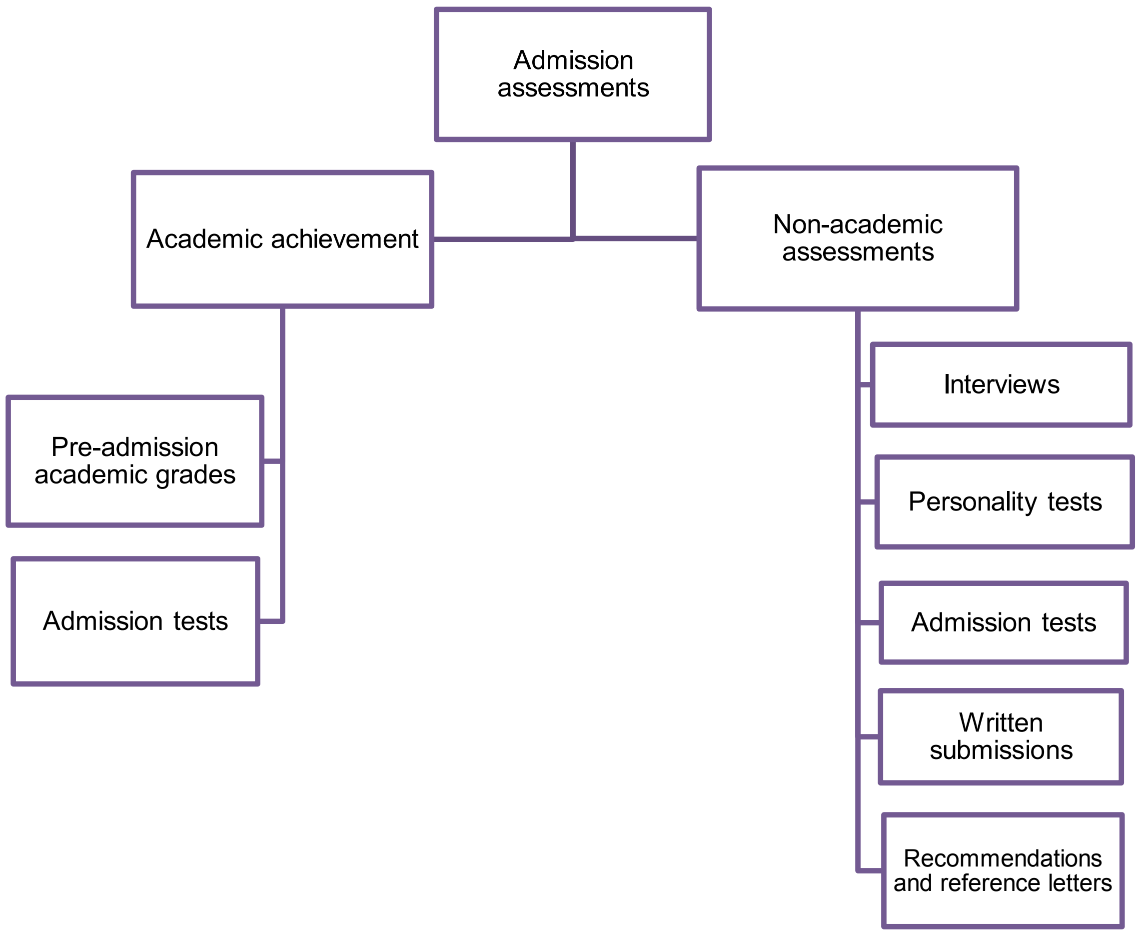

Figure 1: Outline of the admission assessments explored in the introduction

1.3.1.1 Academic achievement

1- **Pre-admission academic achievements**

In the UK, undergraduate selection has traditionally been dependent on predicted or actual school-end exam results. In a study conducted by McManus et al, students' in-course performance was highly predicted by the academic performance in national exams that are used at the end of secondary school (e.g., A levels in the UK), representing 65% of variance in first year performance (McManus et al., 2013). However, it was questioned by other researchers whether differences in pre-admission academic achievement is related to clinical performance (Barbour and Sandy, 2014b). Another study found that only 23% of the variability in student performance was attributed to previous academic achievement, and that percentage became smaller for postgraduate performance, reaching only 6% which mean that the predictive validity of previous academic achievement may decrease overtime (Ferguson et al., 2002b). Additionally, they also found that the predictive value of the grades reduced as the students moved from preclinical to clinical years of the course. In addition to the predictive validity issue, the weight given to school examination results has raised the debate over the social exclusivity of school selection methods because of the potential for A-level results to reflect type of schooling and social class (Schwartz, 2004). For instance, in a study conducted by Hoad-Reddick and Macfarlane, they investigated the relation between the applicants' characteristics and their A-level results and interview performance. They found that students from the private school sector achieved higher A-level results, specifically in mathematics, in comparison to students from the state sector. However, there was no difference between the students of these two sectors and their overall interview score (Hoad-Reddick and Macfarlane, 1999). Furthermore, according to research findings, high A level grades are significantly less likely to be achieved by individuals from skilled manual, partly skilled or unskilled families in the UK than by those from professional, intermediate or skilled non-manual families (Schwartz, 2004). Another issue is that admissions decisions are made primarily on the basis of predicted exam scores that are later validated. Generally, only half of predictions are accurate and it appears that prediction accuracy differs by school/college and subject (Schwartz, 2004). In a study conducted by Hayward et al, it was found that predicted grades were inaccurate in more than 50% of cases and that the errors were more related to students of lower social class (Hayward et al., 2005). Numerous institutions handle this issue by lowering their dependence on past educational achievement and supplementing it with alternative selection methods or contextualised admissions schemes. However, information about the extent to which this shift in practise has widened participation is contradictory (Fielding et al., 2018). Some of the recommendations proposed that the education sector use a post-qualification applications (PQA) system in which admissions offers are made after examination marks are determined, however after a consultation period this was rejected (Department of Education, 2021). This approach is anticipated to be more equitable and efficient. Additionally, it may benefit students who lack confidence, for example, due to their unfamiliarity with higher education as some pupils may opt not to apply at all or may limit their course selection because they believe their grades will be insufficient. If the PQA is applied, they would already be aware of their grades prior to applying. Another issue is that the average A-level score has steadily grown over the past few years. Consequently, A levels are losing their discriminative power and distinguishing among a large number of highly qualified applicants on the basis of academic accomplishment is getting increasingly challenging. All of the aforementioned limitations of the use of academic qualifications led institutions to the use of aptitude tests in the selection process (Cleland et al., 2012b).

2- Admission tests

National admission exams are used as assessment tools of the cognitive quality of applicants irrespective of pre-admission academic achievement (Rees et al., 2016a). They can be defined as standardised examinations that are used to assess a person's ability to learn skills and knowledge (Cleland et al., 2012b). However, it is necessary to differentiate between crystallised intelligence (knowledge-based intelligence, developed by schooling) and fluid intelligence (biologically-based cognitive ability). This is important, specifically in regard to widening participation. Aptitude tests are measures of fluid intelligence, and it has been suggested that such tests should be utilised for school admissions in order to widen access by identifying raw talent regardless of educational background. Therefore, admissions exams are increasingly being employed to assist in differentiating between high achievers and comparing applicants from diverse educational backgrounds and countries (Emery and Bell, 2009b).

Many medical and dental institutions use the UCAT to assess different students' abilities such as quantitative and verbal reasoning, decision analysis, and abstract reasoning. The objective of using the UCAT is to employ assessments for selection that were less prone to bias than A levels (James et al., 2010). Tiffin et al study revealed that that different approaches (in borderline cases, as a factor in admissions, or as a threshold) to administering the UCAT could result in a larger number of students from under-represented groups being admitted to UK medical schools (Tiffin et al., 2012). However, another study was conducted by James, et al in which they aimed to investigate whether the UCAT may mitigate the socioeconomic bias associated with A levels, indicated that the test is in favour of male applicants, those from a better socioeconomic level, and those who attended independent or grammar schools (James et al., 2010). However, because the applicants' in-course performance was not assessed in this study, it is difficult to decide if these findings represent real differences between the groups or if the test is truly biased. Likewise, the evidence of the predictive validity of UCAT is also contradictory. Some studies found significant correlations between UCAT and students' performance (Foley and Hijazi, 2015, Lambe et al., 2018). while in other studies the correlations did not reach statistical significance. Such contradictory findings are to be expected due to the diverse outcome measures and cohorts being assessed. Further discussion is reported in the following chapter.

In 2012, the situational judgement segment, which is used to assess qualities such as empathy and integrity, was launched as a pilot sub-test, and in 2013, it was made a live part of the test (McAndrew and Greatrix, 2014). In situational judgment tests (SJT), applicants are assessed on their ability to make judgements in role-relevant settings. They are given a scenario and a set of responses, being tasked with considering the situation and judging the importance of possible responses (Cleland et al., 2012b). In a study carried out by Lievens et al., SJTs had a low negative impact on minority groups (Lievens et al., 2008). Furthermore, Lievens and colleagues found that SJTs become increasingly valid as a performance predictor over the years of medical school training (Lievens et al., 2005). On the other hand, Lambe et al did not find any significant correlation between any of the SJT bands and the outcome measures they considered. However, this could be explained by their outcome variables being focused on academic attainment assessments (Lambe et al., 2018).

BMAT (Biomedical Admissions Test) is another admission test that has been used to aid in the selection process. While the BMAT serves as an admission test utilized by several medical schools, it was employed by only one dental school in the UK, namely the School of Dentistry at the University of Leeds. It appears to predict future course performance equitably for candidates from a wide variety of educational, social and geographical backgrounds. Therefore, UCAT was substituted with BMAT at the Faculty of Medicine and Health. The BMAT has three sections: aptitude and skills, scientific knowledge & application and a writing task. Table 1 provides further information regarding the BMAT parts.

Davies et al. (2022) investigated the association between BMAT sections and written& clinical assessments across all the programme in four cohorts at the Imperial College School of Medicine and Lee Kong Chain School of Medicine. Therefore, representing two different populations and multiple cohorts. It was found that BMAT section 2 scores predicted performance in all written assessments in both schools. However, sections 1 & 3 showed few correlations between written assessments and clinical assessments, respectively, in one institution only. Multivariate analysis has also confirmed that section 2 was the most predictive of the BMAT sections. when looking at clinical performance, a study by Paton et al, assessed the if BMAT scores predicted performance on the postgraduate membership of the Royal College of Physicians including the clinical examination practical assessment of clinical examination skills. The found that section 1 was the most important predictor of clinical performance (Paton et al., 2022). Additionally, BMAT has been found to predict students' examination scores equitably for different background variables such as gender and school type (Emery et al., 2011).

Table 1: BMAT sections

Section	Description
Section 1: Aptitude and skills	Measures skills in problem solving, argument comprehension, data and graphical interpretation and inference. -Multiple-choice questions or numerical answers. -Marked objectively.
Section 2: Scientific knowledge and applications	Measures familiarity with core biology, chemistry, physics and maths materials normally encountered in non-specialist UK schools up to the age of 16 years. -Multiple-choice questions or numerical answers. -Marked objectively.
Section 3: Writing task	Assesses written communication clarity and argument skills via a choice of three short essay questions, of which one must be attempted. -The writing task was not marked by the test provider prior to 2004 and this institution continues to use the essay only as a piece of qualitative evidence and to promote discussion during the interview. -Writing task marks are used in selection by some other institutions.

1.3.1.2 Non-academic criteria assessments

Institutions utilize a variety of methods to assess the non-academic criteria of candidates. These include interviews, written submissions, letters of reference, and personality tests. These will be briefly explained in this section.

1- **Interviews**

Admission interviews are usually performed for the purposes of decision making, confirmation of the application data provided by the applicant, and, most importantly for the institutions, for information gathering, specifically non-academic information that are hard to be obtained in other ways such as motivation, leadership and altruism (Edwards et al., 1990, Salvatori, 2001a). Interviews can be classified to structured, semi-structured and unstructured interviews (Edwards et al., 1990). Structuring an interview involves analysing what makes a student successful to develop the interview content, standardising questions for all candidates and providing sample answers using panel interviews. Interviews that meet some of these criteria are categorised as semi-structured, and those that have none of the above criteria are unstructured. Interviews can vary in their formats between one to one, group, panel, and a combination (Edwards et al., 1990).

Panel interviews do not seem to possess adequate reliability that guarantees the appropriate selection of the applicants (Kreiter et al., 2004). This type of unstructured interviews has many shortcomings, including lack of standardisation, possible interviewer and social bias and the poor predictive value for future performance (Kreiter et al., 2004, Razack et al., 2009). For instance, at McMaster University, it was found that candidates who “excelled” as family medicine residents were identified successfully by the interviewers, however those who experienced major problems were not identified (Salvatori, 2001a). Additionally, traditional panel interviews do not seem to predict how students performed on the Objective Structured Clinical Examination (OSCE) either within medical school or during licensing examinations, although OSCEs are partially designed to assess part of the non- academic abilities that panel interviews are expected to evaluate, such as problem exploration and communication skills (Barbour and Sandy, 2014b). Furthermore, unstructured interviews are known to fail to systematically capture the skills needed in the applicant (Mirghani et al., 2019a). They have been considered to be one of the most subjective aspects in an admissions process (Lemay et al., 2007).

The reported reliability of admission interviews can vary widely between studies. These differences depend on the type of interview carried out by the institution. For example, structured interviews have better reliability and validity in comparison to unstructured ones. Nevertheless, these reliability estimates may be falsely increased if the interviewers have sight of information regarding the candidates’ previous academic achievement or if non-verbal communication between interviewers occurred during the interview (Eva et al., 2004c). For example, subtle cues from an interviewer such as facial expressions, body language, and eye contact can unconsciously convey favouritism or prejudice which may influence the decision of the other interviewer. For instance, one interviewer may retain good eye contact and an engaged posture, whereas the other interviewer could consistently display a sceptical expression. In this case one of them could influence the decision of the other leading to unintentional transmission of biased non-verbal cues that can influence the overall evaluation of the applicant, jeopardise the interviewer objectivity and undermine the fairness of the interview process. Additional biases that also influence the interview include the interviewers' expectations and backgrounds (Eva et al., 2004b). Actually, Harasym et al. (1996) found that 56% of the variance in interview marking is attributed to interviewer variability. Moreover, the independence of an interviewer's impressions toward a candidate's response to another cannot be guaranteed (Eva et al., 2004a). This means that an applicant's performance in an interview may be affected by a specific interviewer, questions asked, or other factors that might be unrelated to the applicant's appropriateness (Uijtdehaage et al., 2011).

Different approaches have been suggested to increase the reliability of an interview. This includes interviewer training prior to interviews, using structured interviews, or involving multiple interviewers (Salvatori, 2001b, Uijtdehaage et al., 2011). It was also suggested to evaluate the applicant's performance independently, multiple times on separate occasions by multiple raters: the multiple independent sampling (MIS) method. The multiple mini interview (MMI) is the most notable application of this technique (Hanson et al., 2012). In 2004, the School of Medicine at McMaster University in Ontario, Canada began implementing a multiple-station-based assessment method, namely the multiple mini-interview (MMI). It was initially used as a selection method for undergraduate students (Eva et al., 2004b). On the grounds that OSCE has become the gold standard for assessing medical student clinical competencies, a similar technique to the OSCE was used to form the MMI structure, in an attempt to improve the validity of interviews. This was based on the finding that multiple independent observations are essential to gain a generalisable assessment of an individual (Eva, 2003). Similar to the OSCE, the MMI is designed to include multiple focused stations, each with a different examiner. However, it could be said that the MMI is not clinical nor is objective. However, following research on the OSCE, it was found that subjective ratings can be reliable and valid in estimating an individual's abilities (Eva et al., 2004b). By taking into account the interviewer bias and the poor predictive validity of unstructured interviews discussed previously, MMIs were developed to overcome the following problems: the interviewer bias effect noted in traditional panel interviews and the inability of such interviews to predict future student performance, and for the importance of recruiting students possessing certain non- academic skills that are believed to be important in healthcare providers (Alaki et al., 2016). They can be defined as a highly structured selection tool so that all applicants respond to the same questions. They are proposed to evaluate many of the non-academic characteristics that were inadequately assessed by the panel interview. In addition to its flexibility that allows designing the stations with a blueprint of the qualities desired by the institution. Determining the characteristics that need to be assessed in an applicant is the first step in designing a programme-specific MMI. These characteristics are usually chosen based on literature search and stakeholder analysis (Knorr and Hissbach, 2014). Then the content of the MMI can be ensured by forming a blueprint of the non-academic attributes chosen to be valued by the institution and stations are created according to this blueprint (Eva et al., 2004b). According to Knorr and Hissbach (2014) these attributes range between three and nineteen. These attributes can be evaluated by asking the candidate to discuss a topic or a dilemma with the interviewer or by answering few standardised questions. Candidates can be also evaluated for their interaction with a simulated patient (actor) or for performing a practical task. Some MMIs may also contain problem-solving, prioritising or creative tasks, presentations, film clips or writing samples. The stations are meant to assess the candidate's capability to 'sort out' the problem given and express their opinions with clarity, rather than evaluating the applicant's specific knowledge (Eva et al., 2004c, Knorr and Hissbach, 2014). In the systematic review conducted by Rees et al, the number of stations ranged between seven and twelve, each with a single assessor (Rees et al., 2016b). It was also reported that the MMI's reliability is more affected by the increase in the number of stations rather than by the increase in the period of a station or the number of assessors in a station (Sebok et al., 2014, Rees et al., 2016b).

The MMI also permits several independent samples of insight into an applicant's abilities as each candidate moves through a circuit of several short, standardised interview stations, each with a different interviewer. Besides the advantage that the candidates can be more comfortable and confident knowing that if they did not perform well in a particular station, there will be a chance of recovery by moving onto a new station with a different interviewer (Eva et al., 2004c, Pau et al., 2013, Knorr and Hissbach, 2014, Barbour and Sandy, 2014a). Additionally, it was found by Uijtdehaage et al that a wide-ranging total applicants MMI scores were obtained proving that MMIs can distinguish between large number of applicants presenting with an excellent academic record (Uijtdehaage et al., 2011).

When assessing the correlation between MMI and other admission assessments, it was found that MMI scores have low correlations with pre-entry academic achievement such as GPA (Eva et al., 2012) and with UCAT Test (O'Brien et al., 2011). This confirms that MMI is providing us with additional information other than that provided by the academic. Achievement assessments. On the other hand, it was found by Cheung et al. (2017) that BMAT scores demonstrated a significant correlation with the candidates' performance in the MMI. This need more investigation to see whether this finding is replicated and which section of the BMAT correlates with the MMI. It is possible that this result varies depending on what the MMI is designed to measure. Furthermore, the relation between MMI scores and the 'big five' personality types have also been assessed in several studies. Some found no correlation such as (Dore et al., 2010) while others found that extroversion, agreeableness and conscientiousness to be related with MMI total score (Griffin and Wilson, 2012). Knowing this correlation between various admission assessments might help admission committees determine the most effective combination of assessments. It also emphasizes the importance of identifying which skills to be assessed in the MMI. The objective should be to utilize assessments that provide us with additional information that aids in applicants' selection.

The predictive ability of MMI for students' performance varies from one institution to another, depending on the attributes assessed and the outcome measures considered (Rees et al., 2016a). For example, a study by Eva et al. (2012) compared the candidates interviewed and accepted at McMaster University Medical school using an MMI, with those who were interviewed and rejected but gained entry in another institution with regard to their eventual licensing examination scores. They found that that in comparison with the candidates who had been rejected following the MMI interview, the candidates who had been accepted scored more highly on Canadian national licensing examinations.

However, when Hofmeister et al. (2009) assessed the correlation between the MMI scores of candidates for family medicine residency programme in Alberta and the licensing examination scores, they found a non-significant correlation between MMI scores and the licensing examinations scores. These conflicting findings could be due to the differences in the attributes assessed by the institutions and the difference in cohorts (Knorr and Hissbach, 2014). For example, in Eva et al. (2012) study, the MMI was focussed on ethical issues, communication, and collaborative tasks, while Hofmeister et al. (2009) focused on the professionalism competency using clinically-related professionalism challenges. Similarly in the dental field, the MMI's predictive validity showed contradictory findings. For example, Foley and Hijazi (2013), Foley and Hijazi (2015) found that MMI was a predictor of students' performance while McAndrew et al. (2017) did not. This emphasizes the need to assess the predictive validity of each MMI station in order to determine which skills are critical for predicting student performance.

2- Personality tests

According to the literature searched, personality tests are not used currently in the admission process of the undergraduate dental programmes in the UK. However, integrating personality tests into admissions processes, may improve decision-making over who is admitted to a programme and help to obtain additional information that other admission assessments do not provide (Poole et al., 2007). A variety of personality measures have been used in different countries. One of the most reported personality test used is the five-factor model (FFM), referred to earlier as the 'Big-Five'. It was found to be associated with students' academic achievement across several academic disciplines. The five factors are conscientiousness, agreeableness, openness, neuroticism and extraversion. Multiple narrow facets are also assessed under each factor (Poole et al., 2007). Generally, mixed results have been found on the association between personality and students' performance in the dental school (Poole et al., 2007). Inconsistent results between institutions could be explained by differences in the criterion variables being assessed. Moreover, some of the personality facets may be not useful in the early years of academic modules and exhibit more importance as the student progresses to clinical practice (Cleland et al., 2012b).

Conscientiousness may be a particularly significant facet in student performance as more conscientious individuals tend to develop and fulfil their own goals. In fact it was found to predict clinical and academic students' performance (Chamberlain, 2004, Poole et al., 2007). In regards to agreeableness, a positive significant association with students' performance was also in another study (Evans and Dirks, 2001). Additionally, their results showed that trust, compliance and straightforwardness, which are three of the narrow facets of agreeableness, were also positively and significantly associated with few grades. On the other hand, Chamberlain et al. were able to find a negative association between 'neuroticism' and the measure they used for the professional student behaviour in the clinic (Chamberlain, 2004). Chamberlain has also supported the use of narrow facets. In fact, Poole et al found in their study that narrow facets predicted almost all their outcome criteria. That said, personality tests could be considered for exploration and research to further investigate their value in admissions.

3- Written Submissions

Personal statements, essays, and other kinds of autobiographical submissions are often used to evaluate the appropriateness of an applicant. There is variability among institutions in terms of how data from autobiographical contributions are utilised. Some schools officially use the data in determining admissions decisions, whereas others disregard this information because they are concerned that it may unjustly bias selection judgments (Cleland et al., 2012b). The evidence regarding the use of written submissions as a predictor of the candidate's performance is limited and conflicting (Salvatori, 2001a). In a study carried out by Ferguson et al, found that neither the categories of information contained in personal statements nor the quantity of information contained in personal statements were shown to be predictive of future students' performance (Ferguson et al., 2000). However, in another study it was found that personal statements were predictive of the clinical aspects of the training (Ferguson et al., 2003). The legitimacy of personal statements is undermined due to the absence of standard parameters, such as amount of time to finish the writing, and the potential of third-party input, which renders them unrepresentative of the applicant's true character. Moreover, if the submitted statement has a free-form non-standardised nature, each statement will represent a number of personal characteristics that differ from another candidate's statement. This makes the comparison between applicants very challenging. It was suggested that an essay written at the time of interview and scored on format, neatness, spelling, writing style and quality of content, was a better discriminator between students (Salvatori, 2001b, Albanese et al., 2003, Cleland et al., 2012b). As research have indicated, the quality of personal statements as selection tools is undermined by a variety of limitations despite their widespread use.

4- Recommendation / Reference letters

Kirchner and Holm (1997) reported poor predictive validity of reference letters. Furthermore, as the letter is usually free in form and the referees are selected by the applicant, it is hard to know how representative a letter is of the applicant and to evaluate the letters of an applicant against a letter of another (Salvatori, 2001a). Albanese et al. (2003) suggested that if national standards were created to specify the content of the letters in reference letters, the letters' content might be easier to evaluate. Moreover, the data contained in the reference letters may bias admissions panels (Cleland et al., 2012b).

1.4 Summary

This chapter provided a brief introduction to the key research topics related to what will be explored in subsequent chapters. Specifically, the concept of predictability of admission assessments and the influence of personal characteristics on applicants' and students' performance, which contributes to the fairness of the admissions process. As we have seen, admission processes of both the dental and medical fields involves different assessments that are used in combinations which vary from an institution to another. Prior academic achievement has been the key criterion for selection, and is often evaluated at an initial screening step, for the purpose of shortlisting, followed by different assessment methods. However, in addition to limiting admission of those from widening participation backgrounds, the amount of variance that prior academic achievement accounts for and its ability to predict future clinical performance has been argued. This has resulted in a greater emphasis on the importance of assessing non-academic attributes, however little is known about which attributes are predictive of future performance. Moreover, dental and medical school admissions processes generate considerable attention and sometimes face criticism regarding its fairness in applicants' selection. This highlights the critical need for more research into the admissions process and the optimal combination of screening assessments. Therefore, we aim in this thesis to explore is whether the admission process at the dental school provides insight into future dental student performance and if the existing admissions assessments discriminate against or towards candidates based on socio-demographic variables. The overarching aim across the following studies is to generate a body of work that can be used to inform dental educators on the factors that can predict a dental student's performance and to identify, if any, the factors that could result in discrimination between applicants. However, in order to have a comprehensive understanding of the key concept of predictability covered in this thesis, we will first systematically review the literature available about the predictive validity of selection methods in the undergraduate dental programmes in the United Kingdom. This is presented in the next chapter. The thesis outline is explained below.

1.5 Thesis outline

The thesis is structured into five chapters as follows:

The first chapter, as presented, was a brief introduction to the concepts predictability and fairness of the admission systems.

The second chapter will present a systematic review of the literature which reports the findings from the previous two decades of research investigating the predictive validity of dental school selection methods used in the United Kingdom.

The third chapter will present the research methodology, aim and objectives and the general ethical considerations of the project.

The fourth chapter of the thesis will present the results of the data analysis.

The fifth chapter of the thesis will provide a discussion of the research findings and our recommendations for improvement of the admission process.

Chapter 2 The predictive validity of selection methods in the undergraduate dental programmes in the United Kingdom: A Systematic Review

2.1 Methods

2.1.1 The research question

The overall question for this systematic review is: In populations of undergraduate dental students, what are the predictive admission selection methods and personal qualities of student' performance during the course of study?

The following PICO structure was used:

P: Undergraduate dental students

I: Admission selection assessments including personal qualities assessments that an applicant had to take in order to be offered a place at a dental school:

Admission tests

Pre-admission academic records

Personal statements, essays and autobiographical submissions

Reference letters

Interviews

Personality tests

C: No comparator

O: Academic performance, clinical performance, completion of programme, professional behaviour

2.1.2 Information sources

The nine databases listed below were searched for (In populations of undergraduate dental students, what are the predictive admission selection methods and personal qualities of student’ performance during the course of study?) The search was peer-reviewed by an Information Specialist at the University of Leeds, School of Dentistry. All databases were searched from February to March 2020 and was updated for eight databases on the 28th of July 2022 as Proquest dissertation and thesis access was no longer available for the University of Leeds.

1- Ovid MEDLINE(R) ALL <1946 to July 27, 2022>
2- Embase Classic + Embase <1947 to 2022 July 27>
3- APA PsycInfo <1806 to July Week 3 2022>
4- ERIC - Education Resources Information Center (EBSCO) 1966-present
5- British Education Index (EBSCO) 1986-present
6- Web of Science Core Collection: Citation Indexes (Clarivate Analytics) 1900-present
7- Scopus (Elsevier B.V.) 1823-Present
8- BIOSIS Previews (Clarivate Analytics Web of Science) 1969-present
9- Dissertations & Theses A&I (Proquest) 1743-present

2.1.3 Search strategy

Searches were developed for the concepts: [Undergraduate dental students, Admission tools and selection criteria and students’ outcomes]. Subject headings and free text words were identified for use in the search concepts and words tested from relevant papers. Within each concept, terms were joined using the Boolean operator “OR.” The three concepts were then combined with the operator “AND.” Further terms were identified and tested from known relevant papers. Please see Appendix [A] for the full search strategies. No language or type of study restrictions were applied during the searching phase. Further relevant studies were sought by citation searching (forwards and backwards) of the included studies. References were managed in Endnote. The de-duplicated set was exported to Rayyan for screening.

2.1.4 Selection process

The database searches identified records were all transferred to EndNote database, duplicates were removed (by automatic deduplication and manual check). Once duplicates were removed, the remaining records were checked independently by two reviewers. First all titles were assessed for relevance to the research question and the clearly irrelevant studies were excluded. Where disagreement arose, the record was included for review of abstract. Then the abstracts of all retained records were also assessed independently to identify those to be assessed in full text. Where disagreement arose, the full text of the paper was read. Finally, the full text of the remaining records was assessed independently to determine those to be included in the review.

2.1.5 Eligibility criteria

The eligibility criteria were applied in three phases. Each phase narrowed the criteria for eligibility of the final records to be reported in the review. This approach allowed for initial exploration of the entirety of the extant literature on this topic, which will be the subject of separate systematic reviews at a later date before reducing the review in line with the scope of this project.

The predictor variables included in this review cover any assessment methods used in the admission process for the purpose of selection of undergraduate dental students. However, any paper that evaluated an admission tool at a level other than admission, such as on enrolled student, was excluded. Applications to postgraduate dental courses or postgraduate training programmes were not considered in this review. Studies that are purely descriptive were excluded as well as commentary and opinion pieces. In other words, studies had to provide primary data to be included in this review. After determining all the relevant records according to the previous inclusion criteria, we extracted those that were published in the last 20 years due to the progressive nature of this field in which recent studies update and expand on previous historical practice. Moreover, many of the selection methods in current use were either not available or widely used prior to 2000 such as the emergence of MMIs as a selection tool since 2004. Finally, only those which were carried out in the

United Kingdom were included in the review due to relevance to this research project. See table 2 for a summary of the inclusion and exclusion criteria.

Table 2: Inclusion and exclusion criteria

	Inclusion criteria	Exclusion criteria
1st phase		
Population	Applicants to Undergraduate dental programmes	Applicants to: -Non-dental professions -Postgraduate dental courses and programmes
Intervention	Any admission test or pre-entry assessment carried out at admission level	If the admission test or assessment was studied on enrolled students during their programme of study or not used in the actual selection of applicants.
Outcome	Any outcome carried out during the undergraduate programme.	-
Study design	Studies which provide primary data	Purely descriptive studies Commentary or opinion articles
Language	English	Non-English with no translation provided by the author
2nd phase		
Publication date	On 2000 onwards	Before 2000
3rd phase		
Location	UK	Non-UK

2.1.6 Data extraction process

The following data was extracted by one reviewer from each of the included papers in an excel sheet: Title, author/s, publication year, country, university, aim, sample details, study design, predictor variables, outcome variables, follow up, entry requirements if specified, data collection method, reported tests, reported tests values, overall findings and conclusion. A summary of the data collected from each of the UK-based papers included in this review is presented in table 9.

2.1.7 Quality assessment strategy

Quality assessment of the included papers was carried out by two reviewers using the Medical Education Research Study Quality Instrument (MERSQI). This assessment instrument was designed to measure the methodological quality of experimental, quasi-experimental, and observational studies of medical education research and therefore, most appropriate given the research designs included in the review (Reed et al., 2007). It includes a ten-item checklist reflecting six domains of study quality. Items are scored on ordinal scales and summed to determine a total MERSQI score. The maximum total score is 18 with each domain having a maximum score of 3. The scoring was discussed by the two reviewers and consensus was reached regarding the score grid's interpretation. In cases were the studies included multiple aims, the MERSQI scoring was only applied to the part of the study that assessed the predictive validity of the admission criteria, as this is the focus of this review. Any disagreements between the reviewers were resolved by discussion. For details about the MERSQI domains, items and scoring, please see appendix [B].

2.1.8 Evidence synthesis

Due to the heterogeneity of studies, the wide variety of selection methods being studied and outcome measures used, and the variety of research designs and methods, it was not possible to pool results statistically. Therefore, the evidence is synthesised into a narrative review. This evidence synthesis was used to identify, summarize and evaluate the research papers relevant to the aim of this review, making the existing evidence more accessible. The findings will be provided in the next section, as illustrated in the figure 2 below:

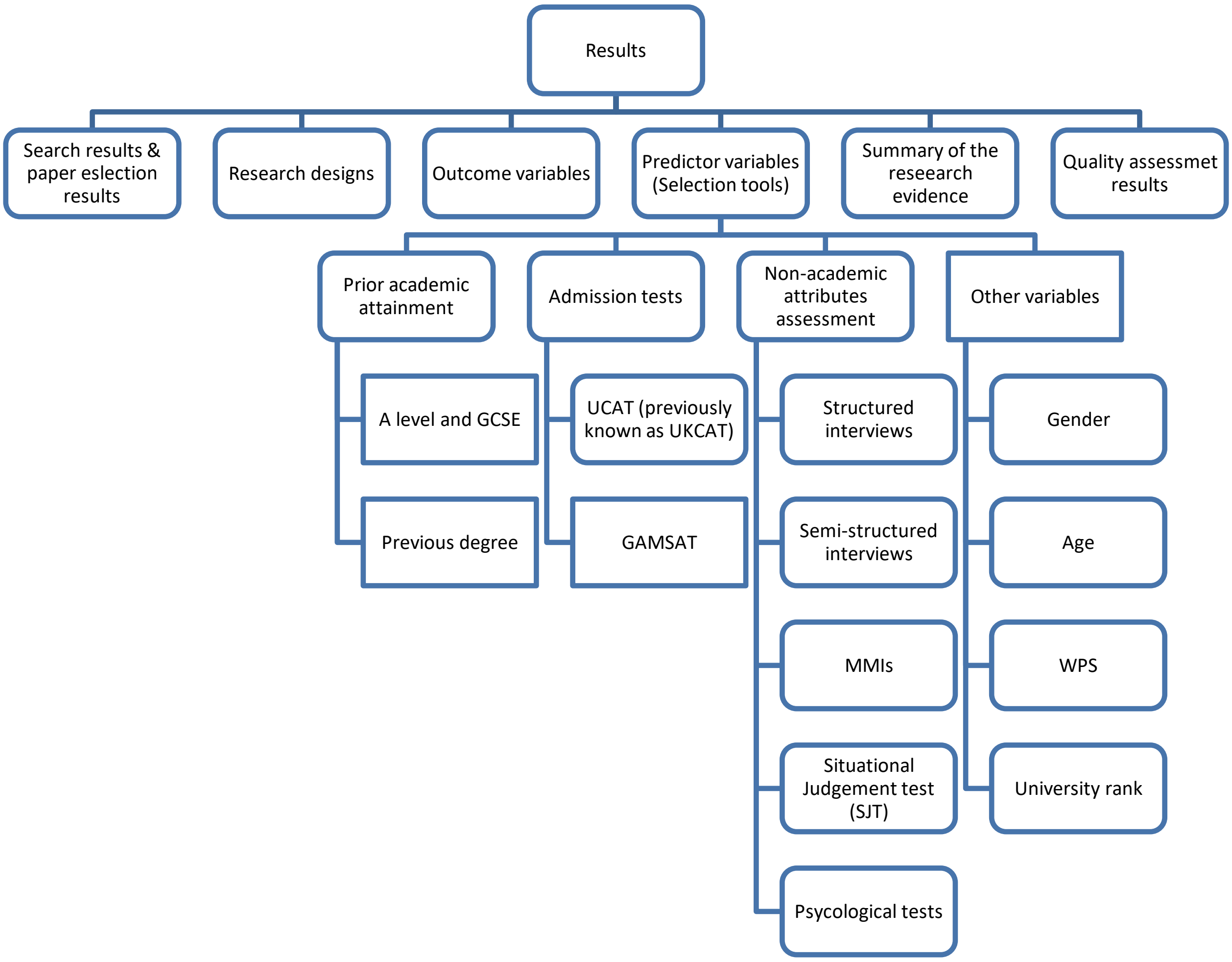

Figure 2: Outline of the systematic review findings as discussed in the results section

2.2 Results

2.2.1 Search results and paper selection results

The database searches identified 6050 records which were all transferred to EndNote database, duplicates were removed (by automatic deduplication and manual check). Once duplicates were removed, the remaining records (Total n=3958) were checked independently by two reviewers. First all titles were assessed for relevance to the research question and the clearly irrelevant studies were excluded. Where disagreement arose, the record was included for review of abstract. Then the abstracts of all retained records were also assessed independently to identify those to be assessed on full text, with 97.9% agreement. Where disagreement arose, the full text of the paper was read. This left a total of (n=178) records which were read in full text and independently assessed against the review question. Subsequently (n=147) reports were included for full review and (n=31) were excluded. One additional paper was identified after performing the citations searches of the included papers and another paper was identified through personal communication. After identifying the papers that answer the review question, date limit was applied to identify the papers published in the last two decades leaving 81 papers. When the location limit (UK) was applied, 8 papers were left to be included in this review. Figure 3 illustrates a summary of the paper selection process. Prior to the application of the date and location limit, papers were found to originate from 23 country. UK-based research represented 12% of the search results from the period between 1974 to 2018. Papers' distribution is illustrated in figure 4. A list of the UK-based papers is presented in table 3.

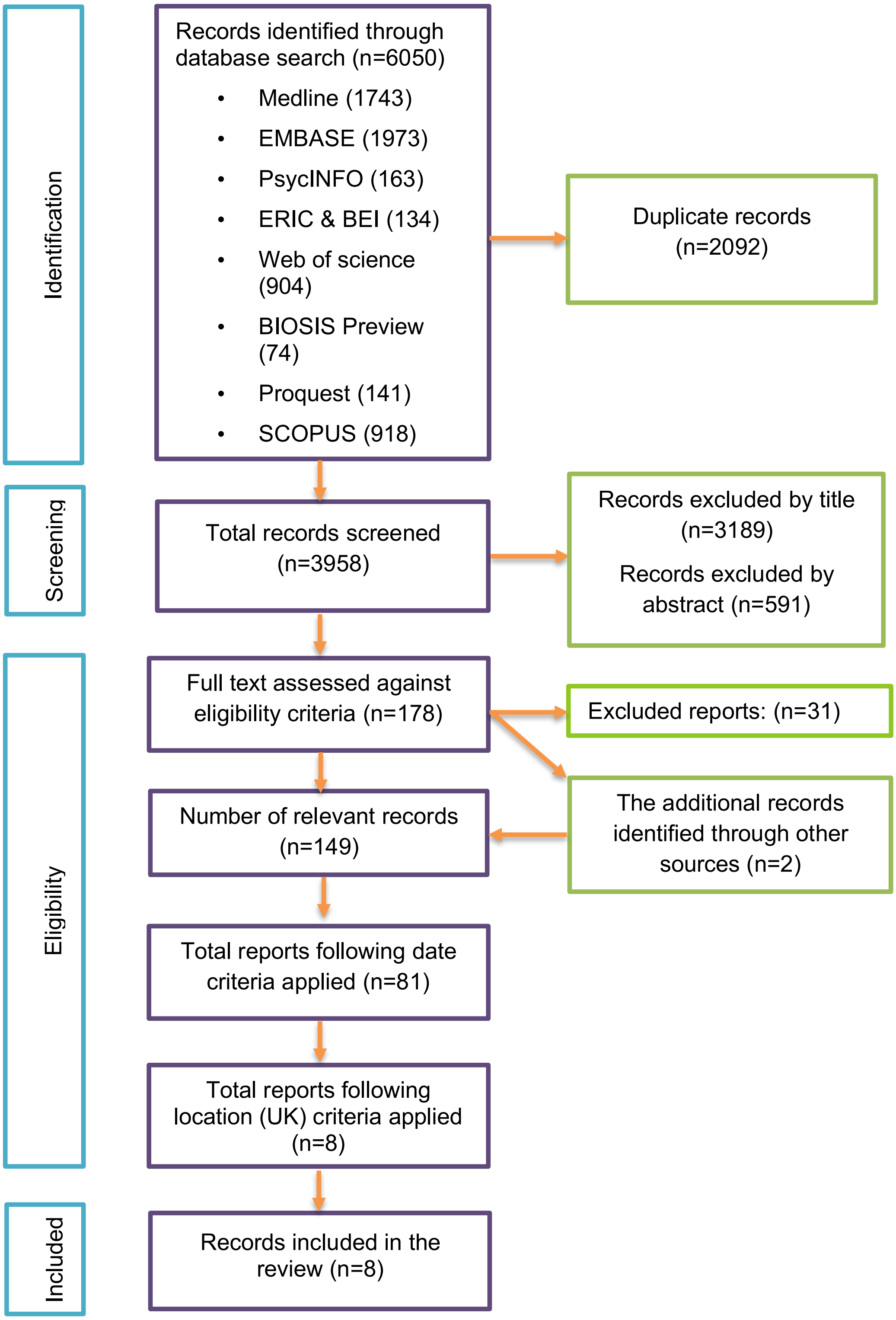

Figure 3: Paper selection process

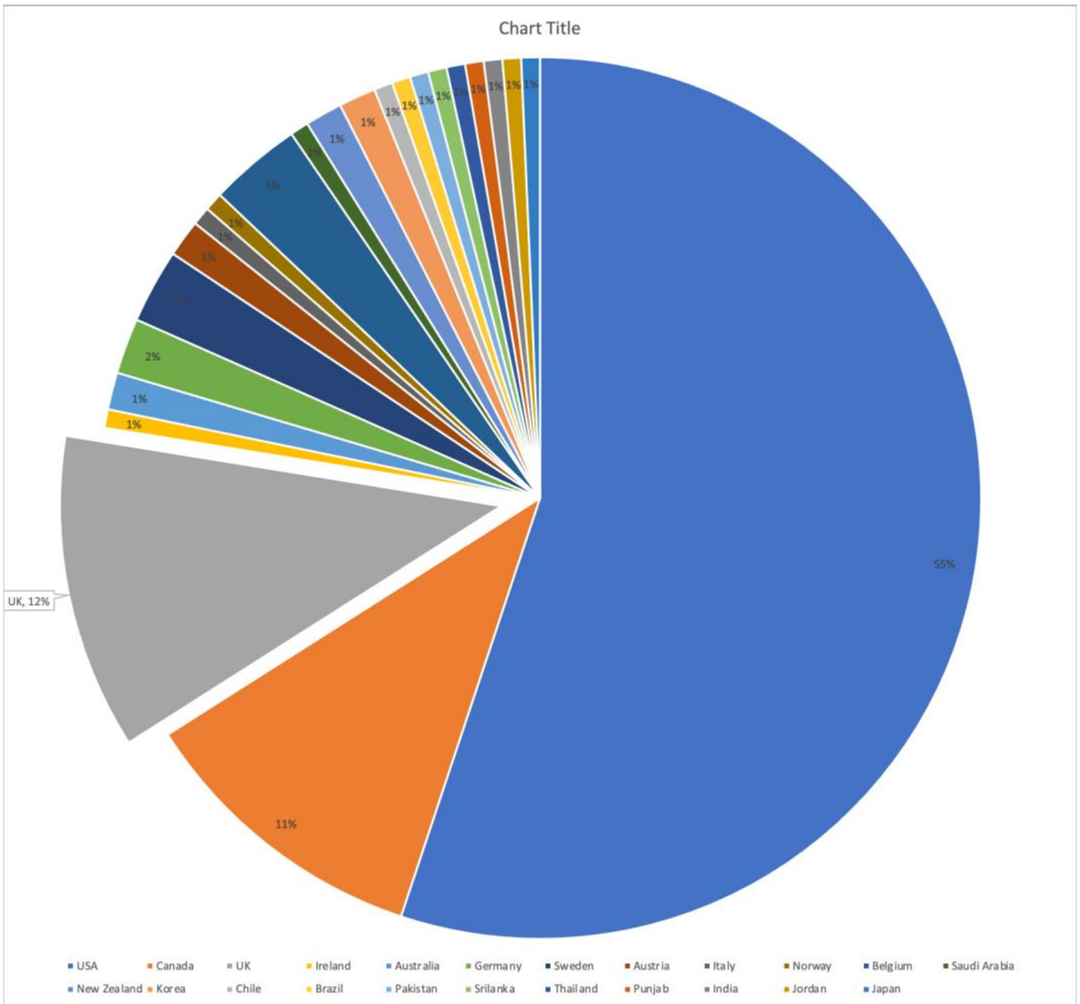

Figure 4: Papers' distribution

Table 3: UK-based studies

Study title	Authors/Year
1-The relationship of advanced level qualifications to subsequent academic performance of dental students	(Whitehead, 1974)
2-Predicting performance in UK dental students using multiple regression analysis	(SMITH, 1975)
3-University examination performance of dental students. Correlation between entry qualifications and non-clinical examinations	(Prout and Hoy, 1976)
4-The value of tests of spatial and psycho-motor ability in selecting dental students	(Smith, 1976a)
5-A comparison of the value of trainability assessments and other tests for predicting the practical performance of dental students	(Smith, 1976b)
6-Dental student selection-the prediction of success	(Jones, 1979)
7-Can past academic criteria predict students at risk of future failure?	(Boreham et al., 1988)
8-A longitudinal study of the value of a spatial relations test in selecting dental students	(Smith, 1989)
9-Assessment of UCAS forms as a predictor of dental student performance	(ROBINSON et al., 1995)
10-An analysis of an admissions system: can performance in the first year of the dental course be predicted?	(Hoad-Reddick and Macfarlane, 1999)
11-Evidence-informed dental student recruitment techniques	(Kay et al., 2010)
12-Validity of the UCAT in applicant selection and predicting exam performance in UK dental students	(Lala et al., 2013)
13-Summary of: The admissions process in a graduate-entry dental school: can we predict academic performance?	(Foley and Hijazi, 2013)
14-Predictive value of the admissions process and the UK Clinical Aptitude Test in a graduate-entry dental school	(Foley and Hijazi, 2015)
15-The Predictive Validity of a Text-Based Situational Judgment Test in Undergraduate Medical and Dental School Admissions	(Patterson et al., 2017)
16-Does a selection interview predict year 1 performance in dental school?	(McAndrew et al., 2017)
17-Exploring uses of the UK Clinical Aptitude Test-situational judgement test in a dental student selection process	(Lambe et al., 2018)
18-MMIs as a Predictor of Undergraduate Dental Performance. Part of a PhD research project.	(Mirghani, 2020a)

2.2.2 Research design

The studies included in this review have a retrospective design. The outcome measures considered were assessed at various follow up periods during the dental programme. Five papers studied the predictive validity of the selection assessments during or at the end of the first year of the programme (Kay et al., 2010, Lala et al., 2013, McAndrew et al., 2017, Patterson et al., 2017, Lambe et al., 2018). One study assessed a single cohort up to the 4th year of a 5-year programme (Mirghani, 2020a). Two studies assessed the participants through the 4-year programme with only one cohort followed up to final year (Foley and Hijazi, 2013, Foley and Hijazi, 2015).

Full number of students in each cohort were included in the analysis in McAndrew et al. (2017) study. Patterson et al. (2017) reported that their study participants represented only 32.6% of the 1st year intake of the four schools. While in Lala et al. (2013) study, the participants included were 85.4% and 82.3% of the total cohort considered for assessing the predictability of offer status and 1st year performance respectively. This is due to exclusion of applicants who did not undertake A levels and due to 29 students missing data. Lambe et al. (2018) reported 10% of missing students' data. In the remaining four studies, it was not specified whether or not the number of participants represents the entire cohort.

Six studies were single site studies (Kay et al., 2010, Foley and Hijazi, 2013, Lala et al., 2013, Foley and Hijazi, 2015, Lambe et al., 2018, Mirghani, 2020b, Mirghani, 2020a). One study was a two-site study, (McAndrew et al., 2017). One study included a single cohort of participants from three medical school and one dental school, (Patterson et al., 2017). In this study, the data of both medical and dental students were analysed together, and the results of the dental participants' analyses were not presented separately.

Three papers studied single cohorts, (Kay et al., 2010, Lambe et al., 2018, Mirghani, 2020a). Two papers studied two cohorts, (Lala et al., 2013) and (McAndrew et al., 2017). Two papers looked into four cohorts at various follow up periods, (Foley and Hijazi, 2013) and (Foley and Hijazi, 2015). In 2013, they assessed cohorts from 2008 to 2011. While in 2015, they assessed cohorts from 2010 to 2014. Table 4 provides a summary of the included papers' study designs.

Table 4: Study design and participants details

Author / Year of Publication	Institution	Number of cohorts	Year	Number of participants	Follow up
(Kay et al., 2010)	Peninsula Dental School	1 cohort	2007	n=62	First year
(Lala et al., 2013)	Sheffield Dental School	2 cohorts	2008-09 2009-10	For outcome 1: n=1809 For outcome 2&3: n=135	First year (1st and 2nd semesters)
(Foley and Hijazi, 2013)	University of Aberdeen Dental School	4 cohorts	2008-2011	n= 75 F=50 M=25	Through the 4 years of study -Only one cohort to final year
(Foley and Hijazi, 2015)	University of Aberdeen Dental School	4 cohorts	2010-2014	n=71 F=44 M=27	
(Patterson et al., 2017)	Three UK medical schools + one dental UK school	1 cohort	2014-2015	Total n= 218 Medical n= 197 Dental n= 21 F= 119, M= 99 Note: These participants represented 32.6% of the first-year intake of the four schools.	First year

Table 4: Study design and participants details, continued

(McAndrew et al., 2017)	Cardiff and Newcastle Universities	2 cohorts		Total n= 177 Cardiff= 77 Newcastle= 100	First year
(Lambe et al., 2018)	Plymouth University Schools of Medicine and Dentistry	1 cohort	2014-2015	Total n=44	First year
(Mirghani, 2020a)	University of Leeds, School of Dentistry	1 cohort	2014-2015	N=60 F= 47 M= 13	Year 1 to 4 (Final year not included)

2.2.3 Outcome variables

All of the studies investigated their routinely used dental assessments as an outcome measure, except for (Patterson et al., 2017) study in which the supervisors were asked to fill an in-training performance questionnaire to rate the students (out of 100) at a single time point taking into account the student's performance across numerous problem based learning (PBL) tutorial sessions when rating the students. The rating of the student's performance was matched to the three situational judgement test (SJT) domains (integrity, perspective taking, and team involvement). The rating of each student was made in comparison with all of the first-year medical or dental students at their school, not independently of other students.

The reliability of the outcome measure was only reported by one study, Foley and Hijazi's study, in which twenty-seven written and practical assessments were included in the analysis and Cronbach's alpha for each suggested broadly acceptable levels of reliability ($\alpha = 0.66$ and $\alpha = 0.83$, respectively). Patterson et al, reported a factor analysis for their outcome measure. A single factor was found to explain 85% of the variance. Therefore, mean supervisor rating was used as the main criterion-matched outcome variable in their study. No other studies reported any psychometric properties or factor analysis of their outcome assessments. Table 5 summarizes the assessments considered as outcome measures in each study.

Table 5: Outcome measures across different studies

Study	The outcome considered
(Kay et al., 2010)	1-Two tests of academic knowledge 2-Two dental progress tests which measures understanding & ability to apply knowledge.
(Lala et al., 2013)	Overall marks of first and second semesters which included two knowledge themes that focus on anatomy, physiology and the pathologic processes underlying disease.
(Foley and Hijazi, 2013) **(Foley and Hijazi, 2015)**	The university Common Assessment Scale (CAS). This is a (0-20) scale to which all end of term and end of year examinations were converted. In their 2013 study, assessments included multiple short answer papers MSAP and objective structured clinical/practical examinations. In their 2015 study, assessments included multiple short answer papers (MSA), single-best answer papers (SBA) and objective structured clinical/practical examinations (OSCE/OSPE). The OSCE stations included, for example, application of rubber dam, facebow use, radiographic analysis, needle/drill desensitisation and management of medical emergencies.
(Patterson et al., 2017)	Educational supervisor ratings for students' in-role performance 2-2-Overall judgment of whether they would describe the student as "particularly promising," "average," or "likely to struggle," was used as an outcome measure.
(McAndrew et al., 2017)	• **In Newcastle course:** Year 1 (end of stage) examination results, which included: 1- SSA (short structured answer) = anatomy, physiology, biochemistry, cell biology, introduction to dentistry; 2- EMI (extended matching item) = anatomy, physiology, biochemistry, cell biology, introduction to dentistry; 3- ANAT_OSPE = first-year anatomy observed structure practical examination; 4- DENT_OSPE = pre-clinical dental observed structure practical examination. • **In Cardiff course:** Year 1 examination results, which included: 1- primary BDS part 1 = anatomy, physiology and bio-chemistry, 2- primary BDS part 2 = oral ecosystems and clinical dentistry.

Table 5: Outcome measures across different studies, continued

(Lambe et al., 2018)	Year 1 Assessments (3 exams): 1- Integrated dental science 1 (IDS 1) 2- IDS 2 3- Inter-professional engagement (IPE 1)
(Mirghani, 2020a)	1- Scores of 23 modules taught up to the fourth year of the course 2- Selected extracted measures on tasks from across the dental curriculum most closely mapped to the skills assessed at interview (i.e., soft skills tasks and visuomotor skills tasks)

Most of the studies assessed the predictive validity of the admission tool by investigating its ability to predict the student's academic attainment in the programme regardless of whether the selection tool was intended to assess academic achievement or not. However, Lambe et al. (2018) reported conducting a factor analysis of their MMI followed by mapping some of the academic assessments into soft and motor skills to match the two factors assessed by the MMI.

On the other hand, Lambe et al. (2018) considered IPE as an outcome measure beside the students' academic attainment in the programme as it is believed that it provides a proxy measure of the student's perspective taking and team involvement. The IPE evaluation entails a three-week placement in the community and requires a reflective report. Additionally, Patterson et al. (2017) mapped their assessment questionnaire to match the three domains that the SJT measures, integrity, perspective taking and team involvement. Table 6 compares what the selection tool intends to measure to what outcome measure examined in the study.

Table 6: Selection tool versus outcome measure

Author	Type of the Predictor variable	Outcome measure
(Kay et al., 2010)	-Non-academic qualities assessment (interview)	-Academic attainment
(Lala et al., 2013)	-Academic attainment -Admission test (cognitive ability)	-Academic attainment -Offer status
(Foley and Hijazi, 2013)	-Academic attainment -Non-academic qualities assessment (UCAS scores +MMI) -Manual dexterity assessment within the MMI	Academic attainment (Included OSCE/OSPE)
(Foley and Hijazi, 2015)	-Academic attainment -Non-academic qualities assessment (UCAS scores +MMI) -Manual dexterity assessment within the MMI -Admission test (cognitive ability)	Academic attainment (Included OSCE/OSPE)
(Patterson et al., 2017)	-Non-academic qualities assessment (SJT)	Attainment mapped to SJT (Performance in PBL matched to the SJT)
(McAndrew et al., 2017)	-Non-academic qualities assessment (Interview + MMI) -Admission test (cognitive ability)	Academic attainment
(Lambe et al., 2018)	-Non-academic qualities assessment (Interview + SJT) -Admission test (cognitive ability)	-Academic attainment -Non-academic attribute assessment (IPE)
(Mirghani, 2020a)	Non-academic qualities assessment (MMI)	Academic attainment, in addition to mapped tasks into soft skills and motor skills tasks.

2.2.4 Predictor variables (Selection tools)

The majority of the dental schools' programmes included in this report were undergraduate ones. In such programmes, the students can be enrolled after completion of high school or an equivalent degree. However, in schools such as the Peninsula Dental School and the University of Aberdeen Dental School, the programmes reported were graduate entry programmes in which the length of the programme and the academic entry criteria is the only difference from an undergraduate one. In such programmes, a university qualification in specific science-related degrees is seen to replace school qualifications (Kay et al., 2010). In Aberdeen Dental School, applicants are expected to have a first or upper second class degree in a medical science or health-related degree, although students with other degrees may be accepted in the programme if they have demonstrated academic excellence in their programme of study and have also completed an additional science-based university summer school programme. (Foley and Hijazi, 2013) Studies that reported data of a graduate entry programme were (Kay et al., 2010) study, (Foley and Hijazi, 2013) and (Foley and Hijazi, 2015).

The selection variables reported can be categorized into:

- Prior academic attainment
- Admission cognitive tests
- Assessments of non-academic qualities which includes personal statements, situational judgement test, interviews and psychomotor skills
- Other variables: gender, age, WPS and university rank

Analysis of the relationship between admission assessments and in-course performance varied between Pearson correlation, ANOVA, linear, binary and multiple logistic regression.

In the following section, the selection tools investigated in each paper are reported along with the general findings of the study. Further details on the statistical analysis results are presented in table 9.

2.2.4.1 Prior academic attainment

Undergraduate dental schools consider the prior academic achievement at GCSE and A level or an equivalent test as the first admission criteria by which the applicants are shortlisted for consideration in other admission criteria. On the other hand, in graduate entry schools such as the Peninsula, the view is different. In such programmes, the applicant's competence for the upcoming academic difficulties is assured through the applicant's acquisition of a science degree or achievement of a suitable standard in an admission test such as the GAMSAT and more focus can be given for personal attributes assessments as the criteria for entry (Kay et al., 2010).

In this review, GCSE scores and predicted A level grades were only assessed by (Lala et al., 2013). While other academic qualifications required as part of the graduate entry programmes admission criteria were assessed for predictability by (Foley and Hijazi, 2013) and (Foley and Hijazi, 2015).

GSCE and predicted A level grades:

Lala et al. (2013) found that applicants with better existing school results and predicted grades were more likely to be accepted for the course. This is expected as high scoring in these is the first consideration by the admissions for shortlisting. Moreover, they found that predicted grades being the weakest predictor. This could be explained by the grade inflation. However, among all the factors considered in their study, only existing school results predicted first-year exam performance in both first and second semesters.

Previous degree

Foley and Hijazi found in their 2013 study a significant correlation between the student's first degree and CAS scores. The highest mean CAS scores were achieved by students with medical or anatomy-related degrees and those who had been healthcare professionals previously. This was followed by students with other non-science-based previous experience who performed better than the genetics, pharmacy, pharmacology and biomedical students. Lowest achieved mean CAS scores were obtained by physiology, physiotherapy and microbiology students respectively.

In Foley and Hijazi 2013 and 2015 studies, pre-admission academic score (PAS) of applicants were obtained from the UCAS forms. PAS is a zero to twenty-five scores scale scored by the admission officer that is based on the academic qualification grade which were assigned based on the first degree's class. For instance, those with master's and PhD degrees received a higher value. A minimum of 19 was necessary for consideration of subsequent admissions. They found that PAS scores did not significantly predict CAS in both of their studies.

2.2.4.2 Admission tests (Tests of cognitive ability)

UCAT predictive validity was investigated by four studies (Lala et al., 2013, Foley and Hijazi, 2015, McAndrew et al., 2017, Lambe et al., 2018). Additionally, SJT's predictive validity was assessed by one study which will be reported in the non-academic attribute assessments section. The UCAT is a one and a half hour examination. It is divided into four independently timed sub-tests: Quantitative reasoning, Decision analysis, Verbal reasoning and Abstract reasoning. In 2013, the UCAT introduced a Situational Judgement Test (SJT) alongside its four cognitive subtests. The SJT is intended to provide an assessment of non-cognitive traits including integrity, perspective taking and team involvement (Lala et al., 2013). Details about the UCAT sub-tests can be found in table 7 below.

Table 7: Component parts of the UCAT

Component parts of the UCAT test	
Sub-test	**Description**
Verbal reasoning (VR)	Ability to think logically about written information and to arrive at a reasoned conclusion
Quantitative reasoning (QR)	Ability to solve numerical problems
Abstract reasoning (AR)	Ability to infer relationships from information through convergent and divergent thinking
Decision analysis (DA)	Ability to deal with various forms of information, to infer relationships, to make informed judgements, and to decide on an appropriate response
Situational judgement test	Judgement related to healthcare related scenarios testing interpersonal skills and ethical values. It also measures traits such as perspective taking, integrity and team involvement.

Lala et al. (2013) found that applicants with higher mean UCAT scores and subtest scores were more likely to receive an offer. This is expected as the UCAT is used a selection tool in the dental school. However, UCAT mean score did not significantly predict students' performance in the first or second semester. However, higher decision analysis scores were significantly related to better marks in both semesters.

It's worth noting that in this study the mean UCAT score was used instead of the actual score. This mean score was calculated using 3 subtest scores for 2008-09 cohort and all 4 subtest scores for 2009-10 cohort, to eliminate the disparity between the cohorts included, as the AR score on the UCAT was missing for the 2008-09 cohort due to a nationwide error. When assessing the UCAT predictive validity of the offer status, all the subtests QR, DA, VR, and AR were included in the analyses, but the AR analysis was limited to one year due to the missing data. However, when considering the first-year performance as an outcome, the subtest scores were not assessed due to the small sample size.

Similarly, McAndrew et al. (2017) found no significant correlation between UCAT scores and examination performance in both Cardiff and Newcastle universities. However, they reported that when considering students' academic performance by the grades' boundaries, they found that there were associations between poor examination performance and UCAT scores with significant values being obtained for the students who received a third or failed the primary BDS part 1 ($P = 0.06$) and primary BDS part 2 ($P = 0.03$) examinations in Cardiff and a borderline failure at Newcastle ($P = 0.001$).

On the other hand, Foley and Hijazi (2015) found a significant correlation between UCAT scores and UCAT percentile with CAS scores. Similarly, Lambe et al. (2018) found a significant positive correlation between UCAT cognitive scores and performance in first-year examinations of academic ability (Integrated Dental Science 1 & 2). However, no significant association was found between UCAT and Inter-professional engagement assessment.

2.2.4.3 Non-academic attributes assessment

Other non-academic attribute assessments were also investigated in multiple studies. For example, structured interviews were assessed in two studies (Kay et al., 2010) and (Lambe et al., 2018). While semi-structured interview was only studied by McAndrew et al. (2017). MMI was assessed in four papers: (Foley and Hijazi, 2013, Foley and Hijazi, 2015, McAndrew et al., 2017, Mirghani, 2020a). Predictability of motor skills to in-course performance was reported in two studies: (Foley and Hijazi, 2013) and (Mirghani, 2020a). Situational judgement test (SJT) was also reported by two studies: (Patterson et al., 2017) and (Lambe et al., 2018). Personal statement, on the other hand, was not investigated in any of the included papers although it was used by Sheffield institute for initial shortlisting of applicants for interview in addition to using the applicants' existing school results and predicted grades and references. However, personal statements, references, and interviews were assessed subjectively by admissions tutors; consequently, these selection tools had no quantifiable data available for analyses (Lala et al., 2013).

Structured interviews

In Kay et al. (2010) study, a structured interview strategy was employed. The attributes examined were chosen from a list of desired attributes of dental professionals which was gathered from a comprehensive search of the literature, excluding those that were thought to be learned within the dentistry school curriculum, such as clinical technical skills or knowledge. The attribute themes and interview measures which were considered in their interview are presented in table (8). Possession of these attributes was then assessed by objectively scoring the candidate's replies to questions set around a clinical scenario on a 0-3 scale. Three of seven scenarios were offered to each candidate. Nine scripted questions with scripted prompts (to be used when a student found a question difficult) were asked by three or four panellists, and the answers to eight of them were scored. Interviewers were given formal training. Additionally, panellists were also asked to give an overall global judgement score to the question, 'Would I like this person as my dentist?'. The scores for each of the panellists were then averaged. Kay et al. found that their structured interview scores correlated weakly with all the outcome measures considered and did not reach statistical significance.

Table 8: The attributes regarded as desirable in literature and the behaviours assessed in the Peninsula interview

Attribute theme	Interview measure
Communication with patients	Communication
Communication with staff	Communication
Sensitivity to others	Self-insight Empathy Pro-social behaviour
Ethical behaviour	Honesty Empathy
Judgement and analysis	Decision making Flexibility
Management of people	Team playing
Conscientiousness	Self-insight
Professionalism	All
Life-long learning	Reflectiveness

Similarly, Lambe et al. (2018) used a structured interview that is similar to the one used at the Peninsula School of Dentistry. Applicants choose one of three possible scenarios, focussing on contemporary ethical dilemma. Then, they are asked four of nine questions which are based on the scenario. The interview is aimed to analyse the following personal characteristics:

- Empathy and pro-social behaviour
- Reflective manner
- Being non-judgemental
- Demonstrates a suitable approach to life and people
- Self-insight
- Honesty, integrity and veracity
- Know own limitations, strengths and weaknesses
- Insight into roles and responsibilities of dentist
- Ability to work in a team, to be a team player
- Flexibility
- Communication skills
- Insight into stress
- Decision-making skills
- Insight about illness and dentistry

They additionally investigated the ability of SJT bands to assess students' performance. The attributes assessed by the SJT include perspective taking, integrity and team involvement. They found that neither the SJT Band nor interview score significantly predicted first-year dental student examination performance in the assessments of Integrated Dental Science. Moreover, neither the SJT Band nor interview score predicted performance in the assessment of Inter-Professional Engagement.

SJT

In contrast to the previous study, Patterson et al. (2017) results showed a significant predictive validity of the SJT for both the mean supervisor rating of the students' performance considering their performance across multiple PBL sessions and for a more general judgment about the students' in-role performance.

Semi-structured interviews

At Newcastle University, a semi-structured interview was employed in the selection process in which applicants were interviewed for twenty minutes by 2 academic staff members with at least one of the interviewers is a clinical staff member. The applicants are asked a set of agreed published topics. However, no significant correlation was found between the interview scores and the examination performance (McAndrew et al., 2017).

MMIs

In Foley and Hijazi (2013) study, the UCAS forms of applicants who matched the minimum academic requirement, which was a 19 PAS score, were reviewed for qualities such as career aspirations, experience of patient care and interpersonal and practical skills. This was scored independently by two calibrated admission selectors. A combined score of the PAS, UCAS and UCAT scores was then calculated and ranked. Applicants who fell in the top 60 ranking were invited for a seven-minutes MMI in which the criteria listed below were assessed by one admission selector and given a score on a scale from 0-100:

- Commitment to the University of Aberdeen
- Experience of teamwork
- Exploration of the core qualities of a dental practitioner
- An assessment of communication skills

- Review and assessment of a research article
- Previous work experience within dentistry
- Manual dexterity skills.

They found that UCAS scores did not significantly predict CAS. However, significant association was found between CAS and MMI stations for work experience and manual dexterity and significant but weaker association with teamwork and communication skills stations. The rest of the stations did not show any significant association with CAS. However, no details were provided about the type of motor skill assessment used in their study.

Similar admission procedure was studied by Foley and Hijazi in 2015. UCAS forms were scored for the same personal qualities assessed in their 2013 study and a combined score of the PAS, UCAS & UCAT was calculated. Applicants were then shortlisted for the MMI (five-minute/station) which looked at:

- previous work experience;
- problem solving and analytical skills;
- communication and inter-personal skills;
- manual dexterity and enthusiasm;
- and interest and motivation to study dentistry

Similar to their findings in 2013, they found that MMI significantly predicted the outcome measure considered while UCAS scores did not. No details were provided for specific stations correlations.

On the other hand, Cardiff University found no significant correlation between the MMI scores and the examination performance. They employed a 10-station MMI in their selection process. The interviewers were staff members who have direct contact or responsible for students' education and training of the students.

Mirghani (2020a), have also reported a predictive validity assessment of the MMI used at the university of Leeds School of Dentistry as part of a PhD project. The MMI stations' scenarios were determined by academics, the admissions teams and professional/specialist staff within the dental school based largely on clinical experience of the requirements for successful dental practice. All staff members (clinical academics and researchers) and students (4^{th} & 5^{th}

year undergraduate dental students) who took part in the MMIs received extensive training beforehand. This was a ten-station interview in which each station lasts for about 7-8 minutes Except for the interactive digital stations which took around 20 minutes each to complete (10 minutes to explain the task and 10 minutes to perform the task). Further details on the marking criteria and the procedure used in each station to assess the skills were presented in the thesis. Stations were rated by one or two assessors. The following skills were assessed:

- Observation skills and ability to describe objects from memory
- Ethical awareness and reasoning
- Communication skills
- Origami station: Ability to follow instructions and manual dexterity
- Insight into issues
- Communication skills and empathy
- Analytical data interpretation skills
- Tangram: Communication of complexed instructions
- CKAT: Manual dexterity
- Simodont: Manual dexterity

The results of the MMI factor analysis which they carried out revealed two factors were sufficient to explain the underlying structure of the MMIs. The first factor reflected soft skills (presentation, memory, ethics, interpretation, insight and communication). The second factor represented visuomotor skills as the four items origami, simulator performance, CKAT and tangram loaded most highly on it. There was an association between admission performance at the MMI soft skills stations and subsequent some module performance, soft skills tasks and motor skills tasks. On the other hand, the MMI visuomotor stations had only one significant positive correlation with the health promotion Module in Year 1 and no significant correlation with any of the motor skills tasks.

Psychological tests

None of the institutions in which the studies were carried out tested or used psychological tests.

2.2.4.4 Other admission variables

Gender

Gender was assessed by (Lala et al., 2013, Foley and Hijazi, 2013, Foley and Hijazi, 2015) and (McAndrew et al., 2017).

Lala et al. (2013) found that women were more likely to be accepted for the course despite their lower performance in the mean UCAT score and on VR and QR subtests scores. This was explained by the author by the higher existing school scores achieved by women in comparison to men. In fact, together with the socioeconomic group, gender was the strongest predictor of receiving an offer in the course. However, they did not significantly predict first year students' performance. Similarly, McAndrew et al., found no significant correlation between gender and examination performance. On the other hand, Foley and Hijazi (2013) found a significant correlation between gender and CAS in which female students achieved greater CAS scores in comparison to male students. However, a contrary finding was reported in their 2015 study.

WPS

WPS was only assessed in one study by Lala et al. (2013). They found that WPS applicants were more likely to receive an offer for the course despite their lower mean UCAT scores and DA subtest score. This possibly can be explained as they were offered a guaranteed opportunity for the interview and offered a place with lower school grades. Moreover, WPS significantly predicted students' performance in the first year of their course.

Age

Age was assessed in two papers by (Foley and Hijazi, 2013) and (Foley and Hijazi, 2015). Foley and Hijazi found no significant association between age and CAS scores in their 2013 study. However, they reported age as a significant predictor in their 2015 study.

University rank

University rank was only assessed by Foley and Hijazi (2013) paper in which they found a significant correlation with CAS.

2.2.5 Quality assessment of the included studies

The MERSQI ratings for the included records ranged from 11.5 to 15.5 out of a total possible score of 18. The mean MERSQI score was 13.6. Appendix [C] presents the completed MERSQI scoring table for all records. By comparison with a review of over 200 published peer review medical education papers determined that the mean MERSQI of published papers was 9.95 (range 5–16)(Reed et al., 2007). This indicates that the overall quality of the retained records was generally of moderate quality, reflecting the standard of currently available literature investigating the predictive validity of the admission assessments in dentistry.

Reasons of low scoring of the papers was mainly attributed to being the studies carried out at a single site. Additionally, most of the studies lacked assessment of the structure of the evaluation instrument that they are using. In addition, most of the studies reported knowledge-based outcome only with only one study reporting a clinical outcome measure.

Furthermore, most of the studies assessed the ability of the selection tools to predict the outcome measures without matching the skills that each was assessing as most of the outcome measures were knowledge-based assessments rather than assessment of non-academic attributes. However, in Mirghani study, they mapped the skills assessed in the MMI into two factors that were matched to similar factors assessed as outcome measures. This approach could give a better assessment of the validity of these tools in predicting the performance they are intended to measure.

Another issue of the papers included in this review was the lack of length of follow up. For example, five out of a total of eight included papers evaluated the predictability of their selection tools at a one-year follow up which is not enough to represent the students' performance in a 4-to-5-year programme. Moreover, the fact the investigations were carried out on the pool of accepted students only may result in underestimation of the predictive validity of the admission assessment. Additionally, the cohorts included were all of high prior academic achievement as this is the initial requirement for shortlisting for further admission assessment. This also can affect the measure of the validity of the assessment of these tools.

2.2.6 Summary of the research evidence

Table 9: Summary of the included papers results

	Predictor measures	Outcome measures	Reported test/s	Reported findings and test value	Conclusion
(Kay et al., 2010)	Structured interview scores	1- GAMSAT overall score 2-Test of academic knowledge at the end of first year 3-Two dental progress tests	Pearson correlation	**Correlations were weak and did not reach statistical significance:** **1- GAMSAT:** r= 0.001, p= 0.996 **2- Academic knowledge test:** - MCQ Dental Science: r= 0.007, p= 0.958 - MCQ Life science: r= 0.028, p= 0.827 **3-The dental progress tests:** -1st progress test: r= 0.036, p= 0.780 -2nd progress test: r= 0.023, p= 0.860	They concluded that the interview is a valuable selection technique because it examines traits that are not easily captured by more conventional selection methods and that the limited relationships between interview scores, GAMSAT scores, and academic success demonstrate this.
(Lala et al., 2013)	1-Gender 2-Being part of a WPS 3- GCSE scores 4-Predicted A level grades 5-Mean UCAT score 6-UCAT subtest scores	1- Offer status 2- 1st semester of 1st year: Score of the Human Body theme 3- Second semester of 1st year: Score of the Oral Cavity in Health and Disease theme	Binary logistic regression + Multiple regression	**Predictive Value for offer status:** -Gender: p= 0.047 -WPS: p= 0.018 -Predicted grades: p= 0.001 -GCSE: p= 0.000 - Mean UCAT: p=0.000	The findings indicated that The UCAT is unable to predict first-year dental exam performance and that the only predictor of dental exam performance was existing school results (GCSE).

Table 9: Summary of the included papers results, continued

				Predictive Value of 1st Year Exam scores: **For 1st semester results:** **-**GCSE scores were the only statistically significant predictor (β=0.42, p<0.001). **For 2nd semester results:** **-**GCSE scores were the only statistically significant predictor (β=0.33, p<0.005).	
(Foley and Hijazi, 2013)	1-PAS 2-UCAS scores 3- MMI total score 4-MMI stations scores 5- Degree 6- University rank 7- Student gender 8- Student age	CAS (Combined assessment score)	-Multiple linear regression -Pearson correlation - ANOVA	**1- MMI total score:** (r = 0.180, p = 0.001) **2- Significant MMI stations:** -previous work experience (p= 0.001) -manual dexterity (p= 0.003) -teamwork (p= 0.024) -communication skills (p= 0.035) **3-PAS :** (r = 0.050, p = 0.248). **4-UCAS scores** (r = 0.059, p = 0.169) **5- university rank** (r= 0.201, p = 0.001) **6- student gender** (r= 0.156, p = 0.001) **7-Age**: No association noted **8-Subject of the first degree** (p = 0.001)	1-There is a correlation between MMI performance and future performance. 2-Certain prior degrees appear to be a significant predictor of future performance.

Table 9: Summary of the included papers results, continued

(Foley and Hijazi, 2015)	1- Gender 2- Age 3-PAS 4- UCAS 5-UCAT score 6-UCAT percentile score 7- MMI	CAS (Combined assessment score)	Pearson correlation + multiple regression	**A) Pearson correlation:** 1-Student age, MMI, UCAT scores and UCAT percentiles demonstrated a significant correlation with CAS scores. Student age: r = 0.119, P = 0.001 MMI: r = 0.136, P = 0.001 UCAT scores: r = 0.077, p = 0.019 UCAT percentiles: r = 0.118, p = 0.001 2-Student gender, PAS and UCAS were not significantly predictive of CAS scores. Student gender: r = 0.050, p= 0.112 PAS: r = 0.043, p= 0.176 UCAS: r = 0.032, p= 0.315 **B) Multiple regression analysis revealed:** Age: p= 0.015 MMI: p= 0.001 UCAT Percentile: p= 0.004	Student age, candidate performance at MMI and the UCAT might be a predictor of academic achievement for graduate-entry dental students.

Table 9: Summary of the included papers results, continued

<table>
<tr>
<td>(Patterson et al., 2017)</td>
<td>SJT</td>
<td>-Mean supervisor rating

-overall judgment of whether they would describe the student as “particularly promising,” “average,” or “likely to struggle,”</td>
<td>Pearson correlation
+
linear regression analysis</td>
<td>1-Pearson correlation:
SJT scores had a significant correlation with both mean supervisor ratings ($p < .001$; $r = 0.34$) and overall judgments ($p < .05$; $r = 0.20$).
2-Linear regression:
SJT scores significantly predicted mean supervisor ratings, ($p < .001$)
3-One-way ANOVA:
1-Significant differences between SJT scores for students in the three overall judgment categories ($p< .05$).
2-Students rated as “likely to struggle” had significantly lower SJT scores than those rated as being “particularly promising” ($p < .01$).
3-Those rated as “average” did not differ significantly in their SJT scores compared with students in either of the other two groups.</td>
<td>The results indicate that text-based SJT may be implemented into the selection process for undergraduate dental school and add value to the process.</td>
</tr>
<tr>
<td>(McAndrew et al., 2017)</td>
<td>1-Interview score:
-Semi-structured interview (Newcastle)
-MMI (Cardiff)
2- UCAT
3-Gender</td>
<td>Summative examinations:
- In Newcastle, year 1 assessments = 4 exams:

- In Cardiff, year 1 Assessments = 2 exams</td>
<td>Pearson’s product-moment correlation coefficient</td>
<td>In Newcastle university:
The reported correlation coefficients below were all not statistically significant:
<table>
<tr><td></td><td>SSA</td><td>EMI</td><td>ANAT-OSPE</td><td>DENT-OSPE</td></tr>
<tr><td>UCAT</td><td>0.088</td><td>0.100</td><td>0.159</td><td>-0.168</td></tr>
<tr><td>Interview</td><td>0.017</td><td>-0.021</td><td>0.006</td><td>-0.168</td></tr>
</table>
</td>
<td>-Examination performance did not correlate significantly with admission interview scores at either school.
- UCAT score had an association with grades’ boundaries only and</td>
</tr>
</table>

Table 9: Summary of the included papers results, continued

<table>
<tr>
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<td>
In Cardiff university:
The reported correlation coefficients below were all not statistically significant:
<table>
<tr><th></th><th>Primary BDS part 1</th><th>Primary BDS part 2</th></tr>
<tr><td>UCAT</td><td>0.098</td><td>-0.26</td></tr>
<tr><td>MMI</td><td>-0.011</td><td>-0.009</td></tr>
</table>
Looking at academic performance by grades achieved [for Cardiff, the academic grade boundaries of 1st, 2i, 2ii, 3rd and fail, and for Newcastle, merit, satisfactory, borderline fail and fail] revealed there are associations between poor examination performance and UKCAT scores with significant values being obtained for the students who received a third or failed the primary BDS part 1 (P = 0.06) and primary BDS part 2 (P = 0.03) examinations in Cardiff and a borderline fail at Newcastle (P = 0.001).
</td>
<td>linked to poor academic performance.</td>
</tr>
</table>

Table 9: Summary of the included papers results, continued

(Lambe et al., 2018)	1- Interview scores 2-UCAT SJT component (Band 1 & 2) 3-UCAT sections scores, including SJT	Year 1 Assessments (3 exams): 1- Integrated dental science 1 (IDS 1) (MCQ) 2- IDS 2 (MCQ) 3- Inter-professional engagement (IPE 1)	Spearman or Pearson's correlation	**A) SJT:** IDS 1 ($r = -0.33$, $p = 0.14$) IDS 2 ($r = -0.24$, $p = 0.12$) IPE 1 ($r = -0.15$, $p = 0.34$) Not statistically significant **B) Interview score:** IDS 1 ($r = -0.01$, $p = 0.89$) IDS 2 ($r = -0.07$, $p = 0.62$) IPE 1 ($r = -0.04$, $p = 0.79$) Not statistically significant **C) Total UCAT score:** IDS 1 ($r = 0.32$, $p < 0.01$) IDS 2 ($r = 0.38$, $p < 0.05$) Statistically significant, but not at the individual UCAT subtest level. IPE 1 ($r = -0.04$, $p = 0.79$)	They concluded that the SJT does not add value to their dentistry school's existing selection process.
(Mirghani, 2020a)	MMI soft and visuomotor skills stations	1- 23 academic modules 2- Selected tasks from the curriculum which is mapped to the skills assessed at interview: **A) Selected soft skills tasks:** Year 1: Group work presentation Year 2: Poster presentation Year 3 & 4: OSCE	Pearson's correlation coefficient	**1-MMI soft skills stations and module performance:** A significant positive correlation was found: **Year 1:** Oral disease ($r = .35$, $p = .039$), Oral environment ($r = .30$, $p = .031$) Clinical Practice ($r = .20$, $p = .039$) **Year 2:** Clinical Skills A ($r = .22$, $p = .029$), Social sciences ($r = .45$, $p < .001$) Biomedical Sciences ($r = .35$, $p = .021$).	This study suggested that there is a correlation between performance at the MMI soft skills stations and subsequent module performance while the MMI visuomotor stations did not predict any of the motor tasks.

Table 9: Summary of the included papers results, continued

		A) Selected motor skills tasks Year 1: Simodont induction Year 2: Spotter test Year 3: OSCE + pre-clinical crown test Year 4: OSCE + Spotter test + crown test		**Year 3:** Professional Development (r = .28, p = .018), Clinical Practice (r =.62, p < .001) Clinical Skills B (r = .28, p = .011). **Year 4:** Clinical Practice (r = .51, p < .001), Complex Adult Dentistry (r = .42, p = .001) Child-Centred Dentistry 2 (r = .30, p = .007) **2-MMI Soft skills stations and selected soft skills tasks** **There was a significant positive correlation between the MMI soft skills stations and:** OSCE year 3 (r = .57, p = .028) OSCE year 4 (r =.52, p = .050). No significant correlation between MMI soft skills stations and group presentations year 1, poster presentation year 2, presentation year 3 or presentation year 4. **From the MMI soft skills stations, the stations that had a significant positive correlation with OSCE year 3 scores were:** Communication station (r =.48, p <.001), Interpretation station (r = .49, p = .002), Presentation station (r = .36, p = .005).	

Table 9: Summary of the included papers results, continued

				The Year 4 OSCE scores had a significant positive correlation to: Insight station (r = .48, p = .003) Communication station (r =.48, p < .001) Interpretation station (r = .40, p = .008) No statistically significant correlation between students' performance at the MMI soft skills stations and the group work presentation, poster presentation scores in Year 2 or presentation year 3 or poster presentation scores in year 4 (r = .05, p = .607) **1- MMI visuomotor stations and module performance** There was only a significant positive correlation between the MMI visuomotor stations and the health promotion Module in Year 1 (r = .33, p = .012). **2- MMI visuomotor stations and selected motor tasks** No significant correlation was found between students' performance in the MMI visuomotor stations and the five motor tasks.	

2.3 Discussion

Through the search strategy explained previously, eighteen UK-based research papers from the period between (1974 to 2019) were found, eight of which were carried out during the last two decades. There are sixteen dental schools that provide undergraduate dental programmes in the United Kingdom of which two are graduate entry schools. However, the papers reported in this review originated from only six dental schools. There could be existing unpublished research in relation to the admission processes of different institutes that we could not identify. However, based on the number of papers located in this review, it appears that further research is required on this topic area for dental admission practises to be supported by evidence.

2.3.1 Prior academic attainment

In the UK, undergraduate selection has traditionally been dependent on predicted or actual school-end exam results. However, since almost all applicants are required to obtain three As at A level, A levels are losing their discriminative power (Cleland et al., 2012b). In this review, GCSE scores and predicted A level grades were only assessed in one study: Lala et al. (2013). While other academic qualifications required as part of the graduate entry programmes admission criteria were assessed for predictability by (Foley and Hijazi, 2013) and (Foley and Hijazi, 2015).

Lala et al. (2013) found that among all the factors investigated in their study, only existing school results predicted first-year exam performance in both first and second semesters. The multiple regression models showed that 20.9% and 15.9% of the variance of the overall first semester and 2nd semester marks, respectively, were explained by gender, whether student was part of WPS, existing school results and predicted grades. Existing school results was the only significant predictor in both semesters. For the 1st semester, it explained 16.2% of the total variance. As for the 2nd semester, it explained 9.7% of the total variance of the model. This might be due to the fact that previous school scores have a great diversity in the disciplines studied; thus, they may give a broader evaluation of the candidate's cognitive ability, in addition to the wide range of existing school results in Lala’s study which gave them a discriminatory potential as the author explained. However, it is worth noting that personal statements, references & interviews were not analysed in their study as no quantifiable data were available for analysis. Much evidence exists in the medical and dental fields which support the finding that previous academic achievement can predict students' future performance. For example, the predictive validity of prior academic attainment has also been confirmed in Stringer's et al. study. It was found to be associated with medical students' performance at the University of Sheffield. However, in their findings, both A-level Score and GCSE scores were significantly and positively associated with students' performance (Stringer et al., 2017). This could be attributed to the differences in the range of A level grades required in the different fields. Similarly, in a retrospective study which assessed the association between in-course performance and academic and non-academic characteristics of 2270 medical students at the Nottingham medical school between 1970 and 1990, it was found that prior academic attainment in secondary school can predict how well students perform in the course (James and Chilvers, 2001). These findings were explained by McManus, using an old adage of psychology that "the best predictor of future behaviour is previous behaviour," which, in this context, refers to the strongest predictor of future success in passing medical school tests being prior performance (McManus et al., 2005). However, previous academic performance seems to only partly predict the variability in dental and medical school academic achievement. Additionally, it has been found that the predictive value of the grades reduced as the students moved from preclinical to clinical years (Ferguson et al., 2002a). Moreover, the use of predicted grades has added more uncertainty to the admission process as those predicted grades could have more social class bias in comparison to actual grades (Cleland et al., 2012b). These concerns led to the use of aptitude tests in the selection process.

As for the qualification grade, Foley and Hijazi 2013 and 2015 studies, pre-admission academic score (PAS) of applicants were obtained from the UCAS forms. PAS scores did not significantly predict CAS in both of their studies. However, when considering previous academic qualifications in specific subjects, Foley and Hijazi found in their 2013 study a significant correlation between the student's first degree and CAS scores. The highest mean CAS scores were achieved by students with medical or anatomy-related degrees and those who had been healthcare professionals previously. This was followed by students with other non-science-based previous experience who performed better than the genetics, pharmacy, pharmacology and biomedical students. Lowest achieved mean CAS scores were obtained by physiology, physiotherapy and microbiology students respectively. In the same context, a study carried out by Beier et al. in Austria to determine if having a medical degree is a predictive factor for dental students' scores on the performance in the dental clinic, and scores on final exam. They found students with a medical degree had significantly better performance in the composite course and the occlusion course in their 1st clinical year. Also, students performed significantly better in prosthodontics and oral and maxillofacial surgery on their final exam. They concluded that dental students at Innsbruck Medical University with a prior medical degree had significantly performed better in their first clinical year and on the final dental licensure examination than those without a medical degree (Beier et al., 2012). However, Wilkinson et al. explained such findings by the age of the student rather than the previous degree earned. Age upon entering may be more significant than prior education as age provided certainty and motivation about the career choice while a prior degree had some influence on methods to studying and cooperativeness (Wilkinson et al., 2004). Such an argument might explain the findings of a USA-based study in which they categorized undergraduate majors into six categories: English and humanities, biological sciences, physics and chemistry, social sciences, double science major, and double major in a natural and social science. The researchers next investigated the association between undergraduate majors and the preclinical and clinical performance of students with a mean age of 23±2.2 at beginning of the dental school programme. They determined there was no significant association between the different majors and students' performance (Price and Park, 2018). Evidence can be contradictory; however, the variations in the cohorts, locations, educational systems and outcome measures evaluated in each study, among many other differences, may explain these contradictions or differences.

2.3.2 Admission tests (Tests of cognitive ability)

Four studies assessed the predictive validity of the UCAT (Lala et al., 2013, Foley and Hijazi, 2015, McAndrew et al., 2017, Lambe et al., 2018). Foley and Hijazi found a significant positive correlation between UCAT scores and percentiles with CAS scores. This remained significant for the UCAT percentile when the regression analysis was carried out. In this study, however, the data of four cohorts followed throughout their programme, with only one cohort in their final year, were all combined. This was carried out because there was only an average of twenty students per year available for analysis. This may affect the interpretation of the result as the predictive value for a student in their early years of study may differ from that of a student nearing graduation. Likewise, but limited to a one-year follow up, Lambe et al. found a significant correlation between UCAT scores and students' performance at year 1 integrated dental science exams, but not at the UCAT subtest level. However, they found no significant correlation between UCAT scores and inter-professional engagement assessment.

On the other hand, McAndrew et al. investigated the UCAT score's correlation with students' performance in two institutions. In both institutions, the correlation did not reach statistical significance. Similarly, in Lala et al. study, UCAT scores were not found to be a significant predictor of students' performance. Nevertheless, when considering subtest scores, correlational analyses revealed that decision analysis scores were significantly related to better students' marks in the first two semesters. They explained this finding by stating that, unlike the other UCAT subtest, the DA component was created primarily for clinical use. However, in Lala et al. study the sample size was small and limited to first year students. Moreover, the abstract reasoning subtest scores were only available for half of the sample. Therefore, the results' generalizability may be affected.

A recent systematic review looked into the predictive validity of the UCAT across measures of medical and dental students' performance at both undergraduate and post graduate levels. They found that the UCAT had no statistically significant predictive validity for over 70% of univariate data points, and that its predictive ability was weak for the remaining 30%. However, they concluded that the data supports utilization of the verbal reasoning subtest and the cognitive total subtests in the medical school selection as they have shown a weak positive prediction of the students' performance in a large evidence base. (Bala et al., 2022) Similarly, in Greatrix et al. (2021) systematic review, fifteen out of eighteen medical papers reported an association between UCAT cognitive test and undergraduate medical students performance. This association was found to be weak in 14 studies (r=0.00–0.29) and moderate (r=0.30–0.49) in four of them. They have also found that this association was the strongest for UCAT total and the verbal reasoning subtests.

It’s worth noting that in almost all studies that reported the UCAT's predictive validity, the outcome variable was solely a measure of academic performance, with the exception of Foley and Hijazi, whose outcome included a practical component; however, this was combined as previously indicated. It was found in Greatrix et al. (2021) study that the association between UCAT scores and outcome measures were higher with knowledge-based assessments scores than with assessments of skills. However, the number of research published in dentistry is small and the findings are contradictory, making it difficult to reach a meaningful interpretation of the findings. As can be seen, no agreement was achieved between the reported studies in relation to the predictive validity of the UCAT. Furthermore, due to the small sample size used in some of the research and the analysis being confined to simple correlation analysis without considering a regression analysis adjusted by other admission variables in other studies, interpreting the findings to derive a conclusion is challenging.

Given that the UCAT's is used at the majority of the dental schools in the UK as a selection tool, there is a compelling need to investigate the ability of UCAT to predict for dental students’ performance in more institutions and for a longer follow up periods. Moreover, further investigation about the ability of the UCAT subtest scores in predicting students’ performance is needed. If correlations were proven, dental institutes may consider using subtest scores instead of the total score. Similarly, the predictive validity of the BMAT should be investigated at dental facilities that employ it in their admission process as no study was found that investigates the predictive validity of the BMAT as a selection tool in dental schools.

2.3.3 Non-academic attributes assessments

Two of the reported studies in this review investigated the predictive validity of structured interviews: (Kay et al., 2010, Lambe et al., 2018). Both studies reported weak correlations with the assessment measures which also did not reach statistical significance. Likewise, when semi-structured interview and MMI were assessed by McAndrew et al. (2017) at Newcastle and Cardiff dental schools, non-significant weak correlations were found. This could be explained by the fact that these correlations were assessed only in the first year of the dental programme in which the focus is knowledge-based. As researchers found a significant positive association between MMI scores and patient management grades which represents aspects of the students' professional behaviour in fourth year clinical setting. They concluded that the MMI can be used as a valid tool in predicting key behavioural traits related to professionalism (Duff et al., 2020). Therefore, the discrepancy in the findings between the studies might be explained in part by the differences in the follow-up periods and hence the outcomes evaluated in the research. As some of the personality facets may be not useful in the early years of academic modules and exhibit more importance as the student progresses to clinical practice (Cleland et al., 2012a). This can be seen in the significant correlations which were identified in the Foley and Hijazi research, where students were followed up until the end of their graduate-entry dental programme, and in the Mirghani study, where students were followed up until their fourth year of their undergraduate dental programme. In Foley and Hijazi 2013 & 2015 studies, CAS was considered as an outcome measure, in which the assessments included multiple short answer papers and objective structured clinical examinations (OSCE). However, as previously indicated, this score was a combined score of all years, which does not allow distinction about the predictability of the students' clinical, preclinical or academic performance. When MMI stations were assessed for predictability of performance, the following stations had significant correlations with students' performance: previous work experience, manual dexterity, teamwork and communication skills. In Mirghani study, the researcher found an association between admission performance at the MMI soft skills stations and subsequent some module performance, soft skills tasks and motor skills tasks. On the other hand, the MMI visuomotor stations had only one significant positive correlation with the health promotion Module in Year 1 and no significant correlation with any of the motor skills tasks. The author explained this finding by stating that a portion of this course includes cardiopulmonary resuscitation, which requires a degree of motor performance in addition to clinical reasoning required in performing a dental procedure, and thus some of the variance in this score may be captured by the visuomotor score from the MMI. Motor skills were assessed by Foley and Hijazi (2013) and Mirghani (2020a) as part of the MMI. The type of motor test used was not specified in Foley and Hijazi paper. However, they reported a significant correlation (P=0.003) with the outcome measure considered in their study. However, a correlation between the employed motor test and clinical performance might have offered valuable knowledge had it been evaluated independently rather than a combined score of all years. In contrast, when the visuomotor skills were assessed in Mirghani (2020a) study using CKAT, Tangram, Simodont and Origami, no significant correlation was found between students' performance in these assessments and the five motor skills selected as outcome measures (Simodont induction data year 1, spotter test year 2, pre-clinical crown test year 3, spotter test year 4, clinical crown test year 4). It is worth noting that the MMI candidates in this study were informed that performance on the Simodont and CKAT would not contribute to their assessment and therefore this may have impacted on their motivation and performance. This could explain the conflicting evidence with previous studies that reported a positive association between student performance on haptic simulators assessment and preclinical and clinical performance (Urbankova and Engebretson, 2011, Al-Saud et al., 2020). There is an abundance of contradicting findings regarding the predictive validity of motor skills tests. Some studies suggest that motor skills tests are good predictors of future pre-clinical and clinical performance (Urbankova and Engebretson, 2011, Arnold et al., 2011, Al-Saud et al., 2020) while other researchers found them to be poor predictors. For example, Oudshoorn (2003) found that carving test was weakly correlated with students' psychomotor performance in operative grades. Similarly, Gansky et al. (2004) assessed the predictive validity of a block carving test and found that it did not significantly predict the lowest performing students. In fact Giuliani et al. (2007) considered motor skills learnable and therefore can be learnt and improved by practise. It is not unexpected that the evidence is conflicted given the differences in the manual skills test used in the research, follow up periods and outcome measures. Regardless, it is debatable whether these skills should be utilised as a criterion for selection or whether it is the role of the curriculum to assist students acquire them via practise.

SJT was looked into by two studies (Patterson et al., 2017, Lambe et al., 2018). The results in Patterson et al study revealed predictive validity of the SJT for both a criterion-matched outcome (mean supervisor rating, matched to the three domains targeted by the UCAT SJT) and for the overall supervisors' judgment about the students' in-role performance. Comparably, when Lievens et al assessed video-based SJT, they found that video-based SJT had significant predictive validity and incremental validity for predicting interpersonally oriented criteria which included students' scores on interpersonally oriented courses that taught interpersonal and communication skills (Lievens and Sackett, 2006). However, it is worth noting that the cohort analysed in Patterson et al research included a mix of medical and dental students, with a relatively small number of dental students (21 student). Furthermore, the outcome measure considered in this paper was subjective, relying on a single supervisor's subjective rating of each student's performance at a single point in time. Conversely, Lambe et al did not find any significant correlation between any of the SJT bands and the outcome measures they considered. This could be on the other hand explained by their outcome variables mostly focused on were academic attainment assessments. Therefore, the lack of association with a completely different ability measure may actually provide some criterion-related validity evidence in favour of the usage of the UCAT SJT. However, no significant correlation was noted even with the inter-professional engagement assessment. Comparatively, Bala et al. (2022) reported in their systematic assessment of the predictive validity of the UCAT that the SJT was a weak predictor of professional behaviour throughout medical school. Further examination of this association in dental school settings throughout the course of study may provide further clarity to the findings.

2.3.4 Limitations of this study

One of the most significant limitations of the reported evidence in this review is that the majority of studies were done at single institutions, with single cohorts and short follow-up periods, with minimal evidence for the validity of the assessment instrument. Moreover, there was no evidence of the incremental validity of the admission assessments in any of the included studies. Another limitation of the evidence reported in this review is the variability of the selection tools utilised even between the structure of a single selection tool such as MMIs making it difficult to compare the findings. Furthermore, only research papers which reported quantitative data was included in this review. Qualitative publications or opinion letters, on the other hand, may have substantially contributed to the understanding of the selection processes. Moreover, papers in which they evaluated selection methods on enrolled or accepted students were excluded. This was done as the performance of the students might be affected knowing that the assessment being tested will not have an impact on their offer status or future performance. Additionally, papers that were not published in English were excluded. This may have influenced the reporting of the number of published articles throughout the world, but it should not have changed the findings of the UK publications. Due to the relevance to the PhD project, only the findings of the research carried out within the United Kingdom were reported. It is acknowledged that looking into the findings of the worldwide literature would improve our understanding of the predictive value of the various selection procedures utilised globally. The reporting of the retrieved papers globally will be the focus of a future study.

2.4 Conclusion

As was evident, the majority of dental schools have moved away from subjective evaluations such as personal statements and references and toward more evidence-based selection approaches. However, given the limited number of research and significant outcomes, it was difficult to reach conclusions from the published findings regarding the predictive and incremental validity of the different admission tools in dentistry. In addition, the variation in admission processes and selection methods, such as interview type, utilised by dental schools, as well as the variation in curriculum and assessment methods, limit the generalizability of the findings. However, this review highlights some gaps and weaknesses in the scientific evidence regarding the predictive validity of the selection tools used in dental admission settings. In addition, it would be useful to know which attributes were assessed in the interview and if any were more predictive of performance than another. In order for dental schools to make evidence-based decisions regarding which selection tools to use and why, we propose a future research agenda that includes longitudinal research examining predictive validity and following students over the course of their studies and possibly into their postgraduate years or professional career. Such evidence can contribute to the body of evidence and permit the drawing of more meaningful conclusions. The following chapters of this project will explore the admission process at the School of Dentistry of the University of Leeds in an attempt to further learn about the predictive validity of the admission assessments used at the institution.

2.5 Registration and protocol

The review was not registered at Prospero as was informed that the outcomes of this review are not directly related to heath outcome and therefore, I was advised not to register. There was no published review protocol.

The next chapter proceeds to specify the research objectives and describe the methodology to be utilized.

Chapter 3
Methodology

3.1 Aim

The following sections outline a project investigating the admission process in the Dental Surgery Programme at the School of Dentistry, University of Leeds in terms of predictability and fairness. It aims to:

1- Assess if the admission assessments are biased towards or against certain socio-demographic characteristics.
2- Assess if the admissions process in the University of Leeds, School of Dentistry predicts students' performance throughout the dental surgery course.

3.2 Objectives

Prior to addressing these aims, it is imperative to establish an understanding of the admission assessments. Therefore, the admission assessments will first be investigated by:

- Assessing the correlation between the different admission assessments.
- Assessing the structure of the multiple mini-interview.

Subsequently, the first aim will be addressed by investigating the following associations:

- the association between demographic characteristics, Access to Leeds eligibility and the applicant's/student's performance in the admission assessments, including GCSE score and level 3 score.
- and the association between demographic characteristics, Access to Leeds eligibility and the student's performance in the in-course assessments.

To address the second aim, series of investigations will be conducted to facilitate the comprehension of various facets related to the prediction of in-course performance. The key points summarizing these investigations are as follows:

- Assessing the correlation between the different admissions assessments and the students' in-course performance.
- Assess the incremental validity of the different admissions assessments.
- Assess if the predictive validity of the different admissions assessments varies as the student progresses in the course.
- Assess if any of the admission assessments, student's demographic characteristics or Access to Leeds eligibility are able to identify students of risk of failure or professionalism breach.

3.3 Ethical considerations and data management

3.3.1 Ethical considerations

The ethical approval for the project was obtained from the Dental Research Ethics Committee at the School of Dentistry (DREC reference numbers 090320/EA/297 and 191020/EA/308). Application forms and confirmations of application acceptance are presented in the appendix [D].

Prior to data collection, an opt-out consent form was emailed by a staff member, who has access to the students' contact details, to those students currently registered from admission cycles 2016, 2017 and 2020 along with an information sheet. Additionally, the consent form and information sheet were emailed to all applicants of admission cycle 2021 after the BMAT exam was conducted. This timing was determined to have the least impact on the applicants during the admission process. The Alumni Office emailed the opt out consent form along with the information sheet to the graduated students of admission cycles 2014 and 2015.

Participants were provided with contact details of the lead supervisor and myself, to send their withdrawal consents if they choose not to be included in the study or to use if they had any questions about the research. This was explained in the information sheet and consent form. It was highlighted in the information sheet that their participation is voluntary and that their withdrawal from the study is optional for 2 weeks from when they receive the opt out consent email. As the research supervision team includes members of staff at the University and the cohorts studied include applicants and registered students, participants could feel that they have a dependent relationship. The information sheets reassured students that their involvement (or not) in the study will have no bearing on their current studies, future studies, applicants' admission assessments or their future studies, if they were offered a place in Leeds University, and that all their data will be anonymised. Nineteen opt-out consents were received in total. Four of them were from the 2020 cohort and the rest were from the 2021 cohort.

After consenting the participants as described previously, data collection proceeded. All the data required for this study are existing data and are routinely collected as part of the admissions process and in-course evaluation. Therefore, the study did not require any active involvement from students. In other words, they were not asked to do above and beyond the tasks necessary to satisfy the requirements of their undergraduate degree. First, the admission data required were extracted from the routinely collected data as part of the admission process and Access to Leeds application forms. These included, admission assessments scores, demographic data and Access to Leeds eligibility of the participants. Regarding information about widening participation, only one indicator which is the participants' eligibility to Access to Leeds was used. Using only this widening participation measure will ensure that there are fewer fields of data that could lead to inadvertent identification of an individual. Moreover, age of participants has been grouped to mature (>21) and school leavers (≤21). The aim was to use the data generated as part of the typical degree process alongside their performance on the admission assessments and their socio-demographic characteristics. This will help us to identify patterns that will allow us to build statistical models identifying the predictors of applicants’ performance in the admission process used at Leeds University and predictors of enrolled students’ performance during the course of study.

However, during data collection, it was determined that the admission data for the 2014 cohort, could not be located. Therefore, this cohort was excluded from the analysis. Additionally, difficulty was encountered to obtain the A-level scores and GCSE scores of cohorts 2015, 2016 and 2017 from the admission office. To try to obtain this missing data, amendments were submitted to the ethical committee to allow us to contact the students to provide their A-level scores, and GCSE details. This was approved and an electronic form was sent by staff members, who have access to the students’ contact details, to the registered students of admission cycles 2016 and 2017 and the graduated students of admission cycle 2015. The students were given an opportunity to respond to the email for 2 weeks from when they received the email. The form was designed so that when the student fills the form, the data are automatically forwarded to the lead supervisor. The data was then forwarded to the independent third party performing the encoding. However, the response rate was very low and not sufficient to carry out the analysis. Additionally, some participants either did not provide complete data or did not provide enough data to enable the anonymizer to link this with the previously collected data. Therefore, this data was not used in the analysis.

Moreover, tracking of students' performance during the application cycles of 2014, 2015, 2016 and 2017 as they progressed through their programme was carried out. After data was collection was completed, all data were anonymised.

3.3.2 Data management strategies

The terms of the General Data Protection Regulation (GDPR) were adhered to by following a robust data management plan which ensured all data was anonymised and stored. Arrangements were made for an independent third party to perform the encoding. Ensuring data anonymity was a key priority and personal identifiers of the applicants and enrolled students were removed. The data was anonymised prior to data analysis with removal of the student's name or ID. Participants were only identifiable to the research team who are involved in the data analysis by a unique 3-digit identifier (UID). There was no record linking UIDs to personal details kept by any of the researchers responsible for the data analysis. A member of staff who was not involved in the data analysis at the University of Leeds retained a record of student's UPNs linked to their name. Keeping of this record is precautionary (in the event if a student asks to view their data or if the addition of their progress through the programme was needed). Data management followed University research guidance including password protection on secure storage sites and appropriate anonymisation.

3.4 Design

This was a retrospective cohort study of data from four cohorts in the School of Dentistry in the University of Leeds. Two of these cohorts were followed up to the end of the programme while data of the other two cohorts was only collected until the end of the admissions process.

3.5 Participants

Participants included in the analysis of this project were the enrolled students of entry of 2015 and 2016 and all applicants for entry of 2021 and 2022 at the undergraduate dental surgery programme at the University of Leeds.

Cohorts of entry of 2014, 2017 and 2020, were considered for inclusion, however, during data collection it was determined to exclude them from the analysis. This was because either full or multiple admission data of cohorts 2014 and 2020 was not retrievable from the admission office. As for the 2017 cohort, the plan was to follow them up to 4th year, however due to COVID situation, many modules in addition to 3rd year OSCE were scored as pass/fail with no numerical scoring given. Therefore, this cohort was also not included in the analysis.

The rejected applicants of cohorts of entry of 2015 and 2016 were not included as it was not possible to consent them as their contact information was not retrievable from the admission office. Moreover, students who have dropped out of the course were excluded as it was not possible to consent them. The cohorts included in this project are summarized in figure 5 below

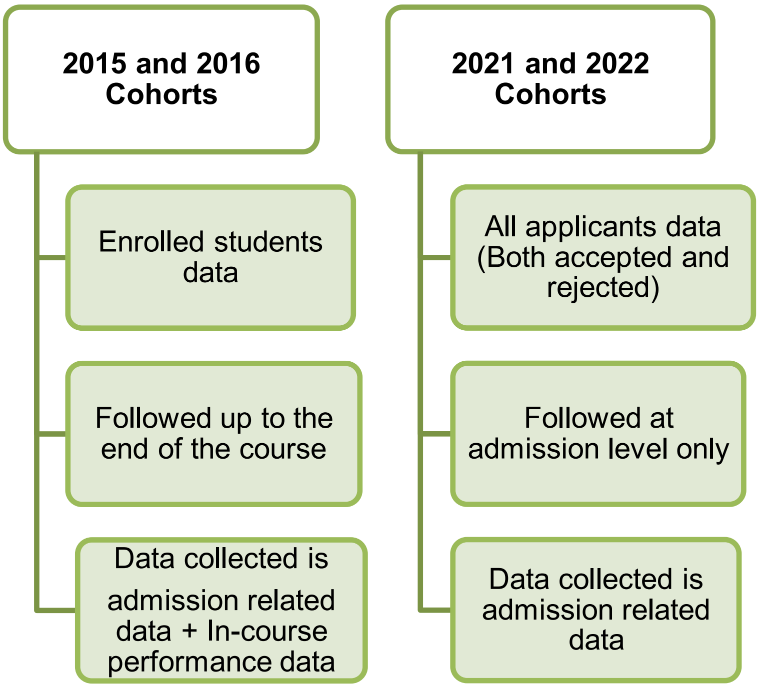


Figure 5: Research participants

3.6 Measures considered in the project

3.6.1 Admission measures

The admission process for the Dental Surgery Programme consists of several steps, beginning with the receipt of applications via UCAS (Universities and Colleges Admission Service) and concluding with the MMI, in which the overall performance determines who gets a place in the programme. Applicants are evaluated holistically, and contextual considerations, such as educational or socioeconomic background, have been taken into account during this evaluation. Offers are made on the basis of merit by determining the ability of each applicant to meet the academic and non-academic criteria for admission to the relevant course. The admission process steps are summarised in figure 6 below.

Figure 6: Admission process steps at the School of Dentistry, University of Leeds

Initial evaluation of applications is based on academic merit. Applicants may be refused purely on the basis of academic criteria if the entry qualifications presented are not those identified by the school as being within suitable subject areas or if the predicted or achieved performance in any qualification falls short of the standard entry requirement.

Entry requirements for the academic criteria include a minimum of 6 GCSEs at Grade 6/B or higher including Chemistry, Biology (or Dual Science), English and Maths in addition to AAA score at A level including Biology and Chemistry, excluding General Studies and Critical Thinking. An applicant must achieve a pass in the practical element of any science A levels. The School of Dentistry also accepts applications from students pursuing a variety of Level 3 equivalent qualifications. The A level entry requirement score is reduced to ABB for Access to Leeds eligible applicants. All applicants who meet the entry requirements are considered; no additional score is awarded for exceeding the requirements. The GCSE subject scores and level 3 score were available for the 2021 and 2022 cohorts of both rejected and accepted applicants. A total of GCSE score was calculated to represent the applicant's performance in GCSE or equivalent qualification which will be used in few sections of the analysis. However, this data was not retrievable for the cohorts of 2015 and 2016.

The personal statement has been used to assess the nature of the applicant's interest in a career in dentistry. This was considered until 2021 intake. UCAS personal statements are blind scored, by two markers: one admissions officer and one academic tutor (both trained and calibrated assessors); if a difference of 5 or greater between the two scores exists, the admission tutor moderates the scores and their final scores are taken; where the difference is less than 5, an average is taken. The personal statement is scored on 4 criteria: life experience and social awareness, motivation and insight, reflective skills and interests and achievement. The scores are then ranked. Where applicants share a ranking that falls over the cut off for the number of interview places, their BMAT score is considered and the applicants with the lower personal statement score but greater BMAT are called to the MMI. However, from entry of 2021 onwards, the personal statement was not considered in admissions. Instead of scoring personal statement and using ranked scores to determine the cut-off for interview, a combined score of academic achievement and BMAT was used.

Both total and criteria scores of the personal statements for students of entry of 2015 and 2016 were included in the analysis. Further details regarding the personal statement scoring are stated in appendix [E].

Additionally, all applicants for the Dental Surgery program leading to the degrees of MChD, BChD and Oral Science BSc are required to sit BMAT in August or October in the year of application. Where an applicant takes the test in both sittings, only their first attempt will be considered. Any applicants who do not sit the test will be rejected automatically. For cohorts 2015 and 2016, applicants were ranked by their overall BMAT score as previously explained. However, for 2021 and 2022 cohorts, this has changed. The BMAT score were incorporated into the academic scoring and used to rank the applicants. However, in the analysis, the BMAT total and sections scores were used in the same way for all the included cohorts in the analysis.

All applicants for the Dental Surgery program leading to the degrees of MChD, BChD and Oral Science BSc, Dental Hygiene and Dental Therapy BSc are asked to attend an interview. The interview allows to further assess the personal qualities of the applicants. The overall performance in the MMI determines who is offered a place in the course. The MMI stations' scenarios were primarily created to evaluate various skills. Tables 11 to 14 provide a description of the MMI stations in each of the assessed cohorts. The skills assessed in the MMI stations were aligned with the NHS six values which all dental professionals are expected to demonstrate. These values are working together for patients, respect and dignity, commitment to quality of care, compassion, improving lives and everyone counts (NHS, 2022). Admission tutors who contributed to the development of the MMI stations included academics and members of the dental school's admissions committee, with additional input provided by other academics in the school. Tables 11, 12, 13, and 14 provide a summary of the stations, the skills these stations were intended to evaluate, and the tasks used to evaluate these skills. The interviewer pool was made of dental school staff, including academics and support staff, and student ambassadors. All assessors who took part in the MMIs received training beforehand and practised the scoring system to assure a seamless operation of the stations and familiarise the examiners with the scoring system. Additionally, on the days of the interviews, the staff were briefed. MMI setting varied year on year. Details of MMI setting for each cohort considered in this study are presented in table 10. The scoring was a 4-5 Likert scale in addition to global rating of how happy the examiner is to offer a place for the candidate. Individual MMI stations scores were collected. In situations where each station’s individual questions scores were provided, an average of these scores was calculated to represent the station score. A total MMI score was calculated to represent the overall performance of the applicant/student in the MMI. Furthermore, each global rating was given a score and a total of these was calculated. This score was used to represent the examiner’s perception of the candidate/student as a predictor variable of their performance.

In addition, and when available, the following information was collected for each participant:

3- Gender
4- Age
5- Ethnicity
6- When considering widening participation within the social characteristics of the participant, Access to Leeds eligibility was considered as a representation of this as this is the main widening participation contextualised admissions scheme at the University.

In Access to Leeds, applicants who do not meet the standard entry criteria for an offer but are Access to Leeds eligible will be considered for an offer that is “Access to Leeds only” and require successful completion of the Access to Leeds module and making the University of Leeds their firm choice in order to have their place confirmed. Such applicants must meet the University's GCSE matriculation standard and, for courses which require particular subject skills, have gained at least GCSE grade C/4 (or equivalent) in the requested subject area. Applicants who meet two or more of the following criteria are eligible to apply for the Access to Leeds scheme:

- From a household with an annual income of £25,000 or below OR in receipt of 16-19 Bursary Fund or Discretionary Learner Support with income threshold of £25,000, OR in receipt of free school meals during their GCSE studies
- In the first generation of their immediate family to apply to higher education
- Attends, or has attended, a school which achieved less than the national average at GCSE (attainment 8 score)
- Only option is to attend a local university
- Studies disrupted by circumstances in their personal, social or domestic lives
- Live in a geographical area with low levels of progression onto higher education
- A care leaver or have spent time in public care.

A summary of the admission variables considered in this project is provided in table 15.

Table 10: MMI setting

	Entry of 2015	Entry of 2016	Entry of 2021	Entry of 2022
MMI setting	onsite	onsite	online	Online
Number of days in which the MMI took place	7	7	7	12
Number of MMI circuits performed per session (half day)	4	4	6	3-6
Number of applicants assessed per circuit	8	8	5	5
Number of MMI stations	8	8	5	5
Station duration	7 Minutes +1 minute given to the applicant to be greeted and presented with the task		6 Minutes + 2 minutes given to the applicant to be greeted and presented with the task	
Total MMI duration	68 minutes	68 minutes	40 minutes	40 minutes
Number of candidates examined per day	64	64	60	60/30

Table 11:Description of MMI stations - Entry of 2015

Cohort of entry of 2015			
Number of stations	8		
Station name	**Skills intended to be assessed**	**Procedure**	**Number of assessors**
Observation & Memory	1-Observation skills 2-Ability to accurately describe objects based what they have seen. (Short-term memory)	Candidates were asked to look at a collection of objects for 1½ minutes. They were allowed to touch/rearrange/pick items up if they wish, but they must be returned to the tray when the time runs out. At the end of 1½ minutes the objects were hidden and candidates were given 2 minutes to list all the objects they remember seeing. Of the items which they remembered; the examiner asked them to describe some of them in greater detail.	1
Ethics & Professionalism	Ethical awareness/reasoning	The candidates were asked to read an article carefully. Then, they were asked to identify the ethical dilemmas posed, and discuss the strengths and weaknesses of possible solutions. This station was a two-way discussion with the assessor, not a presentation. The candidates were not expected to arrive at a definite solution instead they were allowed to argue and consider multiple viewpoints and opinions.	1

Table 11:Description of MMI stations - Entry of 2015, continued

Presentation	Communication skills (Preparation + Communication + Understanding)	The candidate was required to give a 5-minute presentation to a member of staff and a senior student. At the end of the 5 minutes there were 2 minutes of questions, based on the content of their presentation. The candidates have all been given the title and instructions in advance so they were fully prepared to present. They have been told they are not allowed to use PowerPoint or other visual aids. Their notes were taken off them.	2
Origami	1-Ability to follow instructions 2-Manual dexterity	The candidate was given a sheet of printed A4 paper, some scissors and a workbook with pictures and instructions showing how to create a paper flower. The candidate should use the instructions and paper provided to make a paper flower.	1
Insight	Insight into issues that the public face when accessing healthcare.	Candidates were provided with a picture and they were asked to discuss the barriers or issues that the individuals in the picture might have if they had to access/get healthcare.	1
Empathy and communication	Empathy and communication skills	Candidates were required to communicate and explain to a disbelieving and upset mother that her child had several decayed teeth.	1+ An actor
Data analysis and interpretation	Analytical and data interpretation skills	Candidates were given 2 minutes to read through a graph and a study information after which the examiner asked them to describe the study and data.	

Table 11:Description of MMI stations - Entry of 2015, continued

Tangrams	Ability to communicate complex instructions	Candidates were provided with a photograph of an object made of wooden blocks of various shapes. The student examiner was seated behind a low screen with face visible. They had a set of tangram pieces on the desk in front of them. The candidate was seated opposite the student examiner so that they cannot see the tangram pieces or the student examiner's hands. They were provided with a laminated photograph of the solution to a tangram puzzle shape. In each run, 8 different shapes were used, one per candidate. Their task was to explain to the student examiner how to construct the object step by step using the same shaped wooden pieces (not coloured) that they had in front of them. The objective observer (staff examiner) was standing so as to be able to observe both the candidate and the student examiner's actions in response to the instructions given. They were not allowed to speak to the student examiner or to the candidate. The staff examiner could not show the student examiner the picture of the solution and he was not able to see the shape that they are making. The candidate must give verbal instructions only and not allowed to use hand gestures.	2 A staff examiner and a student examiner

Table 12: Description of MMI stations - Entry of 2016

Cohort of entry of 2016			
Number of stations	8		
Station name	**Skills intended to be assessed**	**Procedure**	**Number of assessors**
Observation & Memory	1-Observation skills 2- Ability to accurately describe objects based what they have seen. (Short-term memory)	A number of different cards with pictures of different dental objects listed in a different order were given to each candidate randomly. Each card contains 15 pictures of pre-selected dental objects presented in a particular order from 1 to 15. The candidate will have 2 minutes to study it. They will be required to memorise the objects presented on the card and their positions in the order from 1 to 15. After 2 minutes, they were asked to select the required dental objects from a pool of many objects and reproduce them in the same order from 1 to 15.	1
Ethics & Professionalism	Ethical reasoning	The candidates were asked to read an article carefully. Then, they were asked to identify the ethical dilemmas posed, and discuss the strengths and weaknesses of possible solutions. This station was a two-way discussion with the assessor, not a presentation. The candidates were not expected to arrive at a definite solution instead they were allowed to argue multiple viewpoints and opinions.	1

Table 12: Description of MMI stations - Entry of 2016, continued

Presentation	Communication skills (Preparation + Communication + Understanding)	The candidate was required to give a 3-minute presentation to a member of staff and a senior student. At the end, there was 4 minutes of questions, based on the content of the presentation. The candidates have all been given this title and instructions in advance so they were fully prepared to present. They have been told they are not allowed to use PowerPoint or other visual aids. Their notes were taken off them.	2
Origami	1-Ability to follow instructions 2-Manual dexterity	The candidate was provided with a folder containing laminated instructions and a sheet of origami patterned paper for the task to make a paper zebra. The candidate should only use one piece of paper but they may be given a second one if they tear it or there is good reason for them to require it.	1
Insight	Insight into issues that the public face when accessing healthcare.	Candidates were asked to discuss how any of the protected characteristics described in the Equality Act 2010 might impact a person's oral health and access to oral healthcare.	1
Communication	Communication Skills Sensitivity	Candidates was provided with the following scenario: Your mum has asked you to call and check on your neighbour, of whom you have known since your childhood. Your mum has mentioned to you that Pat is anxious about a forthcoming hospital appointment. You sometimes pop round for a chat with him/her. You are due to meet a friend at the cinema in half an hour. The candidate was required to call to see how she/he is and were rated by the examiner for their verbal and non-verbal communication skills and their ability to acknowledge Pat's concerns.	1 + An actor

Table 12: Description of MMI stations - Entry of 2016, continued

Data analysis and interpretation	Analytical and data interpretation skills	Candidates were given 2 minutes to read through the study information and a graph after which the examiner asked them to describe the study and data.	
Tangrams	Ability to communicate complex instructions	Candidates were provided with a photograph of an object made of wooden blocks of various shapes. Their task was to explain to the student examiner how to construct the object using the same shaped wooden pieces (not coloured) that they had in front of them. (Similar to the 2015 tangrams station)	2 Staff examiner (Objective observer) and a student examiner

Table 13: Description of MMI stations - Entry of 2021

Cohort of entry of 2021		
Number of stations	**5**	
Station name	**skills intended to be assessed**	**Procedure**
Motivation and insight	-Motivation: Exploring the candidate's reasons for choosing a career in dentistry and evidence that they have made efforts to gain information about the profession from different sources. -Insight: Exploring evidence that the candidate has considered the challenges and opportunities of the profession.	The candidate was asked to explain how has been dentistry affected by the COVID-19 Pandemic. If the participant was unable to answer, follow up questions were initiated by the examiner such as: - Tell me something you learned about dentistry that interests you. This was followed by questions such as: -How did you find out about this? -What do you think is going to be the hardest thing about being a dental student? -How will you manage the challenges?
Professionalism	This station is designed to assess the candidate's integrity and understanding of what it is to be an honest dental professional and allow the candidate to demonstrate their reasoning when faced with a difficult situation.	The candidate was given a scenario and asked to discuss the issue of dishonesty with the assessor.

Table 13: Description of MMI stations - Entry of 2021, continued

Social awareness	This station explores the candidates' attitudes toward the challenges that some members of society may face with regard to health.	The candidates were provided with a graph about the hours missed in school due to unplanned dental treatment and they were asked questions about the graph and its relevance to dental care in society.
Resilience	This station assesses the ability of a candidate to bounce back when things don't go as planned, to deal with emotionally negative situations and manage stress by exploring their understanding of why they feel the way they do, and developing strategies to help them deal with situations more effectively.	The candidate was asked about the activities that they missed the most during lock down? And this was followed up with multiple questions about their feelings about this, what they did to overcome it, longer-term benefits out of this situation and if they looked for support to turn to during this period.
Empathy and communication	1-Empathy 2-Comunication skills	The candidate was provided with a scenario followed by questions by the assessor to discuss a scenario.

Table 14: Description of MMI stations - Entry of 2022

Cohort of entry of 2022		
Number of stations	**5**	
Station name	**Skills intended to be assessed**	**Procedure**
Motivation	commitment; competence; self-awareness	This was evaluated by three questions asked by the assessor regarding a topic in dentistry. The topic discussed was about the 3D printed teeth with dental decay. The questions asked were about the benefits of this in dental education. They were also asked to discuss the importance of practicing on real patients even if those 3D printed teeth were available. Candidate was also asked about their experience in dealing with people in case of presence of a conflict or a raised complaint and how to resolve it.
Ethics	Ethical awareness	The candidates were given a scenario and then asked to discuss the ethical implications of it by asking them few questions. Questions asked were aiming to assess the candidate’s ability to reflect and consider the cultural significance of the ethical issue, ability to provide ideas to compensate for the moral difficulty explained in the scenario, ability to discuss the concept of consent.

Table 14: Description of MMI stations - Entry of 2022, continued

Professionalism	Courage; care; competence	The candidate was provided by a scenario that presents an act of unprofessional behaviour that he faced with a clinical partner and then asked to discuss it by asking the candidate few questions. The questions aimed to assess the candidate's ability to consider the impact of such unprofessional behaviour on patient care and the concept of dishonesty, ability to demonstrate empathy and their ability to explain the importance of for a dental professional to act honestly and with integrity in both their professional and personal life.
Social awareness	This station explores the candidates' attitudes toward the challenges that some members of society may face with regard to health.	The candidate was provided with a graph presenting the dental health in people experiencing homelessness in comparison to the population. The candidate was then asked to interpret the results and then discuss the issue by asking them questions about the barriers that people experiencing homelessness may face to access dental care. They were also asked to reflect on using the term (people experiencing homelessness) rather that (homeless people). Their ability to consider the lack of qualification in terms of temporary/permanent status, societal understanding of the word, assumptions made by society and researchers and danger of attaching labels to people.
Resilience	Ability to overcome challenges	The candidate was asked about a challenge that he/she has overcome. This was followed by few questions to further assess the level of insightful application of personal learning and growth to future challenges, thinking longer-term and considering wider/more complex issues, perhaps with demonstration of insight into own personality traits. Their ability to demonstrate evidence of deeper thinking and contemplation of issues on multiple levels was also assessed by asking a third question about the advantages and disadvantages of accepting application from candidates who resit their exams.

Table 15: Summary of the admission variables considered in the analysis

	Cohort 2015 & 2016	Cohort 2021 & 2022
Collected variables	**How were variables considered in the analysis?**	
A level score	Not available	A Level grades, actual or predicted, were weighted as follows: 8 for grades AAA and above; 4 for AAB, and 2 for ABB; with the best three grades being considered.
GCSE scores	Not available	Weightings were given by the admission team to the best 8 GCSE grades; 3 for A*, 8 or 9; 2 for A or 7; 1 for B, 6 or 5; 0.5 for C or 4 including English Language, Maths and either double science or Chemistry and Biology if taken separately. The weightings were used for the analysis. In addition, a sum of these scores was calculated to have a single score that represents the total GCSE score. As for the individual subjects, only English, Maths, science 1 and science 2 scores were used in the analysis as the rest were only provided with a score with no specification of the subject.
Personal statement	Both total score and individual criteria score were used	Not used for admission
BMAT	Both total score and BMAT sections scores were used	
MMI stations scores	-Where individual questions scores were provided for each station, the average of the station was calculated -MMI total score was then calculated by summing the averages of the stations.	

Table 15: Summary of the admission variables considered in the analysis, continued

MMI Global rating (Perception of the assessor)	The assessor was asked to choose how happy they were with being the candidate offered a place after each station. In such a case, the assessor's choice was given a score and the sum of all was calculated, for example, Not happy at all was given a score of 0, Unhappy was given a score of 1 and so on for unsure, happy and very happy indeed. Then the sum of the scores was calculated.
Gender	This was considered as Male / Female
Age	This was grouped to Mature >21 and school leaver ≤ 21
A2L eligibility	This was considered as being eligible or not eligible
Qualification level	This was considered as A level or equivalent and Degree
Ethnicity	This was classified according to the provided ethnicities to: White – Mixed white & Black African, Black Caribbean, Asian British Indian, Asian British Pakistani, Asian Chinese, Asian Other, Other mixed background – Other ethnic background

3.6.2 In-course performance measures

3.6.2.1 Academic in-course performance

The dental curriculum at the University of Leeds consists of 22 academic modules. There are five modules in year 1 (Health & Health Promotion (HHP), Intro to Oral Environment (IOE), Oral Disease, Defence & Repair (ODDR), Anxiety Pain Management (APM), Personal & Professional Development 1 (PPD1)). Second year consists of four modules (Clinical Skills A (CSA), Social Sciences related to Dentistry (SSRD), Intro to Bio Medical Sciences (IBMS), Personal & Professional Development 2 (PPD2)). Third year consists of five modules (Illness & Wellbeing (I&WB), Undergraduate Project (UGP), Clinical Skills B (CSB), Child Centred Dentistry 1 (CCD1), Personal & Professional Development 3 (PPD3)). Fourth year consists of four modules (Clinical Medical Sciences 1 (CMS1), Complex Adult Dentistry (CAD), Child Centred Dentistry 2 (CCD2), Personal & Professional Development 4 (PPD4)). Fifth year consists of four modules (Clinical Medical Sciences 2 (CMS2), Anxiety Management & Sedation (AMS), Personal & Professional Development 5 (PPD5), Final Year Project (Research Project) (FYP)). A summary of each year's modules is presented in table 16. Assessment details for each module can be found in appendix [F].

Table 16: Academic modules

Year	Modules
Year 1	HHP – IOE – ODDR – APM – PPD1
Year 2	CSA – SSRD – IBMS – PPD2
Year 3	PPD3 – UGP – CSB – I&WB – CCD1
Year 4	CMS1 – CAD – CCD2 – PPD4
Year 5	CMS2 – AMS – PPD5 – FYP

For the purpose of analysis, an average of each year performance was calculated to represent the student's academic performance per year. The sum of these averages was then calculated to represent the student's overall academic performance. These variables were used in the analysis to investigate various aspects of the predictive validity of the admission variables.

3.6.2.2 Clinical in-course performance

For the clinical aspect of students' performance, total clinical practice score of each year was considered to represent the students' clinical performance in each year as they progress throughout the course. Then a sum of these scores was calculated to represent the overall clinical practice performance throughout the course. See appendix [F] for further details about the clinical assessments conducted in each year and their credits.

In addition to the overall clinical practice scores, third and fourth years OSCE results were also extracted as they involve components that provided the closest approximation to the skills evaluated by MMIs i.e. (soft and motor skills). The OSCE stations were mapped into three categories; stations that assess communication skills, stations that assess fine motor skills and stations that assess gross motor skills. The averages of these stations were calculated for each category to represent the student's performance in each. Then, a total of the OSCE stations was calculated to represent the overall performance in the OSCE for each year. These variables will be used in the analysis to investigate various aspects of the predictive validity of the admission variables. A summary of the OSCE stations can be found in figures (7 and 8) and tables (17 and 18) below.

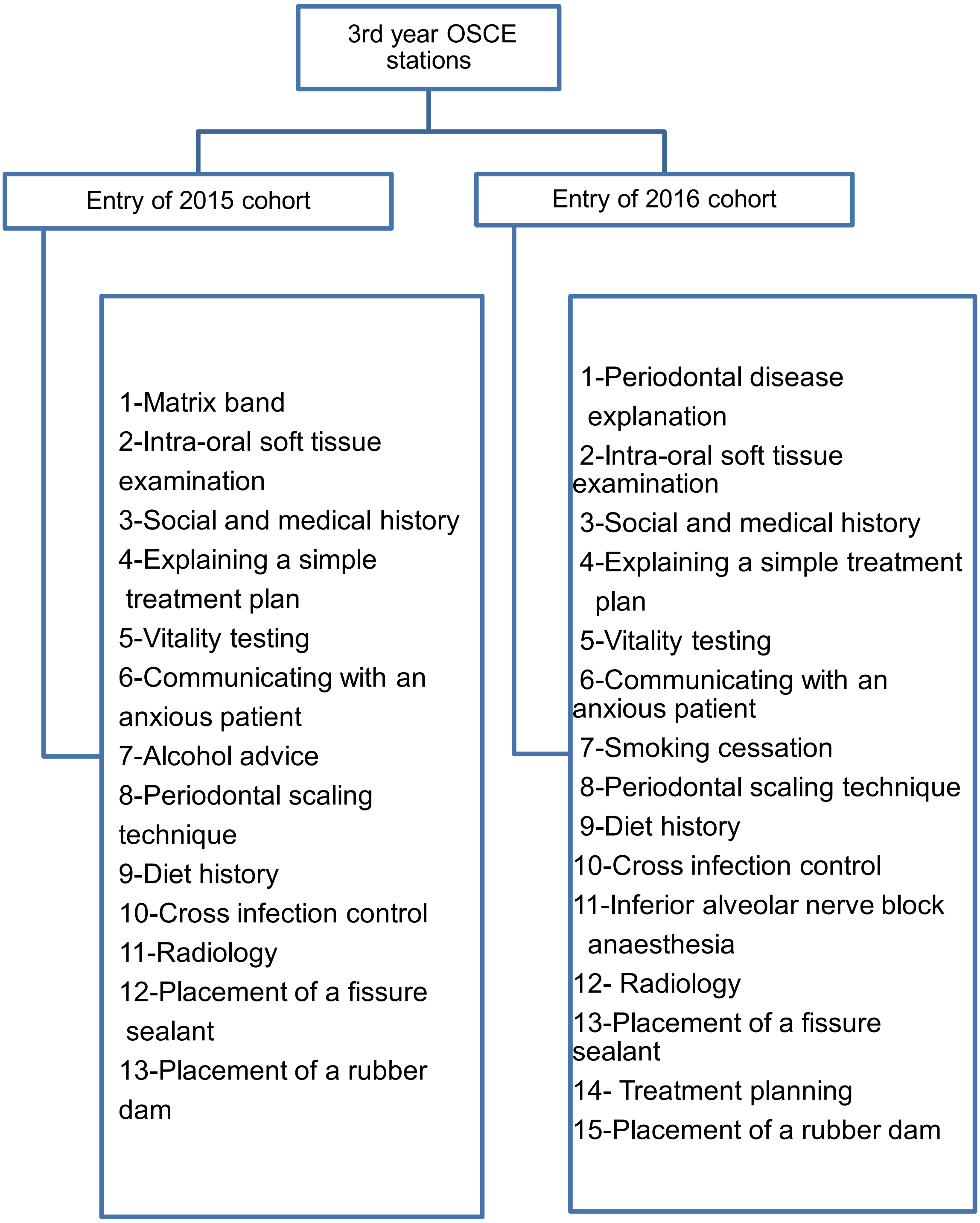


Figure 7: List of the 3rd year OSCE stations for 2015 and 2016 cohorts

Table 17: 3rd year OSCE stations description

OSCE stations for cohorts of entry of 2015 and 2016		
Station name	Procedure	Category of the skill
Matrix band	The student was provided with a Frasaco model in which a lower molar tooth is prepared with a mesial-occlusal cavity. The student is asked to apply a matrix band on the tooth.	Fine motor skills
Periodontal disease communication	The student was asked to explain a periodontal disease diagnosis to a patient and answer the patient's questions.	Communication skills
Intra-oral soft tissue examination	The student was asked to talk through the procedure of soft tissue examination to the examiner.	Communication skills
Social and medical history	The student was required to take a full social and medical history from a patient.	Communication skills
Explaining a simple treatment plan	The student was required to explain a plan of an intended treatment to a patient (composite restoration of a tooth), answer their questions and gain an informed consent for the treatment.	Communication skills
Vitality testing	The student was required to carry out special tests, ethyl chloride test & electric pulp tester, interpret the results and explain it to the patient.	Fine motor skills
Communicating with an anxious patient	The student was required to communicate with an anxious patient who had a previous bad experience with a dentist, understand the reason of her anxiousness and discuss a plan to manage these anxieties.	Communication skills

Table 17: 3rd year OSCE stations description, continued

Alcohol advice	The student was asked to talk to a patient about their AUDIT C score and discuss how to reduce their intake to a lower risk level.	Communication skills
Smoking cessation	The student was asked to talk to a patient about their smoking habit, advice him/her about smoking cessation and explain the support available.	Communication skills
Periodontal scaling technique	The student was asked to select the appropriate scaling instruments for each tooth/surface and demonstrate the action of debridement on different tooth surfaces on a plastic teeth model. They are also asked to talk through the procedure to the examiner and explain what they are doing.	Fine motor skills
Diet history	The student was provided with a diet history sheet of a patient and they are asked to discuss the diet history and give appropriate diet advice.	Communication skills
Cross infection control	The student was asked to demonstrate a decontamination procedure of a dental unit and their performance is observed.	Gross motor skills
Radiology	The student was provided with a history and clinical examination findings of a patient. Then they are asked to prescribe and justify the radiographic views that are indicated for the case. Then they are provided with those radiographs and asked to report on the radiographs taken for the patient.	Communication skills
Placement of a fissure sealant	The student was asked to properly isolate a tooth on a Frasaco teeth model and then place a fissure sealant on the specified tooth.	Fine motor skills

Table 17: 3rd year OSCE stations description, continued

Placement of a rubber dam	The student was asked to isolate a tooth on a teeth model.	Fine motor skills
Inferior alveolar nerve block anaesthesia	The student was asked to give an inferior alveolar nerve block to a manikin patient. The task includes preparing the local anaesthetic equipment, position the patient, simulate the stages of correct deposition of the local anaesthetic injection and dismantle the syringe.	Fine motor skills
Treatment planning	The student was asked to consider the principles of treatment planning in relation to a simple patient case and to answer questions about this to an examiner.	Communication skills

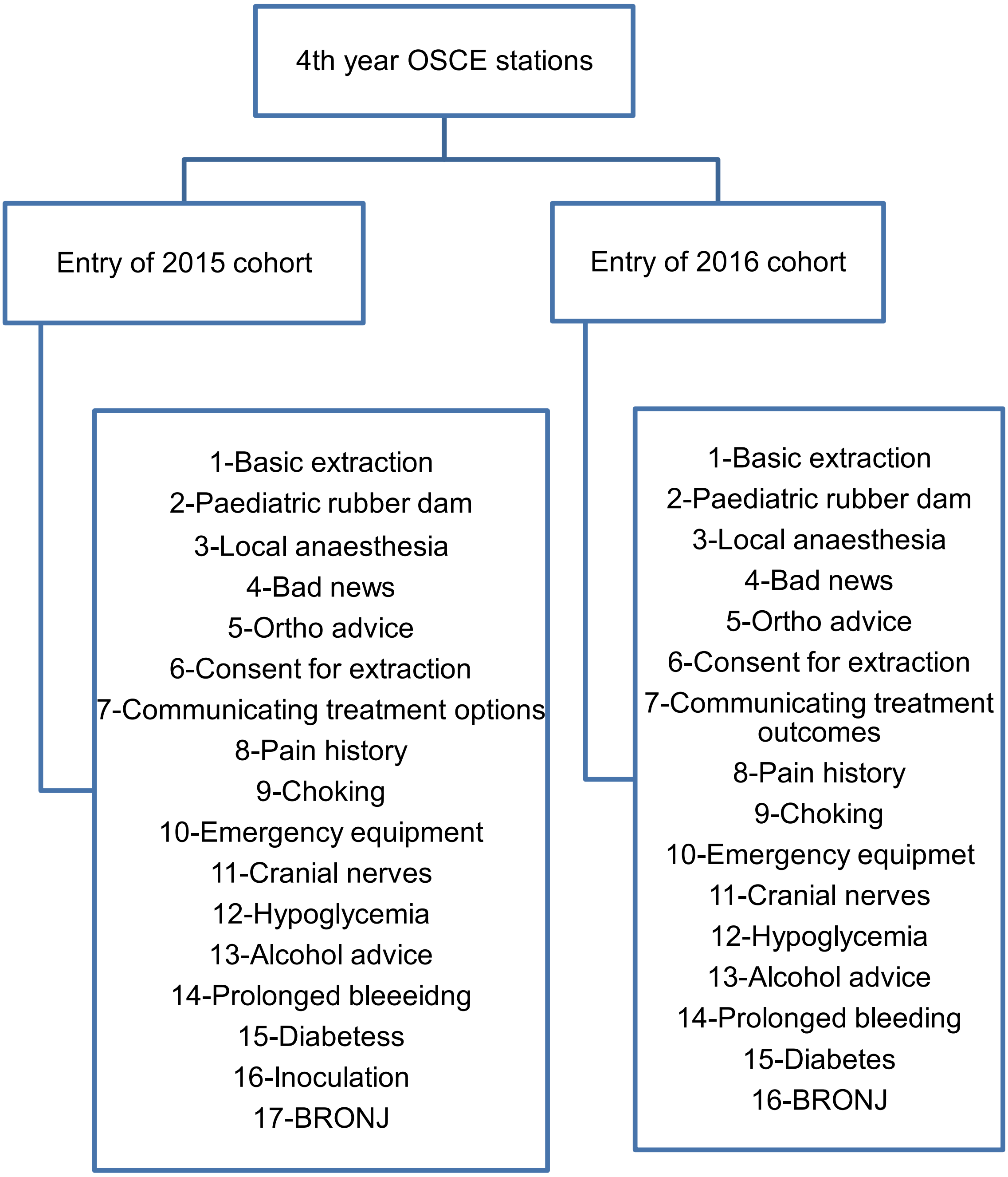


Figure 8: List of the 4th year OSCE stations for 2015 and 2016 cohorts

Table 18: 4th year OSCE stations description

Fourth year OSCE stations for cohorts of entry of 2015 and 2016		
Station name	**Procedure**	**Skills**
Basic extraction	The student was asked to simulate the task of extracting teeth on a phantom head. No need to explain their actions to the examiner who will be observing their actions.	Fine motor skills
Paediatric rubber dam	The student was required to place a rubber dam on teeth model using trough technique.	Fine motor skills
Local anaesthesia	The student was asked to give an inferior alveolar nerve block to a manikin patient. The task includes preparing the local anaesthetic equipment, position the patient, simulate the stages of correct deposition of the local anaesthetic injection and dismantle the syringe.	Fine motor skills
Bad news	The student was asked to break bad news to a patient. The student is required to explain to the patient that he/she will need an extended course of periodontal treatment and that their lower incisor teeth will need to be extracted.	Communication skills
Ortho advice	The student was provided with a clinical photograph of a paediatric patient who is undergoing fixed appliance treatment that he has decalcification. He is then asked to explain to a parent his findings and respond to any questions from the parent.	Communication skills
Consent for extraction	The student was required to gain a consent from a patient for teeth extraction that he requires.	Communication skills

Table 18: 4th year OSCE stations description, continued

Communicating treatment options	The student was provided with a clinical scenario and radiographs and is required to discuss the treatment options with the patient, answer their questions and gain an informed consent for the chosen treatment.	Communication skills
Pain history	The student was provided with a clinical scenario and he/she is required to take a detailed pain history. Then, he is asked to look at a radiograph and suggest a likely diagnosis.	Communication skills
Choking	The student was asked to manage a choking patient represented by a manikin.	Gross motor skills
Emergency equipment	The student was asked to explain the use of emergency drugs and equipment to a new member of the dental team.	Communication skills
Cranial nerves	The student was asked to carry out a clinical examination of the cranial nerves and explain their actions to the examiner as they go along.	Fine motor skills
Hypoglycaemia	The student was asked to interpret a patient's blood glucose level explaining their actions as if talking to a patient.	Communication skills
Alcohol advice	The student was asked to a focused history to identify relevant social habits which may impact oral health.	Communication skills
Prolonged bleeding	The patient was asked to take a focused medical history to allow appropriate planning for teeth extraction. The student then summarizes their findings to the examiner and answer the patient's questions.	Communication skills

Table 18: 4th year OSCE stations description, continued

Diabetes	The student was asked to take a focused history to update the medical history of a patient who has diabetes and hypertension.	Communication skills
Inoculation	The student was asked to help a colleague who sustained an inoculation injury from a dirty syringe needle after injecting a patient. He is asked to take a focused history from the patient to assess their risk of carriage of Blood Borne Viruses.	Communication skills
BRONJ	The student was asked to listen to a patient who takes osteoporosis medication and is concerned about the effect of these medications on her dental care. The student is then asked to address the patients concerns.	Communication skills
Communicating treatment outcome	The student was provided with a clinical scenario in which the dentist exposed the vital pulp whilst excavating the caries. The student is asked communicate the situation to the patient and give advice relevant to short and longer terms.	Communication skills

In summary, this project utilized several predictors to assess students' in-course success, including:

1- Individual student’s academic performance scores (calculations explained previously)
2- Individual student’s clinical performance scores
3- OSCE total scores
4- OSCE stations mapped into three skill categories: stations that assess communication skills, stations that assess fine motor skills and stations that assess gross motor skills, aiming to represent different skill areas.
5- Number of failures in academic and clinical aspects of the course
6- Number of professionalism breaches which reflect instances of unprofessional behaviour exhibited by students.

3.7 Data analysis

The work largely involves quantitative methodology. The analysis was exploratory in nature and aimed to identify the predictive factors of dental school performance and to assess the association between the socio-demographic factors and the applicant's/students' performance at the admission process and in-course performance. The statistical analysis was conducted using IBM SPSS Statistics software version 26. This was carried out in stages due to the exploratory nature, and each stage informed the next. The predictor and outcome variables varied in the analysis sections according to the aim of the investigation. These variables will be specified gradually in the result chapter as the presentation of the results progresses to simplify the presentation of the written material. The analysis is summarised in figure 9 below.

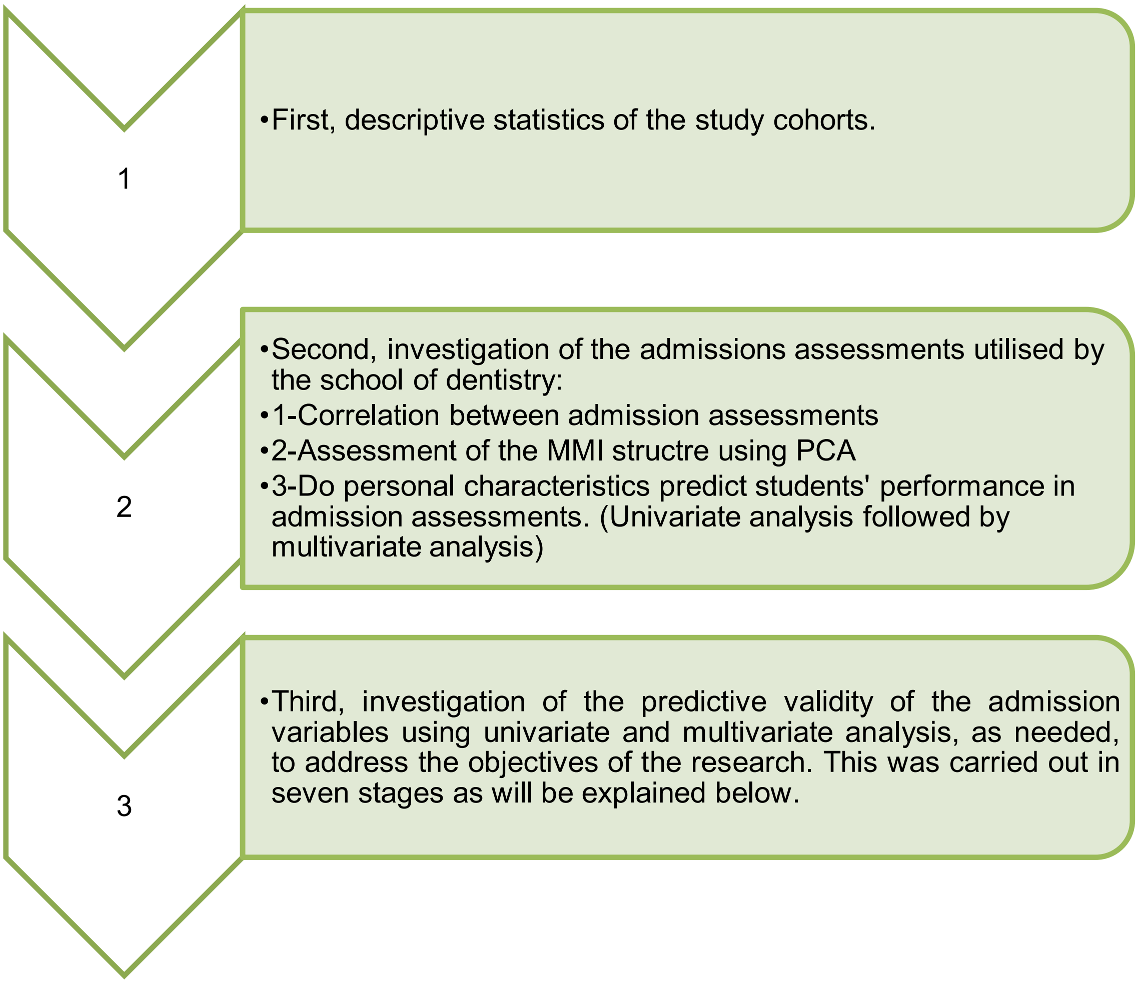


Figure 9: Summary of the data analysis stages

3.7.1 First section

In the first section of the analysis, descriptive statistics of the cohorts included in the project was carried out.

3.7.2 Second section

The second section included the analysis of the admission assessments utilised at the school of dentistry. This included:

1- Assessment of the correlation between the admission assessments using Pearson's correlations.
2- Principal component analysis to assess the structure of the multiple mini-interviews.
3- Assessment of the correlation between the personal characteristics of the applicants/students and their performance in admission assessments, if exists. This was carried out in two stages:

Stage I: Univariate analysis

An independent-samples t-test and one-way analysis of variance were used to explore if a difference exists in admission assessment performance between gender groups, age groups, ethnicity groups, Access to Leeds groups and qualification level.

Stage II: Multivariate analysis

Following the univariate analysis, series of fourteen multiple regressions were carried out to analyse whether the personal characteristics of applicants/students predicted their performance in any of the admission assessments. Further details regarding the variables considered in each regression model are summarized in the table 19 below.

Table 19: Variables included in the regression models

<table>
<tr><th>Multiple regression</th><th>Cohort</th><th>Dependent variable</th><th colspan="2">Independent variables</th></tr>
<tr><td>1</td><td rowspan="3">2015
&
2016</td><td>Total personal statement score</td><td rowspan="3" colspan="2">Gender
Access to Leeds eligibility
Maturity
Qualification level
Ethnicity</td></tr>
<tr><td>2</td><td>Total BMAT score</td></tr>
<tr><td>3</td><td>Total MMI score</td></tr>
<tr><td rowspan="2"></td><td rowspan="6">2021
&
2022</td><td rowspan="2"></td><td colspan="2">Independent variables</td></tr>
<tr><td>2021</td><td>2022</td></tr>
<tr><td>1</td><td>Total GCSE score</td><td rowspan="4">Gender
Access to Leeds eligibility
Maturity
Qualification level</td><td rowspan="4">Access to Leeds eligibility
Qualification level</td></tr>
<tr><td>2</td><td>Level 3 score</td></tr>
<tr><td>3</td><td>Total BMAT score</td></tr>
<tr><td>4</td><td>Total MMI score</td></tr>
</table>

3.7.3 Third section

The last section investigated the predictive validity of the admission variables. This was carried out in multiple stages. Each stage addressed the next to eventually answer all the research questions.

Stage I: Univariate analysis

The association between admission variables and the students' in-course academic and clinical outcome measures was assessed using univariate analysis tests (Pearson correlation).

In addition, an independent-samples t-test and one-way analysis of variance were run to explore if a difference exists in in-course performance between gender groups, age groups, ethnicity groups, Access to Leeds eligible groups and qualification level.

Stage II: Incremental validity

A total of eight hierarchical regression models were conducted for cohorts 2015 and 2016. Each hierarchical regression helped us to understand how much additional variance in the performance of the students in each outcome measure is explained by the addition of each admission variable. Details of the variables considered in each model are described in table 20 below.

Table 20: Variables considered in the hierarchical regression models

Cohorts	Hierarchical regression	Dependent (outcome) variable	Independent (predictor) variables
2015 & 2016	**1**	**Total CP score**	**Step 1** Gender **Step 2** Ethnicity **Step 3** Access to Leeds eligibility **Step 4** Maturity **Step 5** Qualification level **Step 6** Total personal statement score **Step 7** Total BMAT score **Step 8** Total MMI score
	2	**Total academic performance score**	
	3	**Total of 3rd year OSCE score**	
	4	**Total of 4th year OSCE score**	
	5	**Average of communication stations score / 3rd year OSCE**	
	6	**Average of fine motor stations score / 3rd year OSCE**	
	7	**Average of communication stations score / 4th year OSCE**	
	8	**Average of fine motor stations score / 4th year OSCE**	

Stage III: Predictive validity across the years

A total of ten multiple regression models were conducted to further analyse the predictive validity of the admission assessments. This is to determine whether the predictive validity of the admission assessments changed as the student progresses in the course. Yearly averages of academic performance and yearly clinical practice scores were used as the outcome variables in these regression models. While, total scores of personal statements, BMAT and MMI were used as the predictor variables.

Stage IV: BMAT sections predictive validity

This stage was added after the previous analysis was conducted, as BMAT was found to add significant prediction in multiple variables in the hierarchical regression, further analysis of the BMAT sections against all the previously considered outcome variables (dependent variables) was assessed using series of multiple regressions to determine if certain section in the BMAT was more predictive than another. A total of eight multiple regressions were carried out for each cohort. See table 21 for full details of the variables considered in each model.

Table 21: Variables considered in BMAT sections multiple regression

Cohort	Multiple regression	Dependent (outcome) variables	Independent (predictor) variable
		2015 & 2016	
2015 & 2016	1	Total CP score	BMAT Section 1 BMAT Section 2 BMAT Section 3
	2	Total academic performance	
	3	Total of 3rd year OSCE score	
	4	Average of communication stations score / 3rd year OSCE	
	5	Average of fine motor stations score / 3rd year OSCE	
	6	Total of 4th year OSCE score	
	7	Average of communication stations score / 4th year OSCE	
	8	Average of fine motor stations score / 4th year OSCE	

Stage V: MMI predictive validity of OSCE performance

Further analysis of the MMI stations and components was carried out using series of multiple regressions to assess if any predictive validity exists when considering the attributes as assessed by stations. The outcome variables chosen were the 3rd and 4th year OSCE communication and fine motor stations averages. OSCE stations were designed to capture soft skills and relate to specific knowledge. They were picked as they resemble the setting in which the MMI is held and they could be the closest to be mapped against the MMI. See table 22 for full details of the variables considered in each model.

Table 22: Variables considered in MMI multiple regression model

Cohort	Multiple regression	Dependent (outcome) variables 2015	Dependent (outcome) variables 2016	Independent (predictor) variable
2015 & 2016	**1**	**Average of communication stations score / 3rd year OSCE**		-MMI station 1 -MMI station 2 -MMI station 3 -MMI station 4 -MMI station 5 -MMI station 6 -MMI station 7 -Perception of the examiner score, subject to availability -MMI component 1 -MMI component 2 -MMI component 3
	2	**Average of fine motor stations score / 3rd year OSCE**		
	3	**Average of communication stations score / 4th year OSCE**		
	4	**Average of fine motor stations score / 4th year OSCE**		

Stage VI: Risk of failure and professionalism breach

Initial plan was to assess the prediction of professional breach and failure in clinical practice and academic modules using binary logistic regression, however, it was not statistically suitable to run the regression analysis. Therefore, univariate analysis was used to assess the association.

Chapter 4 Results

In this chapter, the findings of the data analysis will be presented. The reporting of the results will be divided into the following three sections as summarised in figure 10 below:

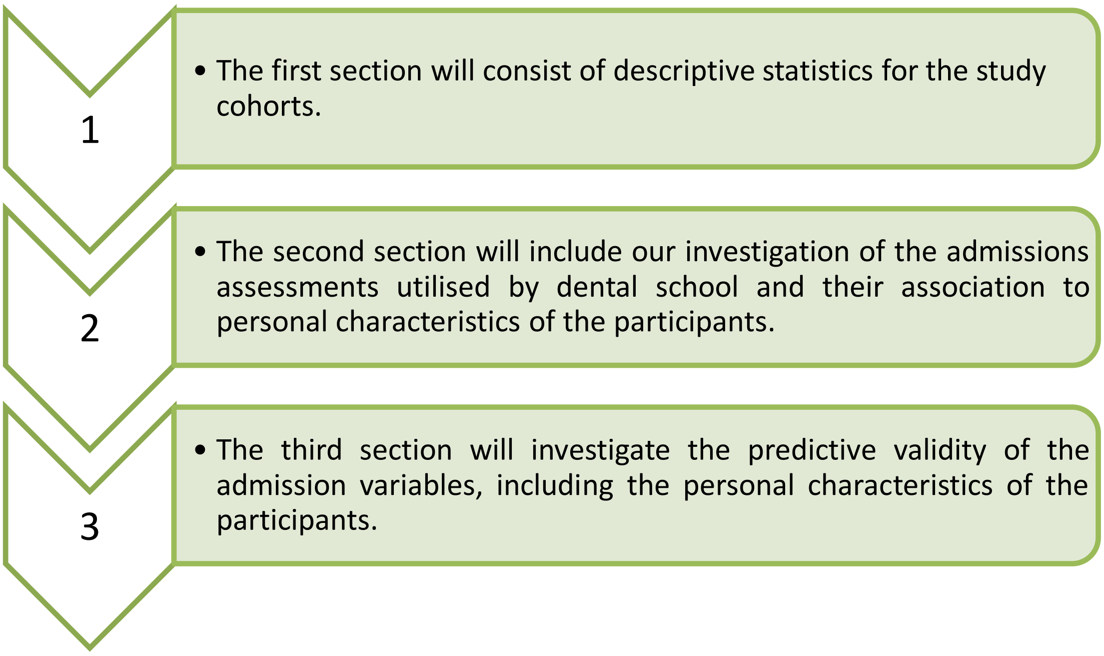


Figure 10: Sections of results reporting

At the beginning of each section, the section's contents will be briefed.

4.1 Section 1: Descriptive statistics

This section will describe the cohorts included in the studies as well as some general observations from the initial data investigation. All the retrieved admission and in-course assessment data of the registered undergraduate dental students for the admission cycles 2015 and 2016 at the Dental Surgery Programme at the School of Dentistry, University of Leeds were included in all the analysis sections. No opt outs were received from these cohorts. The students of these two cohorts were followed from first year to graduation. In addition, admission data of applicants for the Dental Surgery Programme, both accepted and rejected, for the admission cycles 2021 and 2022 were included to analyse the association between personal characteristics and admission assessments on a broader scale, as data for rejected applicants was available. All applicants of the cohort 2022 were included in the analysis, however fourteen opt-outs were received from the applicants of cohort 2021.

Number of students/applicants included in the analysis was 68, 92, 379 and 396 for the 2015, 2016, 2021 and 2022, respectively. The available admission and assessment data were retrospectively retrieved and anonymised as previously described in the methodology chapter. Females and school leavers represented the majority of the cohorts. While males and mature participants make up fewer than half of the cohorts that have been studied. Students and applicants with a prior degree attained prior to their entry/application to the course represented a very small percentage of the cohorts investigated, while those holding an A level or equivalent qualification represented the majority. Access to Leeds eligible students represented 17.65% and 15.2% of 2015 and 2016 cohorts. Unfortunately, the number of rejected Access to Leeds eligible applicants of these cohorts was not available. However, this information was available for the 2021 and 2022 cohorts in which the eligible applicants represented 44.3% and 40.2% of the applicants' pool, respectively. From which only 12.2% and 7.3% obtained an offer.

Understanding the different groups performance in admission assessments followed by investigating their performance in the course will greatly enhance our understanding of the admission process. Further details about the qualification level and the demographic features of the participants of each cohort can be found in tables 23 and 24. Numbers of the participants included in the analysis of admission and in-course assessments are provided in tables 25 and 26.

Table 23: Demographic data of participants

Gender									
		Cohort 2015		Cohort 2016		Cohort 2021		Cohort 2022	
		Frequency	%	Frequency	%	Frequency	%	Frequency	%
Gender	Male	18	26.4	29	31.6	148	39.1	Data was not provided	
	Female	42	61.8	57	61.9	227	59.8		
	Missing	8	11.8	6	6.5	4	1.1		
Maturity	Mature	8	11.7	13	14.1	46	12.1	Data was not provided	
	School leaver	45	66.2	72	78.3	330	87.1		
	Missing	15	22.1	7	7.6	3	.8		
A2L	Not eligible	47	69.11	70	76.1	209	55.2	237	59.8
	Eligible	12	17.65	14	15.2	168	44.3	159	40.2
	Missing	9	13.24	8	8.7	2	.5	0	0
Ethnicity	White	30	44.1	38	41.3	Data not provided		Data not provided	
	Asian British Indian	12	17.6	16	17.4				

Table 23: Demographic data of participants, continued

	Asian British Pakistani	9	13.3	13	14.1		
	Asian Chinese	2	2.9	3	3.3		
	Asian other	3	4.4	11	11.9		
	Black Caribbean	0	0	2	2.2		
	Other mixed background	1	1.5	3	3.3		
	Other ethnic background	1	1.5	0	0		
	Missing	10	14.7	6	6.5		

Table 24: Qualification level of participants

Qualification level								
	Cohort 2015		Cohort 2016		Cohort 2021		Cohort 2022	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
A level or equivalent	49	72.1	56	60.9	349	92.1	349	88.1
Degree	11	16.2	13	14.1	30	7.9	47	11.9
Missing	8	11.7	23	25	0	0	0	0

Table 25: Number of participants in admission assessments

Admission assessments									
		Cohort 2015		Cohort 2016		Cohort 2021		Cohort 2022	
		Frequency	%	Frequency	%	Frequency	%	Frequency	%
GCSE	Available	Data was not available		Data was not available		300	79.2	384	97
	Missing					79	20.8	12	3
Level 3 score	Available	Data was not available		Data was not available		302	79.7	348	87.9
	Missing					77	20.3	48	12.1
Personal statement scores	Available	59	86.8	70	76.1	Personal statement was not used		Personal statement was not used	
	Missing	9	13.2	22	23.9				
BMAT scores	Available	53	77.9	59	64.1	286	75.5	396	100
	Missing	15	22.1	33	35.9	93	24.5	0	0
MMI scores	Available	62	91.2	80	86.9	245	64.6	189	47.7
	Missing/not invited	6	8.8	12	13.1	134	35.4	207	52.3

Table 26: Number of participants in in-course assessments

		In-course assessments			
		Cohort 2015		Cohort 2016	
		Frequency	%	Frequency	%
Academic scores	Available	48	70.6	86	93.5
	Missing	20	29.4	6	6.5
CP scores	Available	53	77.9	87	94.6
	Missing	15	22.1	5	5.4
3rd year OSCE scores	Available	64	94.1	79	85.9
	Missing	4	5.9	13	14.1
4th year OSCE scores	Available	61	89.7	69	75
	Missing	7	10.3	23	25

4.2 Section 2: The admission assessments

This section will be presented in three stages as shown in the figure 11 below:

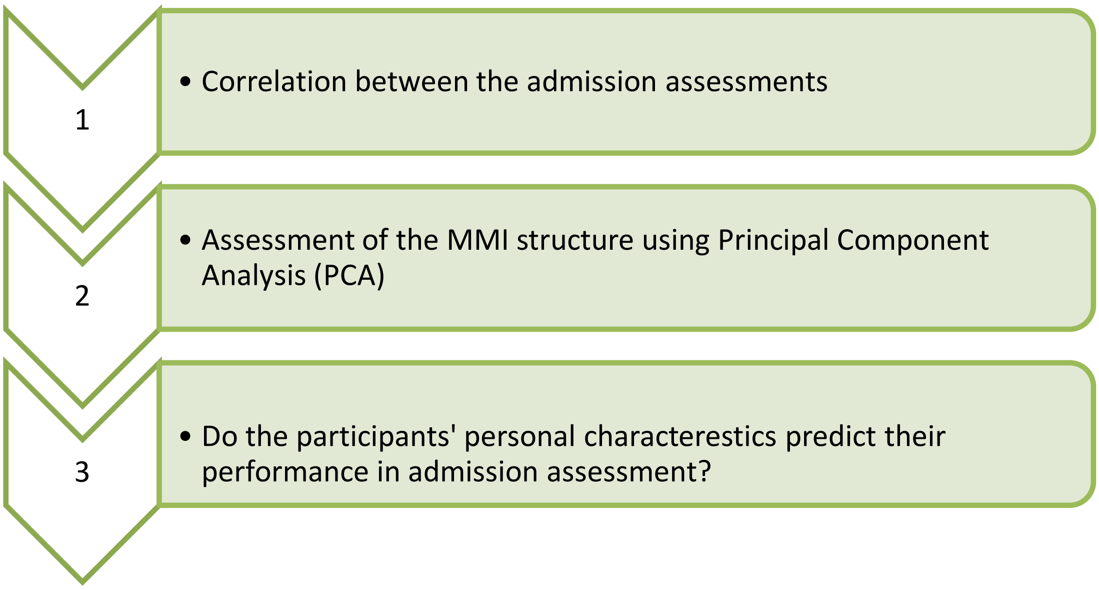


Figure 11: Stages of the second section of results reporting

4.2.1 Correlation between admission assessments

A Pearson's product-moment correlation was run to assess the relationship between the admissions assessments. This was carried out for each cohort separately. Preliminary analyses showed the relationship to be linear with variables normally distributed, as assessed by Shapiro-Wilk's test ($p>0.05$), and there were no outliers. In 2015 and 2016 cohorts, the correlation was assessed between personal statement, BMAT and MMI scores. In 2021 and 2022 cohorts, GCSE and level 3 scores were available, therefore they were also assessed for correlation with BMAT and MMI scores. However, personal statement was not used in the selection of these two cohorts.

In 2015 cohort, personal statement total score and sub-scores had statistically significant multiple negative small to moderate correlations with BMAT total score and sections' scores. As for personal statement correlations with MMI, presentation station had a statistically significant positive moderate correlation with personal statement total score and personal statement reflective skills score. In 2016 cohorts, statistically significant negative correlations were only noted between personal statement reflective skills scores and BMAT section 3 score and significant positive correlation with MMI observation and memory station.

As for MMI, MMI total score and perception of assessors score had positive correlations with BMAT total and sections scores. This correlation with BMAT scores was also found with some of the MMI stations such as communication station, tangrams station, origami station, presentation station, observation and memory station. In 2015 cohort, total BMAT score had statistically positive moderate correlation with MMI perception of assessors score and communication station score. Similarly, BMAT section 3 had a statistically positive correlation with the MMI communication station. However, in 2016 cohort tangrams station, origami station and total MMI score correlated negatively with BMAT. However, in 2021 and 2022 cohorts, in which tangrams and origami were not part of the MMI design, MMI total score as well as with motivation and insight station and social awareness station correlated positively with total BMAT score and sections scores. GCSE English score had also statistically significant small positive correlation with origami and observation and memory stations.

Additionally, it was observed in 2021 and 2022 cohorts that BMAT total score and sections scores had statistically significant multiple positive small to moderate correlations with GCSE total score, GCSE maths score, GCSE English score, GCSE Science scores, Level 3 score. There was also statistically significant small positive correlation between level 3 score and GCSE scores. Further details of the correlation coefficient values can be found in tables 27 and 28.

As multiple correlations were found between both BMAT total and sections' scores with GCSE total score, GCSE sub-scores and Level 3 score, a linear regression was run between BMAT total score and GCSE total score and another linear regression between total BMAT score and Level 3 score. This was done to assess if GCSE and level 3 scores can actually predict BMAT score. In 2021 cohort, the linear regression between GCSE and BMAT score established that GCSE total score could statistically significantly predicted BMAT score, $p=.01$ and GCSE score accounted for 2% of the explained variability in the BMAT score. In 2022 cohort, the linear regression between GCSE and BMAT score established that GCSE total score could also statistically significantly predict

BMAT score, p=.000 and GCSE score accounted for 17.1% of the explained variability in the BMAT score. As for the level 3 score, in 2021 cohort, the linear regression between level 3 and BMAT score established that level total score could not statistically significantly predict BMAT score, p=0.14. However, in 2022 cohort, the linear regression between level 3 and BMAT score established that level 3 total score could statistically significantly predict BMAT score, p=0.000, and level 3 score accounted for 6.5% of the explained variability in the BMAT score.

Similarly, linear regressions were run between BMAT total score and MMI total score. This was conducted to assess if the BMAT predicts the MMI score. In 2015 and 2016 cohorts, the models were not statistically significant and the B coefficient of the total BMAT score did not reach statistical significance in predicting the total MMI score (p=0.073 and p=0.2, respectively). On the other hand, in 2021 and 2022 cohorts the models were statistically significant explaining 2.4% and 3.1% of the total MMI score (p=0.01 and p=0.02, respectively). In fact, the BMAT B coefficient in the 2021 model indicates that a score increase in the BMAT score leads to a 0.092 increase in the predicted total MMI score. While in the 2022 model, the BMAT B coefficient indicates that a score increase in the BMAT total score leads to a 0.137 increase in the predicted MMI total score.

Table 27: Correlations between admission assessments (2015 and 2016 cohorts)

Admission assessment	Correlation details			
	Cohort 2015			Cohort 2016
Personal statement total score	BMAT total score	Negative p= 0.000	Moderate r = 0.54	None
	BMAT section 1	Negative p= 0.000	Moderate r =0.52	
	BMAT section 2	Negative p= 0.001	Moderate r =0.42	
	MMI station 3 (Presentation)	Positive p= 0.017	Moderate r =0.32	
Personal statement-Life experience & social awareness	BMAT total score	Negative p=0.000	Strong r =0.56	None
	BMAT section 1	Negative p=0.000	Moderate r =0.47	
	BMAT section 2	Negative p=0.001	Moderate r =0.45	
	BMAT section 3	Negative p=0.03	Small r =0.28	
	MMI station 3 (presentation)	Positive p= 0.02	Moderate r =0.306	

Table 27: Correlations between admission assessments (2015 and 2016 cohorts), continued

Personal statement Motivation and insight	BMAT total score	Negative p= 0.002	Moderate r =0.41	None		
	BMAT section 1	Negative p= 0.000	Moderate r =0.51			
	BMAT section 2	Negative p= 0.01	Moderate r =0.32			
Personal statement Reflective skills	BMAT total score	Negative p= 0.003	Moderate r =0.39	BMAT section 3	Negative p=0.02	Moderate r =0.405
	BMAT section 1	Negative p= 0.003	Moderate r =0.40	MMI station 1 (Observation and memory)	Positive p=0.03	Small r =0.25
	BMAT section 2	Negative p= 0.04	Small r =0.27			
	MMI station 3 (presentation)	Positive p= 0.03	Small r =0.28			
Personal statement Interests & achievement	None			None		

Table 27: Correlations between admission assessments (2015 and 2016 cohorts), continued

Total BMAT score	Perception of assessors in MMI	Positive p= 0.04	Small r =0.27	MMI station 8 (Tangrams)	Negative p=0.04	Moderate r =0.32
	MMI station 6 (Empathy &Communication)	Positive p= 0.003	Moderate r =0.40			
BMAT section 1				MMI station 4 (Origami) p=0.04	Negative p=0.04	Moderate r=0.32
BMAT section 2				MMI total score	Negative p=0.03	Moderate r=0.34
BMAT section 3	MMI station 6 (Empathy & Communication)	Positive p=0.000	Moderate r =0.505			

Table 28: Correlations between admission assessments (2021 and 2022 cohorts)

Admission assessment	Correlation details					
	Cohort 2021			Cohort 2022		
GCSE total score	Level 3 score	Positive p=0.000	Small r=0.206	Level 3 score	Positive p=0.000	Small r=0.21
	BMAT section 1	Positive p=0.000	Moderate r=0.31	BMAT section 1 score	Positive p=0.000	Moderate r=0.43
	BMAT section 3	Positive p=0.004	Small r=0.17	BMAT section 2 score	Positive p=0.000	Moderate r=0.33
	BMAT total score	Positive p=0.01	Small r=0.15	BMAT section 3 score	Positive p=0.000	Small r=0.27
	Total MMI score	Positive p=0.04	Small r=0.12	BMAT total score	Positive p=0.000	Moderate r=0.41
GCSE Maths	Level 3 score	Positive p=0.01	Small r = 0.13	Level 3 score	Positive p=0.009	Small r=0.14
	BMAT section 1	Positive p=0.000	Moderate r=0.32	BMAT section 1 score	Positive p=0.000	Moderate r=0.43
	BMAT total score	Positive p=0.008	Small r=0.15	BMAT section 2	Positive p=0.000	Moderate r=0.406
				BMAT total score	Positive p=0.000	Moderate r=0.41

Table 28: Correlations between admission assessments (2021 and 2022 cohorts), continued

GCSE English	BMAT section 1	Positive p=0.009	Small r =0.15	Level 3 score	Positive p=0.003	Small r=0.15
	BMAT section 3	Positive p=0.000	Small r=0.22	BMAT section 1	Positive p=0.000	Moderate r=0.32
	BMAT total score	Positive p=0.001	Small r=0.19	BMAT section 2	Positive p=0.000	Small r=0.24
	MMI station 4 (Resilience)	Positive p=0.02	Small r=0.14	BMAT section 3	Positive p=0.000	Small r=0.27
	Total MMI score	Positive p=0.01	Small r=0.15	BMAT total score	Positive p=0.000	Moderate r=0.31
				MMI Station 1 (Observation and memory)	Positive p=0.03	Small r=0.15
GCSE Science 1	Level 3 score	Positive p=0.01	Small r= 0.14	Level 3 score	Positive p=0.005	Small r =0.15
	BMAT section 1	Positive p=0.000	Small r=0.28	BMAT section 1	Positive p=0.000	Moderate r =0.34
	BMAT total score	Positive p=0.02	Small r=0.13	BMAT section 2	Positive p=0.000	Small r=0.27
				BMAT section 3	Positive p=0.009	Small r=0.14
				BMAT total score	Positive p=0.000	Moderate r=0.35

Table 28: Correlations between admission assessments (2021 and 2022 cohorts), continued

GCSE Science 2	Level 3 score	Positive p=0.02	Small r=0.12	Level 3 score	Positive p=0.01	Small r =0.12
	BMAT section 1	Positive p=0.000	Moderate r=0.303	BMAT section 1	Positive p=0.000	Moderate r=0.38
	BMAT total score	Positive p=0.04	Small r=0.12	BMAT section 2	Positive p=0.000	Moderate r=0.307
				BMAT section 3	Positive p=0.000	Small r=0.21
				BMAT total score	Positive p=0.000	Moderate r=0.35
Level 3 score	BMAT section 1	Positive p=0.03	Small r=0.12	BMAT section 1	Positive p=0.001	Small r=0.19
				BMAT section 2	Positive p=0.000	Small r=0.201
				BMAT section 3	Positive p=0.015	Small r=0.13
				BMAT total score	Positive p=0.000	Small r=0.25
				MMI station 3 (Professionalism)	Positive p=0.000	Small r=0.29

Table 28: Correlations between admission assessments (2021 and 2022 cohorts), continued

Total BMAT score	MMI station 1 (Motivation & insight)	Positive p=0.03	Small r=0.13	MMI total score	Positive p=0.01	Small r=0.17
	MMI station 3 (Social awareness)	Positive p=0.02	Small r=0.14	Examiners’ perception score in MMI	Positive p=0.000	Moderate r=0.32
	Total MMI score	Positive p=0.01	Small r=0.16			
BMAT section 1	Total MMI score	Positive p=0.04	Small r=0.12	MMI total score	Positive p=0.01	Small r=0.17
BMAT section 2	Total MMI score	Positive p=0.04	Small r=0.13	MMI total score	Positive p=0.03	Small r=0.15

4.2.2 Assessment of the MMI structure

For statistical analysis, principal components analysis (PCA) was carried out using SPSS statistics. This analysis will allow the identification of the highly correlated variables which enables us to know the variables that measure the same underlying construct. In addition, this analysis allows us to determine if the construct measured "loads" onto all or only some of the variables. This enables us to determine whether some of the variables selected are insufficiently representative of the target construct or if more than one item may be measuring the same construct and should be eliminated.

Performance on all the MMI stations was measured. All the scores were tested for normality and sampling adequacy to ensure the data met the requirements for principal component analysis. A correlation matrix was created to determine the relationship between the variables. A parallel analysis method along with a scree plot were selected to be the extraction methods for determining the number of factors to extract over the eigenvalue rule. The parallel analysis was followed by factor rotation to determine the loadings of each item on the factors.

Four principal components analysis (PCA) were run on the MMI stations of cohorts 2015, 2016, 2021 and 2022. Inspection of the correlation matrix showed that all variables had at least one correlation coefficient greater than 0.3. The suitability of PCA was assessed prior to analysis using the overall and individual Kaiser-Meyer-Olkin (KMO) measure and the Bartlett's test of sphericity. The results indicated that the data was suitable for factor analysis with all KMO values exceeding 0.6 and all sphericity tests returning significant results.

The following pages will report the findings of PCA for each cohort.

4.2.2.1 MMI of entry of 2015

When running a PCA, it will produce as many components as there are variables in the assessment being tested. In our case, this means that it will produce as many components as the number of MMI stations entered. However, it is not the purpose to retain all the components. Instead, the objective of PCA is to maximize the explanation of variance while using as few components as possible. The first component in the PCA captures the highest proportion of overall variance, while each successive component explains a relatively smaller portion of the total variance. Typically, only a few initial components need to be retained for meaningful interpretation, as they account for the majority of the total variance. In the table titled "Total Variance Explained" (Table 29) , both the individual variance accounted for by each component as well as their cumulative contribution to the overall variance is presented. This information is presented under "Initial Eigenvalues."

To decide the number of components to be retained, four key criteria can be used. These are the eigenvalue-one criterion, the proportion of total variance accounted for, the scree plot test, and the interpretability criterion. The eigenvalue-one criterion is widely used as a popular approach for determining the optimal number of components to retain in PCA. An eigenvalue is a measure of the variance that is accounted for by a component. An eigenvalue less than one indicates that the component explains less variance that a variable would and hence shouldn't be retained.

After running the PCA on the MMI of cohort of entry of 2015, PCA revealed four components that had eigenvalues greater than one and which explained 19.470%, 16.863%, 15.091% and 13.899% of the total variance, respectively (Table 29). The four-component solution explained 65.324% of the total variance. Visual inspection of the scree plot indicated that four components should be retained. In addition, a four-component solution met the interpretability criterion. As such, four components were retained.

Table 29: Total variance explained (2015 MMI)

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**1.558**	**19.470**	19.470	1.558	19.470	19.470
2	**1.349**	**16.863**	36.333	1.349	16.863	36.333
3	**1.207**	**15.091**	51.425	1.207	15.091	51.425
4	**1.112**	**13.899**	65.324	1.112	13.899	**65.324**
5	0.896	11.200	76.524			
6	0.859	10.735	87.260			
7	0.581	7.268	94.528			
8	0.438	5.472	100.000			

The **Rotated Component Matrix** table (Table 30) shows how the retained, rotated components *load* on each variable. The presented table 30 shows a (simple structure) in which each variable (each MMI station) has only one component that loads strongly on it. Subsequently, a detailed evaluation of these components is carried out to gain understanding into the underlying reasons for the co-loading of variables (stations) under a certain component. This analysis aids in determining whether the stations effectively measure the intended construct. This helps us to decide if a reduction in the number of stations should be considered in cases where they appear to assess a similar construct or it helps us to determine if modifications are necessary to re-design the stations to measure what we intend to measure. This will be thoroughly discussed in the discussion chapter.

A Varimax rotation was employed to aid interpretability. The interpretation of the data showed strong loadings of presentation skills on Component 1, Ethics and professionalism skills items on Component 2, analytical and visual spacial awareness items on Component 3 and visuomotor skills on Component 4. Component loadings are presented in table 30.

Table 30: Rotated component matrix - 2015 MMI (Rotation Method: Varimax with Kaiser Normalization.)

	Component			
Variables (MMI Stations)	1	2	3	4
Presentation	0.814			
Data analysis and interpretation			0.330	
Ethics and professionalism		0.667		
Origami				0.423
Empathy and communication		0.623		
Insight			0.836	
Tangrams			0.654	
Observation and memory				0.765

4.2.2.2 MMI of entry of 2016

PCA revealed three components that had eigenvalues greater than one and which explained 22.422%, 18.805% and 14.405% of the total variance, respectively (Table 31). The three-component solution explained 55.632% of the total variance. Visual inspection of the scree plot indicated that three components should be retained. In addition, a three-component solution met the interpretability criterion. As such, three components were retained.

Table 31: Total variance explained (2016 MMI)

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**1.794**	**22.422**	22.422	1.794	22.422	22.422
2	**1.504**	**18.805**	41.227	1.504	18.805	41.227
3	**1.152**	**14.405**	55.632	1.152	14.405	**55.632**
4	.883	11.034	66.666			
5	.793	9.909	76.574			
6	.725	9.065	85.639			
7	.635	7.933	93.573			
8	.514	6.427	100.000			

A Varimax orthogonal rotation was employed to aid interpretability. The interpretation of the data showed that Ethics and professionalism items loading on Component 1, analytical and visuomotor skills on Component 2 and visual-spacial awareness on component 3. Component loadings are presented in table 32.

Table 32: Rotated matrix component 2016 MMI (Rotation Method: Varimax with Kaiser Normalization.)

	Component		
Variables (MMI stations)	1	2	3
Insight	0.771		
Ethics and professionalism	0.694		
Presentation	0.510		
Origami		0.795	
Communication		-0.576	
Data analysis and interpretation		0.518	
Tangrams			0.786
Observation and memory			0.765

4.2.2.3 MMI of entry of 2021

PCA revealed one component that had eigenvalues greater than one and which explained 36.371% of the total variance (Table 33). All items, which were all soft skills, loaded in Motivation and insight skills. Visual inspection of the scree plot indicated that one component should be retained. In addition, a one-component solution met the interpretability criterion. As such, one component was retained.

Table 33: Total variance explained (2021 MMI)

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**1.819**	**36.371**	**36.371**	1.819	36.371	**36.371**
2	0.883	17.665	54.036			
3	0.808	16.153	70.189			
4	0.785	15.695	85.884			
5	0.706	14.116	100.000			

4.2.2.4 MMI of entry of 2022

PCA revealed three components that had eigenvalues greater than one and which explained 24.039%, 21.453% and 20.901% of the total variance, respectively (Table 34). The three-component solution explained 66.392% of the total variance. Visual inspection of the scree plot indicated that three components should be retained. In addition, a three-component solution met the interpretability criterion. As such, three components were retained.

Table 34: Total variance explained (2022 MMI)

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**1.202**	**24.039**	24.039	1.202	24.039	24.039
2	**1.073**	**21.453**	45.492	1.073	21.453	45.492
3	**1.045**	**20.901**	66.392	1.045	20.901	**66.392**
4	0.968	19.360	85.752			
5	0.712	14.248	100.000			

A Varimax orthogonal rotation was employed to aid interpretability. The rotated solution exhibited loadings of self and social awareness items on Component 1, Motivation on Component 2, ethics and professionalism on Component 3. Component loadings of the rotated solution are presented in table 35

Table 35: Rotated matrix component 2022 MMI (Rotation Method: Varimax)

Variables (MMI stations)	Component		
	1	2	3
Resilience	0.815		
Social awareness	0.681		
Motivation		0.911	
Ethics			0.832
Professionalism			0.514

4.2.3 Assessment of the relationship between students' personal characteristics and their performance in the admission assessments

An independent-samples t-test and one-way analysis of variance to explore if a difference exists in admission assessment performance between gender groups, age groups, ethnicity groups, Access to Leeds and qualification level. This is an initial step in addressing our aim of assessing if the admission assessments are biased towards or against certain socio-demographic characteristics. However, to be able to assess if bias exists, this needs to be followed by further regression analysis and then assessing the association between students' personal characteristics and their performance in the in-course assessments. This will be explained gradually as we proceed in the analysis.

Independent samples t-tests were conducted for all independent variables with the exception of ethnicity, for which a one-way ANOVA was conducted.

The dependent variables included were:

- GSCE total score
- GSCE Maths score
- GSCE English score
- GSCE Science 1 score
- GSCE Science 2 score
- Level 3 score
- Total personal statement score
- Personal statement sub-scores
- Total BMAT score
- BMAT sections scores
- MMI total score
- MMI stations scores

4.2.3.1 Gender / univariate analysis

In 2015 cohort, there was no statistically significant difference in the admission assessments performance between females and males. However, in 2016 cohort, there was a statistically significant difference in mean score between males and females, with females mean score was 0.32 ± 0.15 and 0.41 ± 0.13 higher than males scores in MMI station 3 and station 5, respectively. In 2021 cohort, there was a statistically significant difference in mean score between males and females, with females mean score was 1.32 ± 0.49 and 0.43 ±0.09 higher than males scores in total GCSE scores and GCSE English score, respectively. See tables 36 and 37 for further details.

Table 36: Difference in the admission assessments performance between gender groups-Independent samples t-test (2015 & 2016 cohorts)

	Cohort 2015					Cohort 2016					
Variables with significant association	**Mean**	**Std deviation**	**t df**	**Mean difference**	**Sig 2-tailed**	**Variables with significant association**	**Mean**	**Std deviation**	**t df**	**Mean difference**	**Sig 2-tailed**
None were statistically significant						MMI Station 3 (Presentation)	Male 3.8 Female 4.1	0.15	2.06 78	0.32	0.04
						MMI Station 5 (Insight)	Male 3.9 Female 4.3	0.13	3.12 71.4	0.41	0.003

Table 37: Difference in the admission assessments performance between gender groups - Independent samples t-test (2021 & 2022 cohorts)

Cohort 2021						Cohort 2022					
Variables with significant association	**Mean**	**Std deviation**	**t** **df**	**Mean difference**	**Sig 2-tailed**	**Variables with significant association**	**Mean**	**Std deviation**	**t** **df**	**Mean difference**	**Sig 2-tailed**
Total GCSE score	Male 18.0696 Female 19.3940	0.49	2.6 297	1.32	0.008	Data of Gender is not available					
GCSE English	Male 2.0302 Female 2.4568	0.09	4.5 299	.43	0.000						

4.2.3.2 Maturity / univariate analysis

In 2015 cohort, there was a statistically significant difference in mean score between mature and school leaver participants, with mature mean score was 6.03 ± 3.06 and 3.37 ± 1.64 higher than school leaver participants' scores in total personal statement scores, Personal statement: life experience & social awareness score, respectively. On the other hand, investigating their performance in BMAT, there was a statistically significant difference in mean score between mature and school leaver participants, with school leaver participants' mean score was 2.67 ± 0.76 and 0.96 ± 0.28 higher than mature participants' BMAT total score and BMAT section 2 score, respectively.

In 2016 cohort, there was a statistically significant difference in mean score between mature and school leaver participants, with mature mean score was 6.15 ± 1.94, 1.5 ± 0.31 and 0.53 ± 0.105 higher than school leaver participants' scores in total personal statement scores, Personal statement: life experience & social awareness score and MMI communication station respectively. Further details are provided in table 38.

In cohort 2021, there was a statistically significant difference in mean score between mature and school leaver participants, with school leaver mean score was 0.444 ± 0.166, higher than mature participants' scores in BMAT section 1 score. On the other hand, there was a statistically significant difference in mean score between mature and school leaver participants, with mature mean score was 0.202 ± 0.08 higher than school leaver participants' scores in resilience MMI station. Further details can be found in table 39.

Table 38: Difference in the admission assessments performance between age groups - Independent samples t-test (2015 & 2016 cohorts)

	Cohort 2015					Cohort 2016					
Variables with significant association	**Mean**	**Std deviation**	**t df**	**Mean difference**	**Sig 2-tailed**	**Variables with significant association**	**Mean**	**Std deviation**	**t df**	**Mean difference**	**Sig 2-tailed**
Personal statement total score	Mature 53.2 School leaver 47.15	3.06	1.96 52	6.03	0.055	Personal statement total score	Mature 69 School leaver 62.9	1.94	3.1 68	6.15	0.002
Personal statement: life experience & social awareness	Mature 22.5 School leaver 19.13	1.64	2.05 52	3.37	0.045	Personal statement: life experience & social awareness	Mature 7.5 School leaver 6	0.31	4.8 68	1.5	0.000
BMAT total score	Mature 13.8 School leaver 16.6	0.76	3.52 52	2.67	0.001	MMI station 6 (communication)	Mature 4.9 School leaver 4.4	0.105	5.1 43	0.53	0.000
BMAT section 2	Mature 3 School leaver 4	0.28	-3.3 52	0.96	0.002						

Table 39: Difference in the admission assessments performance between age groups - Independent samples t-test (2021 & 2022 cohorts)

Cohort 2021						Cohort 2022					
Variables with significant association	**Mean**	**Std deviation**	**t** **df**	**Mean difference**	**Sig 2-tailed**	**Variables with significant association**	**Mean**	**Std deviation**	**t** **df**	**Mean difference**	**Sig 2-tailed**
BMAT section 1	Mature 3.92 School leaver 4.37	0.166	2.6 284	0.444	0.008	Age data is not available					
MMI Station 4 (resilience)	Mature 3.50 School leaver 3.29	0.08	2.53 19.9	0.202	0.02						

4.2.3.3 Access to Leeds eligibility / univariate analysis

In 2015 cohort, there was a statistically significant difference in mean score between eligible and non-eligible participants, with non-eligible participants mean score 5.73 ± 2.66, 3.60 ±1.37, 1.96 ± 0.87, 1.7 ± 0.7 and 0.68 ± 0.16 higher than eligible participants' scores in total personal statement scores, Personal statement: life experience & social awareness score, personal statement reflective skills, BMAT total score and BMAT section 2 score, respectively. On the other hand, there was a statistically significant difference in mean score between eligible and non-eligible participants, with eligible participants' mean score 0.88 ± 0.43, higher than non-eligible participants' in personal statement achievement & interests.

In 2016 cohort, there was a statistically significant difference in mean score between eligible and non-eligible participants, with non-eligible participants mean score 1.008 ± 0.41, 5.1 ± 0.12 and 1.72 ± 0.79 higher than eligible participants' scores in MMI station 4 and 6 and MMI total score, respectively. See table 40 for further details.

Table 40: Difference in the admission assessments performance between Access to Leeds eligible groups - Independent samples t-test (2015 & 2016 cohorts)

Cohort 2015						Cohort 2016					
Variables with significant association	**Mean**	**Std deviation**	**t df**	**Mean difference**	**Sig 2-tailed**	**Variables with significant association**	**Mean**	**Std deviation**	**t df**	**Mean difference**	**Sig 2-tailed**
Personal statement total score	Eligible 47.5 Not eligible 53.3	2.66	2.15 56	5.73	0.03	MMI station 4 (origami)	Eligible 4.5 Not eligible 5.5	0.41	2.4 76	1.008	0.01
						MMI station 6 (communication)	Eligible 4.4 Not eligible 4.8	0.12	4.2 45.8	5.1	0.000

Table 40: Difference in the admission assessments performance between Access to Leeds eligible groups - Independent samples t-test (2015 & 2016 cohorts), continued

Personal statement: life experience & social awareness	Eligible 19 Not eligible 22.6	1.37	2.6 57	3.60	0.01	MMI total station score	Eligible 33.5 Not eligible 35.5	0.79	2.2 76	1.72	0.03
Personal statement: Reflective skills	Eligible 11.57 Not eligible 13.54	0.87	2.2 56	1.96	0.029						
Personal statement: Achievement & interests	Eligible 4.2 Not eligible 3.3	0.43	2.02 56	0.88	0.049						
BMAT total score	Eligible 14.8 Not eligible 16.5	0.70	2.4 52	1.7	0.020						
BMAT section 2	Eligible 3.3 Not eligible 4	0.16	4.27 45.9	0.68	0.000						

In 2021 cohort, there was a statistically significant difference in mean score between eligible and non-eligible participants, with non-eligible participants mean score 1.18 ± 0.48, 0.48 ± 0.18, 0.17 ± 0.086 and 0.12 ± 0.06 higher than eligible participants' scores in total GCSE score, level 3 score, MMI station 1 and MMI station 4, respectively. Similarly in 2022 cohort, there was a statistically significant difference in mean score between eligible and non-eligible participants, with non-eligible participants mean score 1.9 ± 0.29 and 0.23 ± 0.1 higher than eligible participants' scores in level 3 score and BMAT section 1 score, respectively. See table 41 for further details.

Table 41: Difference in the admission assessments performance between Access to Leeds eligible groups - Independent samples t-test (2021 & 2022 cohorts)

Cohort 2021						Cohort 2022					
Variables with significant association	**Mean**	**Std deviation**	**t** **df**	**Mean difference**	**Sig 2-tailed**	**Variables with significant association**	**Mean**	**Std deviation**	**t** **df**	**Mean difference**	**Sig 2-tailed**
Total GCSE score	Eligible 18.23 Not eligible 19.41	0.48	2.44 297	1.18	0.01	Level 3 score	Eligible 5.7 Not eligible 7.6	0.29	6.5 174	1.9	0.000
Level 3 grade	Eligible 7.08 Not eligible 7.56	0.18	2.56 219.3	0.48	0.01	BMAT section 1	Eligible 3.7 Not eligible 3.9	0.1	2.2 344	0.23	0.03
MMI Station 1 (Motivation & insight)	Eligible 2.75 Not eligible 2.92	0.086	1.99 245	0.17	0.04						
MMI Station 4 (Resilience)	Eligible 3.24 Not eligible 3.36	0.06	2.07 245	0.12	0.04						

4.2.3.4 Qualification level / univariate analysis

In 2015 cohort, there was a statistically significant difference in mean score between the two groups participants, with participants holding an A level or equivalent qualification mean score 0.63 ± 0.15 and 1.46 ± 0.48 higher than participants' holding a degree in BMAT section 2 and BMAT total score, respectively.

In 2016 cohort, there was a statistically significant difference in mean score between the two groups participants, with participants holding an A level or equivalent mean score 1.17 ± 0.29, 1.14 ± 0.37 and 5.48 ± 1.74 lower than participants holding a degree in personal statement life experience and social awareness and personal statement total score, respectively. See table 42 for further details.

Table 42: Difference in the admission assessments performance between groups of different qualification levels - Independent samples t-test (2015 & 2016 cohorts)

Cohort 2015						Cohort 2016					
Variables with significant association	**Mean**	**Std deviation**	**t df**	**Mean difference**	**Sig 2-tailed**	**Variables with significant association**	**Mean**	**Std deviation**	**t df**	**Mean difference**	**Sig 2-tailed**
BMAT section 2	A level/equivalent 3.96 Degree 3.3	0.15	4.12 33.2	0.63	0.000	Personal statement life experience and social awareness	A level 5.9 Degree 7.2	0.29	3.9 67	1.17	0.000
BMAT total score	A level/equivalent 16.34 Degree 14.88	0.48	3.01 19.04	1.46	0.007	Personal statement total score	A level 62.6 Degree 68	1.74	3.1 67	5.48	0.002

In 2021 cohort, there was a statistically significant difference in mean score between the two groups participants, with participants holding an A level or equivalent qualification mean score of 0.46 ± 0.17 higher than participants' holding a degree, in BMAT section 1.

In 2022 cohort, there was a statistically significant difference in mean score between the two groups participants, with participants holding an A level or equivalent qualification mean score of 0.51 ± 0.16 higher than participants' holding a degree, BMAT section 2 score. See table 43 for further details.

Table 43: Difference in the admission assessments performance between groups of different qualification levels - Independent samples t-test (2021 & 2022 cohorts)

Cohort 2021						**Cohort 2022**					
Variables with significant association	**Mean**	**Std deviation**	**t df**	**Mean difference**	**Sig 2-tailed**	**Variables with significant association**	**Mean**	**Std difference**	**t df**	**Mean difference**	**Sig 2-tailed**
BMAT Section 1	A level/equivalent 4.36 Degree 3.91	0.17	2.6 284	0.46	0.009	**BMAT section 2**	A level/ equivalent 3.7 Degree 3.2	0.16	3.2 344	0.51	0.002

4.2.3.5 Ethnicity / univariate analysis

In 2015, results of the ANOVA showed a significant difference between ethnic groups in BMAT section 1, section 3 and total score, in addition to MMI stations 6 and 7. In 2015 cohort, post-hoc analysis revealed that Asian British Pakistani had significantly lower scores than white and Asian other categories. However, this was in relation to the BMAT scoring only. In the MMI performance, Asian British Pakistani scored significantly higher on the data analysis and interpretation station compared to white candidates. In 2016 cohort, results of the ANOVA showed a significant difference between ethnic groups in MMI total score and MMI station 2, 5 and 7. Post-hoc analysis revealed that Asian other ethnic group has significantly lower scores than white, Asian British Pakistani, Asian British Indian and Asian Chinese. However, they performed higher than ethnic group of other mixed backgrounds. See table 44 for further details.

Table 44: Difference in the admission assessments performance between ethnic groups - Independent samples t-test (2015 & 2016 cohorts)

Cohort 2015			Cohort 2016		
Variables with significant association	**Sig between groups**	**Sig between variables**	**Variables with significant association**	**Sig between groups**	**Sig between variables**
BMAT section 2	p=0.03 F (6,45) = 2.5	White*Asian British Pakistani (p=0.04, M=0.52) Asian Other* Asian British Pakistani (p=0.05, M=0.49)	MMI station 2 (Ethics and professionalism)	p=0.05 F (6,73) = 2.2	White*Asian other (p=0.05, M=0.63)

Table 44: Difference in the admission assessments performance between ethnic groups - Independent samples t-test (2015 & 2016 cohorts), continued

BMAT section 3	p=0.001 F (6,45) = 4.7	White*Asian British Pakistani (p=0.05, M=0.67) Asian Other* Asian British Pakistani (p=05, M=0.71)	MMI station 5 (Insight)	p=0.01 F (6,73) = 3	Asian British Pakistani*Asian other (p=0.03, M=0.83)
BMAT total score	p=0.001 F= (6,45) = 4.4	White*Asian British Pakistani (p=0.01, M=0.79) Asian Other* Asian British Pakistani (p=0.03, M=0.66)	MMI station 7 (Data analysis and interpretation)	p=0.003 F (6,73) = 3.6	White*Asian other (p= 0.004 Asian British Indian*Asian other (p=0.000, M=0.99) Asian British Pakistani*Asian other (p=0.05, M=1.3)
MMI station 6 (Empathy and communication)	p=0.000 F (6,47) = 6.9	White*Asian British Indian (p=0.05, M=0.19)	MMI total score	P=0.000 F (6,73) = 6.6	White*Asian other (p=0.000, M=4.8) Asian British Indian*Asian other (p=0.001, M=4.1) Asian British Pakistani*Asian other (p=0.000, M=5.1)

Table 44: Difference in the admission assessments performance between ethnic groups - Independent samples t-test (2015 & 2016 cohorts), continued

					Asian Chinese*Asian other (p=0.035, M=4.7) Other mixed background*Asian other (p=0.019, M=-5.07)
MMI station 7 (Data analysis and interpretation)	p=0.04 F (6,47) = 2.3	Asian British Pakistani * White (p=0.05, M=0.29)			

Following the univariate analysis, series of fourteen multiple regressions were carried out to analyse whether the personal characteristics of applicants/students predicted their performance in any of the admission assessments. See table (45) for full details of the variables considered in each model. For each model, assumptions of multiple regression were assessed. There was linearity as assessed by partial regression plots and a plot of studentized residuals against the predicted values. There was independence of residuals, as assessed by a Durbin-Watson statistics. There was homoscedasticity as assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.1. There were no studentized deleted residuals greater than ± 3 standard deviations, no leverage values greater than 0.2, and values for Cook's distance above 1. The assumption of normality was met as assessed by Q-Q plot.

Table 45: Variables used in the multiple regressions (personal characteristics predictive validity of applicants' admission assessments performance

<table>
<tr><th>Multiple regression</th><th>Cohort</th><th>Dependent variable</th><th colspan="2">Independent variables</th></tr>
<tr><td>1</td><td rowspan="3">2015
&
2016</td><td>Total personal statement score</td><td colspan="2" rowspan="3">Gender
Access to Leeds eligibility
Maturity
Qualification level
Ethnicity</td></tr>
<tr><td>2</td><td>Total BMAT score</td></tr>
<tr><td>3</td><td>Total MMI score</td></tr>
<tr><td colspan="3" rowspan="2"></td><td colspan="2">Subject to data availability</td></tr>
<tr><td>2021</td><td>2022</td></tr>
<tr><td>1</td><td rowspan="4">2021
&
2022</td><td>Total GCSE score</td><td rowspan="2">Gender
A2L eligibility</td><td rowspan="2">A2L eligibility</td></tr>
<tr><td>2</td><td>Level 3 score</td></tr>
<tr><td>3</td><td>Total BMAT score</td><td rowspan="2">Gender
A2L eligibility
Maturity
Qualification level</td><td rowspan="2">Qualification level</td></tr>
<tr><td>4</td><td>Total MMI score</td></tr>
</table>

4.2.3.6 Total GCSE / multivariate regression

2021 regression model

The model was statistically significant. R square=0.245, F (2,295) =6.936, p=0.001, Adjusted R square= 0.176. This means that the addition of all independent variables into the regression model explained 17.6% of the variability of the total GCSE score. Looking at the coefficients, found that the slope coefficients were statistically significant for gender and Access to Leeds eligibility. The predicted GCSE score for females is 1.400 greater than that predicted for males (p=.004) and it is 0.899 less for an Access to Leeds eligible applicant than a non-eligible student. (p=0.019)

2022 regression model

The model was statistically significant. R square=0.216, F (1,382) = 4.584, p=0.03, Adjusted R square= 0.105. This means that the addition of all independent variables into the regression model explained 10.5% of the variability of the total GCSE score. Looking at the coefficients, it was found that the slope coefficients were statistically significant for Access to Leeds eligibility. The predicted GCSE score for is 1.257 less for an Access to Leeds eligible applicant than a non-eligible student (p=0.03)

4.2.3.7 Level 3 / multivariate analysis

2021 regression model

The model was statistically significant. R square= 0.025, F (2,297) = 3.848, p=0.02, Adjusted R square= 0.019. This means that the addition of all independent variables into the regression model explained 1.9% of the variability of the total Level 3 score. Looking at the coefficients, it was found that the slope coefficients were statistically significant for Access to Leeds eligibility. The predicted level 3 score for an Access to Leeds eligible applicant was 0.490 less than that of non-eligible one (p=0.007)

2022 regression model

The model was statistically significant. R square= 0.139, F (1,346) = 56.008, p=0.000, Adjusted R square= 0.137. This means that the addition of all independent variables into the regression model explained 13.7% of the variability of the total Level 3 score. Looking at the coefficients, it was found that the slope coefficients were statistically significant for Access to Leeds eligibility. The predicted level 3 score for an Access to Leeds eligible applicant was 1.911 less than that of non-eligible one (p=0.000)

4.2.3.8 Total personal statement score / multivariate analysis

2015 regression model

The model was not statistically significant. R square 0.208, F (6,46) = 2.018, p=0.082, Adjusted R square 0.105. This means that the addition of all independent variables into the regression model explained 10.5% of the variability of the total personal statement score. Looking at the coefficients, there was no statistically significant coefficient.

2016 regression model

The model was statistically significant. R square= 0.185, F (6,61) =2.313, p=0.045, Adjusted R square=0.105. This means that the addition of all independent variables into the regression model explained 10.5% of the variability of the total personal statement score. Looking at the coefficients, there was no statistically significant coefficient.

4.2.3.9 Total BMAT score / multivariate analysis

2015 regression model

The model was statistically significant. R square= 0.4, F (6,46) =5.104, p=0.000, Adjusted R square=0.321. This means that the addition of all independent variables into the regression model explained 32.1% of the variability of the total BMAT score. Looking at the coefficients, it was found that maturity and ethnicity had statistically significant coefficients, with school leaver participants having 2.96 greater predicted BMAT score in comparison to mature students (p=0.02) and non-white ethnic group scoring 0.312 less in the predicted BMAT score.

2016 regression model

The model was statistically significant. R square=0.216, F (6,23) =0.802, p=0.03, Adjusted R square= 0.115. This means that the addition of all independent variables into the regression model explained 11.5% of the variability of the total BMAT score. Looking at the coefficients, it was found that none of the variables had statistically significant coefficients.

2021 regression model

The model was not statistically significant. R square=0.314, F (994) = 0.984, p=0.05, Adjusted R square= 0.119. According to the adjusted R square, the addition of all independent variables into the regression model did not explain 11.9% of the variability of the total BMAT score. However, looking at the coefficients, it was found that none of the coefficients reached a statistically significant value.

2022 regression model

The model was statistically significant. R square=0.302, F (2,393) = 2.157, p=0.015, Adjusted R square= 0.229. This means that the addition of all independent variables into the regression model explained 22.9% of the variability of the total BMAT score. Looking at the coefficients, it was found that qualification level had statistically significant coefficient with a student with a degree having a 1.805 score less than a student with an A level qualification only. (p=0.04)

4.2.3.10 Total MMI score / multivariate analysis

2015 regression model

The model was statistically significant. R square= 0.169, F (6,44) =1.481, p=0.034, Adjusted R square=0.155. This means that the addition of all independent variables into the regression model explained 15.5% of the variability of the total MMI score. Looking at the coefficients, it was found that the qualification level had statistically significant coefficients, with students with a degree qualification scoring 4.37 higher than students with A level or equivalent qualification. (p= 0.027)

2016 regression model

The model was not statistically significant. R square= 0.139, F (6,61) = 0.049, p=0.863, Adjusted R square= 0.107 This means that the addition of all independent variables into the regression model explained 10.7% of the variability of the total MMI score. Looking at the coefficients, it was found that none of the coefficients was statistically significant.

2021 regression model

The model was statistically significant. R square= 0.126, F (4,239) = 2.477, p= 0.031, Adjusted R square= 0.102. This means that the addition of all independent variables into the regression model explained 10.2% of the variability of the total MMI score. Looking at the coefficients, it was found that none of the coefficients reached a statistically significant value.

2022 regression model

The model was not statistically significant. R square=0.012, F (2,186) = 1.137, p=0.32, Adjusted R square= 0.001. This means that the addition of all independent variables into the regression model explained .1% of the variability of the total MMI score. Looking at the coefficients, it was found that none of the variables reached a statistically significant value.

Summary of the findings of assessment of the relationship between students' personal characteristics and their performance in the admission assessments:

A) **Univariate analysis**

Gender:

Where a statistically significant difference was noted between genders, females mean score was higher than males in total GCSE, GCSE English, MMI presentation station and MMI insight station.

Maturity:

Where a statistically significant difference was noted between mature and school leaver participants, mature mean score was higher in total personal statement, Personal statement: life experience & social awareness, MMI communication station and MMI resilience station.

However, they had a lower mean score in BMAT total score, BMAT section 1 and BMAT section 2 scores.

Access to Leeds eligibility:

Where a statistically significant difference was noted between A2L eligible and non-eligible participants, non-eligible participants had higher mean scores in total GCSE score, level 3 score, total personal statement, Personal statement: life experience & social awareness, personal statement reflective skills, BMAT total score, BMAT section 1 score, BMAT section 2 score, MMI origami station, MMI communication station, MMI resilience station, MMI motivation & insight station and MMI total score.

However, they had lower mean score in Personal statement: Achievement & interests.

Qualification level:

Where a statistically significant difference was noted between degree holders and A level or equivalent qualification holders, A level or equivalent qualification holders had higher mean score in BMAT section 1, BMAT section 2 and BMAT total score.

However, they had lower mean scores in personal statement life experience and social awareness and personal statement total score.

Ethnicity:

Results of the ANOVA showed a significant difference between ethnic groups in BMAT section 1, section 3 and total score, in addition to MMI stations: Ethics and professionalism, Insight, Empathy and communication, Data analysis and interpretation and MMI total score. Post-hoc analysis revealed different performance between different ethnic groups as detailed previously.

Continued: Summary of the findings of assessment of the relationship between students' personal characteristics and their performance in the admission assessments:

B) Multivariate regression analysis

Characteristic	**What did it significantly predict?**
Gender	Total GCSE score (Females higher)
Maturity	Total BMAT score (School leavers higher)
A2L eligibility	Total GCSE score (non-eligible higher)
	Level 3 score (non-eligible higher)
Qualification level	Total BMAT score (Degree holders lower)
	Total MMI score (Degree holders higher)
Ethnicity	Total BMAT score (Non-white ethnicity lower)

4.3 Section 3: Predictive validity of admission variables

This section presents the findings in regard to the admission variables' predictive validity. Separate analyses were undertaken for the 2015 and 2016 cohorts. The analysis findings will be reported under each title to the 2015 cohort, followed by the 2016 cohort's findings. This section will begin with presenting the results of the univariate analysis followed by the results of the multivariate analysis. When regression was statistically inappropriate, such as in the assessment of risk of failure and professionalism breaches, univariate analysis was performed. The sequence of the reporting is briefly outlined in figure 12 that follows.

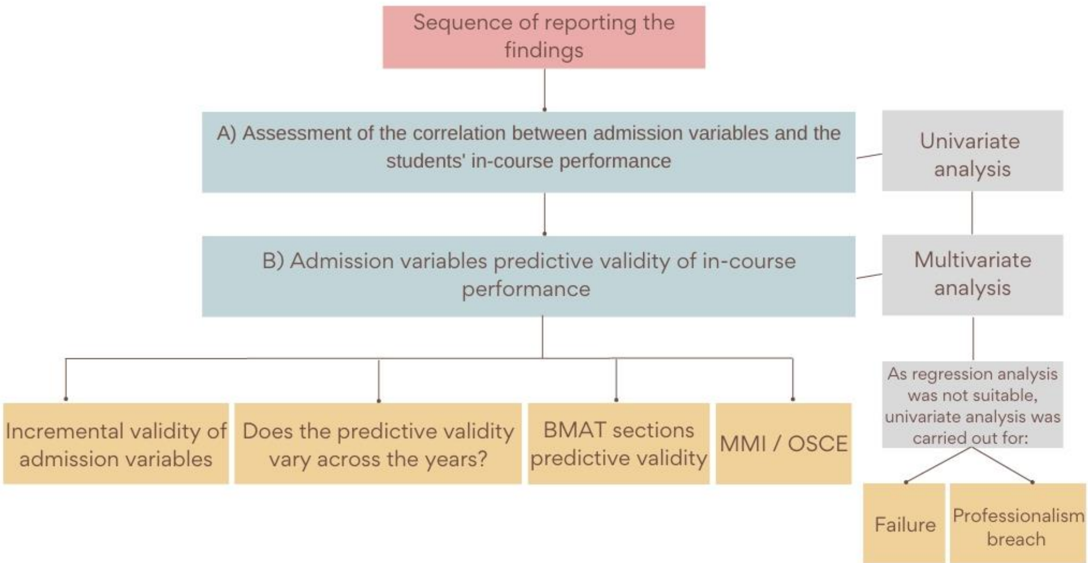


Figure 12: Stages of the third section of results reporting

4.3.1 Is there a correlation between admission variables and students' in-course performance? (Univariate analysis)

A Pearson's product-moment correlation was run to assess the relationship between the admission assessments and in-course academic and clinical performance scores. This was carried out for each cohort separately. Preliminary analyses showed the relationship to be linear with variables normally distributed, as assessed by Shapiro-Wilk's test ($p>.05$), and there were no outliers. The variables included:

- Personal statement total scores and sub-scores
- BMAT total scores and sections scores
- MMI total scores, components scores and examiner perception scores
- Clinical practice total score
- Each year clinical practice score
- Total academic score
- Average score of each year's academic performance
- 3rd and 4th years OSCE total scores
- Averages of communication stations score, procedure stations scores and fine motor stations score & gross motor stations scores.

There were multiple correlations found between admission assessments and in-course scores. The correlations that were determined to be statistically significant will be reported below as well as in tables 45, 46 and 47.

In both 2015 and 2016 cohorts, total personal statement score had no statistically significant correlation with any of the in-course scores listed above. However, there were multiple significant correlation between the personal statement sub-scores and in-course assessments (table 46). For example, scores of life experience and social awareness, had a statistically significant, small, negative correlation with 3rd year OSCE average of procedure stations in 2015 cohort. However, no significant correlations were found in 2016 cohort. Motivation and insight score showed a statistically significant, small, negative correlation with 3rd year OSCE average of gross motor stations score. In 2016, no significant correlation was found. On the other hand, reflective skills score showed a statistically significant, positive, low correlation with both average of 4th year OSCE procedure and gross motor stations scores while no significant correlation was seen in 2015 cohort. In both 2015 and 2016 cohorts, interests and achievement score showed a statistically significant, positive, low to moderate correlation with average of academic modules score of year 5 and 4, respectively.

BMAT scores showed multiple correlations with students' in-course performance. This varied between clinical and academic aspects of the course; however, the statistically significant correlations were only found in 2015 cohort. These are presented in detail in table 47 and summarized in the paragraphs below.

BMAT total score and all sections score has significantly positive correlations with total clinical practice score as well as yearly clinical practice scores of 3^{rd}, 4^{th} and 5^{th} year. Similarly, they all correlated positively with total OSCE scores of 3^{rd} and 4^{th} years of the course except for BMAT section 2 which a statistically significant correlation with only total OSCE score of 3^{rd} year. In addition, BMAT total and all sections scores e has significantly positive correlations with average of communication stations scores of 3^{rd} and 4^{th} year OSCE except for BMAT section 2 which correlated with the average of communication stations score of 3^{rd} year OSCE only. Moreover, BMAT total score, section 1 score and section 2 score significantly correlated positively with average of procedure stations and average of fine motor station of 3^{rd} year OSCE. As for correlations with academic performance, total BMAT score had a significantly positive correlation with 2^{nd} and 3^{rd} academic modules average score while BMAT sections 1 and 2 correlated significantly with 3^{rd} and 2^{nd} year of the course, respectively. These correlations were all positive and ranged between small to moderate.

As for MMI, when assessing the MMI correlations with in-course performance, the correlations varied between small to moderate correlations with various aspects of the course. For instance, there were multiple correlations with CP scores of 3^{rd}, 4^{th} and 5^{th} years of the course as well as academic scores of 2^{nd} to 4^{th} years of the course. In addition, multiple correlations were noted with 3^{rd} and 4^{th} year OSCE total scores and averages of procedure, communication, gross motor and fine motor OSCE stations scores. For details of the correlation coefficients, see table 48.

Table 46: Correlation between personal statement scores and in-course performance (2015 & 2016 cohorts)

Admission assessment	Correlation details					
	Cohort 2015			Cohort 2016		
Personal statement total score	None			None		
Personal statement-Life experience & social awareness	3rd year OSCE average of procedure stations	Negative p=0.04	Small r =0.27	None		
Personal statement Motivation and insight	3rd year OSCE average of gross motor stations	Negative p=0.04	Small r =0.26	None		
Personal statement Reflective skills	None			4th year OSCE average of procedure stations	Positive p=0.02	Small r =0.30
				4th year OSCE average of gross motor skills stations	Positive p=0.01	Moderate r =0.33
Personal statement Interests & achievement	Y5 Average of academic modules	Positive p=0.02	Moderate r=0.33	Y4 academic modules average	Positive p= 0.02	Small r =0.28

Table 47: Correlation between BMAT scores and in-course performance (2015 & 2016 cohorts)

Admission assessment	Correlation details						
	Cohort 2015						Cohort 2016
BMAT total score	**Total CPs score**	Positive p=0.001	Moderate r = 0.48	**3rd year OSCE average of procedure stations**	Positive p=0.000	Moderate r=0.48	None
	CP 3 total	Positive p=0.000	Moderate r =0.49	**3rd year OSCE average of gross motor stations**	Positive p=0.015	Moderate r=0.33	
	CP4 total	Positive p=0.000	Moderate r = 0.51	**3rd year OSCE average of fine motor stations**	Positive p=0.001	Moderate r=0.44	
	CP5 total	Positive p=0.006	Moderate r = 0.41	**4th year OSCE total score**	Positive p=0.001	Moderate r=0.45	
	3rd year OSCE total score	Positive p=0.001	Moderate r = 0.46	**-Y2 modules scores average**	Positive p=0.005	Moderate r = 0.40	
	3rd year OSCE average of communication stations	Positive P=0.001	Moderate r = 0.47	**4th year OSCE average of communication stations score**	Positive p=0.000	Moderate r =0.47	
				Y3 modules scores average	Positive p=0.007	Moderate r = 0.38	

Table 47: Correlation between BMAT scores and in-course performance (2015 & 2016 cohorts), continued

BMAT section 1	**Total CP score**	Positive p=0.03	Moderate r= 0.31	**3rd year OSCE average of communication stations score**	Positive p=0.03	Small r= 0.29	None
	CP3 total	Positive p=0.03	Small r=0.30	**3rd year OSCE average of procedure stations score**	Positive p=0.005	Moderate r= 0.38	
	CP4 total	Positive p=0.01	Moderate r=0.37	**3rd year OSCE average of fine motor stations score**	Positive p=0.008	Moderate r= 0.36	
	Y3 academic modules average	Positive p=0.02	Small r=0.30	**4th year OSCE Total score**	Positive p=0.01	Moderate r= 0.33	
	Y3 total OSCE score	Positive p=0.006	Moderate r=0.37	**4th year OSCE average of communication stations score**	Positive p= 0.01	Moderate r= 0.34	
BMAT section 2	**Total CP score**	Positive p=0.01	Moderate r=0.36	**3rd year OSCE total score**	Positive p= 0.002	Moderate r=0.42	None
	CP3 total score	Positive p=0.02	Moderate r=0.32	**3rd year OSCE average of communication stations score**	Positive p=0.02	Moderate r=0.32	
	CP4 total score	Positive p=0.02	Moderate r=0.33	**3rd year OSCE average of procedure stations score**	Positive p=0.001	Moderate r=0.45	
	CP5 total score	Positive p=0.02	Moderate r=0.33	**3rd year OSCE average of fine motor stations score**	Positive p=0.001	Moderate r=0.45	

Table 47: Correlation between BMAT scores and in-course performance (2015 & 2016 cohorts), continued

	Y2 average of academic modules	Positive p=0.003	Moderate r=0.41				
BMAT section 3	**CP3 total score**	Positive p=0.002	Moderate r=0.43	**3rd year OSCE average of communication stations score**	Positive p=0.002	Moderate r=0.413	None
	CP4 Total score	Positive p=0.006	Moderate r=0.404	**4th year OSCE total score**	Positive p=0.02	Moderate r=0.32	
	CP5 total score	Positive p=0.01	Moderate r=0.36	**4th year OSCE average of communication stations score**	Positive p=0.008	Moderate r=0.36	
	Total CP scores	Positive p=0.004	Moderate r=0.41				
	3rd year OSCE total score	Positive p=0.02	Moderate r=0.304				

Table 48: Correlation between MMI scores and in-course performance (2015 & 2016 cohorts)

Admission assessment	Correlation details					
	Cohort 2015			Cohort 2016		
MMI total score	Total CP score	Positive p=0.007	Moderate r= 0.37	CP5 total score	Positive p= 0.007	Moderate r =0.30
	Y2 modules average score	Positive p=0.03	Small r= 0.28	Total CP score	Positive p=0.006	Moderate r =0.31
	Y3 modules average score	Positive p=0.008	Moderate r= 0.35	Y2 modules average score	Positive p=0.02	Small r =0.25
	CP 3 total score	Positive p=0.01	Moderate r= 0.32	4th year OSCE total score	Positive p=0.01	Moderate r =0.31
	CP 4 total score	Positive p=0.003	Moderate r =0.405	4th year OSCE communication stations average score	Positive p=0.01	Moderate r =0.31
	4th year OSCE total score	Positive p=0.01	Moderate r= 0.31			
	4th year OSCE average communication stations score	Positive p=0.01	Moderate r=0.33			
MMI component 1	None			Y4 academic modules average	Positive p=0.04	Small r =0.23
				3rd year OSCE communication stations average score	Positive p=0.01	Moderate r =0.31

Table 48: Correlation between MMI scores and in-course performance (2015 & 2016 cohorts), continued

				3rd year OSCE average of Procedure stations average score	Negative p=0.04	Small r =0.24
				3rd year OSCE average of fine motor stations average score	Negative p=0.03	Small r =0.25
MMI component 2	CP3 total	Positive p=0.000	Moderate r=0.502	CP5 total score	Positive p=0.02	Small r =0.25
	CP4 total	Positive p=0.000	Moderate r=0.47	Total score of CP	Positive p=0.007	Small r =0.30
	CP5 total	Positive p=0.01	Moderate r=0.34	Y2 academic modules average score	Positive p=0.002	Moderate r =0.33
	Total CP score	Positive p=0.000	Moderate r=0.52			
	Y2 modules average score	Positive p=0.03	Small r=0.28			
	Y3 module average score	Positive p=0.01	Moderate r=0.33			
	Y5 module average score	Positive p=0.04	Small r=0.29			
	3rd year OSCE total score	Positive p=0.004	Moderate r=0.36			

Table 48: Correlation between MMI scores and in-course performance (2015 & 2016 cohorts), continued

	3rd year OSCE average of communication stations score	Positive p=0.000	Moderate r=0.44	
	3rd year OSCE average of procedure stations score	Positive p=0.03	Small r=0.27	
	3rd year OSCE average of gross motor stations score	Positive p=0.03	Small r=0.27	
	4th year OSCE total score	Positive p=0.001	Moderate r=0.41	
	3rd year OSCE average of communication stations score	Positive p=0.000	Moderate r=0.52	
MMI component 3	None			None
MMI component 4	CP4 Total	Positive p=0.05	Small r=0.27	Not applicable
	Y2 average academic modules score	Positive p=0.03	Small r=0.28	
	Y3 average academic modules score	Positive p=0.01	Moderate r=0.32	
	4th year OSCE total score	Positive p=0.03	Small r=0.28	

Table 48: Correlation between MMI scores and in-course performance (2015 & 2016 cohorts), continued

	4th year OSCE average of fine motor stations score	Positive p=0.01	Moderate r=0.32	
MMI examiners' perception score	CP3 total	Positive p=0.001	Moderate r=0.42	Data was not provided
	CP4 total	Positive p=0.000	Moderate r=0.52	
	Total CP scores	Positive p=0.001	Moderate r=0.439	
	Y2 academic modules average score	Positive p=0.01	Moderate r=0.33	
	Y3 academic modules average	Positive p=0.003	Moderate r=0.38	
	3rd year OSCE average of communication stations score	Positive p=0.01	Moderate r=0.31	
	4th year OSCE total score	Positive p=0.001	Moderate r=0.41	
	4th year OSCE average of communication stations score	Positive p=0.001	Moderate r=0.43	
	4th year OSCE average of procedure stations score	Positive p=0.01	Moderate r=0.33	

Table 48: Correlation between MMI scores and in-course performance (2015 & 2016 cohorts), continued

	4th year OSCE average of gross motor stations score	Positive p= 0.02	Small r=0.29	
	4th year OSCE average of fine motor stations score	Positive p=0.03	Small r=0.27	

An independent-samples t-test and one-way analysis of variance were also run to explore if a difference exists in in-course performance between gender groups, age groups, ethnicity groups, Access to Leeds and qualification level. Except for the ethnicity variable, other independent variables consisted of two groups, such as male/female, mature/school leaver, eligible/not eligible, and A level or equivalent/degree. Therefore, independent samples t-tests were conducted for all independent variables with the exception of ethnicity, for which a one-way ANOVA was conducted. Conducting this analysis is a necessary initial step for assessing the predictive validity through univariate tests, which explore the differences between the groups. This will be followed by multivariate tests to determine whether these variables actually predict students' in-course performance. Moreover, by integrating these findings with the previous results regarding the association between personal characteristics and admission assessments performance , it could become possible to determine if bias exists in any of the admission assessments. Integrating these findings will be discussed in the discussion chapter.

The dependent variables included were:

- Clinical practice total score
- Each year clinical practice score
- Total academic score
- Average score of each year's academic performance
- 3rd and 4th year OSCE total scores
- Averages of 3rd and 4th year OSCE communication stations scores, procedure stations scores and fine motor stations scores & gross motor stations scores.

Statistically significant differences are summarized in the tables (48-51).

Gender

In both 2015 and 2016 cohorts, there was statistically significant difference in both clinical, academic and OSCE scores with females performing higher than males in all. Mean differences between the groups are summarized in the table 49 below.

Table 49: Difference in the in-course performance between gender groups – Independent samples t-test (2015 & 2016 cohorts)

Cohort 2015						Cohort 2016					
Variables	**Mean**	**Std. Deviation**	**t df**	**Mean difference**	**Sig**	**Variables**	**Mean**	**Std. Deviation**	**t df**	**Mean difference**	**Sig**
CP4	Males 66 Females 72	2.1	2.8 46	5.8	0.008	CP1 total score	Males 55.8 Females 62	2.12	2.9 82	6.28	0.004
Total CP score	Males 306.8 Females 322	7.5	2 46	15.2	0.05	CP3 total score	Males 55.6 Females 58.8	1.55	2.03 81	3.15	0.04
Y5 modules average score	Males 62.8 Females 68	1.9	2.8 42	5.27	0.007	Total CPs score	Males 303 Females 315	5.1	2.4 79	12.39	0.01
Total 4th year OSCE score	Males 510.5 Females 550.3	13.3	3 19.75	40.26	0.007	Y3 academic modules average score	Males 66 Females 71.2	1.8	2.9 82	5.2	0.005
OSCE 4 average of communication stations score	Males 28.6 Females 31.1	0.9	2.7 19.47	2.5	0.01						

Table 49: Difference in the in-course performance between gender groups – Independent samples t-test (2015 & 2016 cohorts), continued

OSCE 4 average of procedure stations score	Males 32.6 Females 34.97	0.7	3.2 554	2.3	0.00 2						
OSCE 4 average of gross motor stations score	Males 28.2 Females 31.5	1.07	3 54	3.3	0.00 3						

Maturity

In both cohorts, there was no statistically significant difference between mature and school leaver students in clinical or academic performance measures assessed in this analysis.

Qualification level

In 2015 cohort, there was no statistically significant difference in both clinical and academic performance between students holding a degree or an A level or equivalent qualification. However, in 2016 cohort, there was a statistically significant difference between the groups with students holding a degree performing higher than the other in CP1. Mean differences between the groups are summarized below in table 50.

Table 50: Difference in in-course performance between groups of different qualification levels-Independent samples t-test(2015 & 2016 cohorts)

Cohort 2015						Cohort 2016					
Variables with significant difference	**Mean**	**Std. Deviation**	**t df**	**Mean difference**	**Sig 2-tailed**	**Variables with significant difference**	**Mean**	**Std. Deviation**	**t df**	**Mean difference**	**Sig 2-tailed**
No statistically significant difference was found						CP1 total score	A level 58.75 Degree 65	2.9	2.1 66	6.25	0.04

Access to Leeds eligibility

In 2015 cohort, there was a statistically significant difference between A2L eligible and non-eligible groups in clinical and academic measures as summarized the table below with eligible group performing lower than the other group. However, in 2016 cohort, this difference was statistically significant in clinical performance only. Mean difference values are summarized in the table 51 below.

Table 51: Difference in the in-course performance between Access to Leeds eligible groups-Independent samples t-test (2015 & 2016 cohorts)

Cohort 2015						Cohort 2016					
Variables with significant difference	**Mean**	**Std. Deviation**	**t df**	**Mean difference**	**Sig (2-taile)**	**Variables with significant difference**	**Mean**	**Std. Deviation**	**t df**	**Mean difference**	**Sig (2-taile)**
Y 2 modules averages	Eligible 61.30 Not eligible 66.37	2.14	2.4 49	5.07	0.02	CP1 total score	Eligible 54.1 Not eligible 61.2	2.7	2.6 82	7.07	0.01
Y 3 modules averages	Eligible 65.27 Not eligible 69.36	1.9	2.1 49	4.09	0.03	CP4 total score	Eligible 66.48 Not eligible 70.65	1.9	2.2 80	4.2	0.03
OSCE 3 average of gross motor stations score	Eligible 22.09 Not eligible 24.39	0.74	3.1 55	2.3	0.003						
OSCE 4 average of procedure stations score	Eligible 31.8 Not eligible 32.8	0.85	2.06 54	1.8	0.04						
Total OSCE 4 score	Eligible 516 Not eligible 544.8	13.01	2.2 53	28.6	0.03						

Ethnicity

In 2015, results of the ANOVA showed a significant difference between ethnic groups in multiple clinical practise and OSCE scores, in addition to academic modules average score of 2nd year. Post-hoc analysis revealed that Asian Chinese ethnic group has significantly lower scores than Asian British Indian and Asian other in clinical practise and OSCE scores. On the other hand, white students scored significantly higher than multiple ethnic groups in 2nd year academic performance and 3rd & 4th years OSCE scores. In 2016 cohort, results of the ANOVA showed a significant difference between ethnic groups in average of procedure and fine motor stations score of 3rd year OSCE. Post-hoc analysis revealed that Asian Chinese ethnic group has significantly lower scores than Asian British Indian, Asian British and Asian other. Details are provided in table 52 below.

Table 52: Difference in the in-course performance between ethnic groups– One way ANOVA with post hoc (2015 & 2016 cohorts)

Cohort 2015			Cohort 2016		
Variables with significant difference	**Sig between groups**	**Sig between groups**	**Variables with significant difference**	**Sig between groups**	**Sig between groups**
CP3 score	p=0.003 F (6,42) = 3.9	Asian other * Asian Chinese (p=0.03, M= 4.1)	Average of procedure stations score of 3rd year OSCE	p=0.02 F (6,66) = 2.5	Asian other*Asian Chinese (p=0.07, M=4.6)
CP4 score	p=0.05 F (6,39) = 2.3	Asian British Indian * Asian Chinese (p=0.01, M= 5.1)	Average of fine motor stations score of 3rd year OSCE	p=0.010 F (6,66) = 3.1	Asian British Indian*Asian Chinese (p=0.01, M=5.5) Asian British Pakistani*Asian Chinese (p=0.04, M=5.1) Asian other*Asian Chinese (p=0.02, M=5.5)

Table 52: Difference in the in-course performance between ethnic groups– One way ANOVA with post hoc (2015 & 2016 cohorts), continued

Academic modules average score of 2nd year	p=0.03 F (6,42) = 2.7	White* Asian Chinese (p=0.02, M= 5.1)			
Total 3rd year OSCE score	p=0.04 F (6,48) = 2.4	White*Asian Chinese (p=.05, M= 4.2) Asian British Indian*Asian British Pakistani (p=0.05, M= 5.2)			
Average of communication stations score of 3rd year OSCE	p= 0.05 F (6,48) = 2.4	White*Asian British Indian (p=0.03, M=3.9) White*Asian Chinese (p=0.05, M= 4.9)			
Average of gross motor stations score of 3rd year OSCE	p= 0.02 F (6,48) = 2.9	Asian other*Asian Chinese (p=0.04, M=5.2)			
Total 4th year OSCE score	p= 0.000 F (6,46) = 5.3	Asian British Indian*Asian Chinese (p=0.04, M=5.8)			
Average of communication stations score of 4th year OSCE	p= 0.000 F (6,47) = 6.6	White*Asian British Pakistani (p=0.03, M=6.1) White*Asian Chinese (p=0.04, M= 4.2)			

Summary of the findings of assessment of the relationship between students' personal characteristics and their performance in in-course assessments using Univariate analysis:

Gender:

Where a statistically significant difference was noted between genders, females mean score was higher than males in clinical, academic and OSCE scores.

Maturity:

There was no statistically significant difference between mature and school leaver students in clinical or academic performance measures assessed in this research.

Access to Leeds eligibility:

Where a statistically significant difference was noted between eligible and non-eligible groups, eligible group performed lower than the other group in different clinical, academic and OSCE assessments.

Qualification level:

Where a statistically significant difference was noted between degree holders and A level/equivalent holders, students holding a degree performed higher than the other group in CP1.

Ethnicity:

Results of the ANOVA showed a significant difference between ethnic groups in multiple clinical practise scores and OSCE scores, in addition to academic modules average score of 2nd year. Post-hoc analysis revealed different performance differences between ethnic groups as detailed previously.

4.3.2 Can admission assessments predict a student's performance in the course? (Multivariate analysis)

As a first step in addressing this question, series of hierarchical regressions were run for each of the outcome measure as will be explained below. In each regression, the admission variables were entered sequentially. This will help us to understand whether the addition of the students' performance in each admission assessment over the previous improved the prediction of the students' in-course performance and how much of the variance in performance can be explained by the addition of each admission assessment.

4.3.2.1 What Incremental validity do admission assessments have over the personal characteristics of the student?

The cohorts included in this analysis are the 2015 and 2016 cohorts. Eight hierarchical regression models were conducted for each cohort. As explained above, each hierarchical regression allows us to understand how much additional variance in the performance of the students in each outcome measure is explained by the addition of each admission assessment. The findings will be reported for 2015 cohort followed by 2016. See table 53 below for full details of the variables considered in each model.

Table 53: Variables used in the hierarchical regressions

Cohorts	Hierarchical regression	Dependent (outcome) variable	Independent (predictor) variables
2015 & 2016	1	**Total CP score**	**Step 1** Gender **Step 2** Ethnicity **Step 3** A2L **Step 4** Maturity **Step 5** Qualification level **Step 6** Total personal statement score **Step 7** Total BMAT score **Step 8** Total MMI score
	2	**Total academic performance score**	
	3	**Total OSCE 3 score**	
	4	**Total OSCE 4 score**	
	5	**Average of communication stations score / OSCE 3**	
	6	**Average of fine motor stations score / OSCE 3**	
	7	**Average of communication stations score / OSCE 4**	
	8	**Average of fine motor stations score / OSCE 4**	

1- Hierarchical regressions of total CP score

This hierarchical multiple regression was run to determine if the addition of ethnicity, then Access to Leeds eligibility, then maturity, then qualification level, then total personal statement score, then BMAT score and then MMI score improved the prediction of total CP score over and above the Gender of the student.

2015 cohort

The full model of gender, ethnicity, A2L, maturity, total personal statement score, total BMAT score and total MMI score to predict total CP score (model 7) was statistically significant R square= 0.411 F (8 ,34) = 2.972, p= 0.01, adjusted R square= 0.373.

By comparing the models, it is noted that R square value keeps increasing by the addition of each predictor variable. Which means that the amount of explained variance in the student's CP performance keeps increasing by the addition of each predictor variable except for the (maturity) variable which added no difference in the R square value. Which means it did not add an explanation to the178tudentt's performance in CP. The addition of BMAT contributed the most in adding a change of 0.219 in comparison to other variables, which was also the only significant change. This means that the variance explained increased by 21.9% which was due to the inclusion of total BMAT score, and this increase was statistically significant 0.001. In other words, total BMAT score was the only predictor variable that added a statistically significant difference to the prediction of total CP score. In fact, its significant B coefficient value of 7.337 indicates that a score increase in the BMAT scores leads to 7 scores increase in the predicted CP score. On the other hand, the remaining variables, gender, ethnicity, A2L, maturity, total personal statement score and total MMI score contributed to the variance explained by 7.4%, 3.5%, 4.9%, 0%, 0.7% and 2.6%, respectively. However, this was not statistically significant. See table 54 for further details.

2016 cohort

The full model of gender, ethnicity, A2L, maturity, qualification level, total personal statement score, total BMAT score and total MMI score to predict total CP score (Model 8) was statistically significant. R square= 0.522, F (9,20) =2.761, p= 0.05, Adjusted R square= 0.401.

By comparing the models, it is noted that R square value keeps increasing by the addition of each predictor variable. Which means that the amount of explained variance in the student's CP performance keeps increasing by the addition of each predictor variable. The addition of qualification level contributed the most in adding a change of 0.084 in comparison to other variables. This means that the variance explained increased by 8.4% which was due to the inclusion of the qualification level, however, this was not a statistically significant change. On the other hand, the remaining variables, gender, ethnicity, A2L, maturity, total personal statement score, total BMAT score and total MMI score contributed to the variance explained by 7.5%, 0.9%, 2%, 5.9%, 2%, 0.2% and 0.2% respectively. However, this was not statistically significant. See table 55 for further details.

Table 54: Total CP score hierarchical regression model summary-2015

Cohort 2015							
Total CP score							
	Model 1 (Gender)	Model 2 (Ethnicity)	Model 3 (A2L)	Model 4 (Maturity)	Model 5 (Total PS)	Model 6 (Total BMAT)	Model 7 (Total MMI)
R square	0.074	0.110	0.159	0.159	0.166	0.385	0.411
R square change	0.074	0.035	0.049	0.000	0.007	0.219	0.026
F change	3.295	1.586	1.113	0.012	0.302	12.457	1.528
Sig. F change	0.08	0.2	0.3	0.9	0.6	0.001	0.2

Table 55: Total CP score hierarchical regression model summary-2016

Cohort 2016								
Total CP score								
	Model 1 (Gender)	Model 2 (Ethnicity)	Model 3 (A2L)	Model 4 (Maturity)	Model 5 (Qualification level)	Model 6 (Total PS score)	Model 7 (Total BMAT score)	Model 8 (Total MMI score)
R square	0.075	0.084	0.104	0.162	0.246	0.266	0.269	0.270
R square change	0.075	0.009	0.020	0.059	0.084	0.020	0.002	0.002
F change	2.285	0.254	0.275	1.677	2.555	0.610	0.066	0.045
Sig. F change	0.142	0.619	0.762	0.208	0.124	0.443	0.799	0.835

2- Hierarchical regressions for the total academic score

This hierarchical multiple regression was run to determine if the addition of ethnicity, then Access to Leeds eligibility, then maturity, then qualification level, then total personal statement score, then BMAT score and then MMI score improved the prediction of total academic performance score over and above the Gender of the student.

2015 cohort

The full model of gender, ethnicity, A2L, maturity, total personal statement score, total BMAT score and total MMI score to predict total academic score (Model 7) was statistically significant R square= 0.341 F (7, 31) = 2.290, p= 0.05, adjusted R square= 0.192.

By comparing the models, it was noted that R square value keeps increasing by the addition of each predictor variable. Which means that the amount of explained variance in the student's academic performance keeps increasing by the addition of each predictor variable except for the (maturity) variable which added no difference in the R square value. Which means it did not add an explanation to the student's performance in CP. The addition of Access to Leeds and eligibility contributed the most in adding a change of 0.153 in comparison to other variables, which was also the only significant change. This means that the variance explained increased by 15.3% which was due to the inclusion of Access to Leeds eligibility, and this increase was statistically significant 0.014. In other words, eligibility to Access to Leeds was the only predictor variable that added a statistically significant difference to the prediction of total academic score. On the other hand, the remaining variables, gender, ethnicity, maturity, qualification level, total personal statement score, total BMAT score and total MMI score contributed to the variance explained by 3.4%, 2.2%, 0%, 2.6%, 7% and 3.5%, respectively. However, this was not statistically significant. See table 56 for further details.

2016 cohort

The full model of gender, ethnicity, A2L, maturity, qualification level, total personal statement score, total BMAT score and total MMI score to predict total academic performance (Model 8) was statistically significant. R square= 0.308, F(9,20)= .635, p= 0.05, Adjusted R square= 0.216

By comparing the models, it was noted that R square value keeps increasing by the addition of each predictor variable. Which means that the amount of explained variance in the student's academic performance keeps increasing by the addition of each predictor variable. The addition of maturity contributed the most in adding a change of 0.163 in comparison to other variables, which was also the only significant change. This means that the variance explained increased by 16.3% which was due to the inclusion of maturity variable, and this increase was statistically significant 0.027. In other words, maturity was the only predictor variable that added a statistically significant difference to the prediction of total academic score. On the other hand, the remaining variables, gender, ethnicity, Access to Leeds eligibility, qualification level, total personal statement score, total BMAT score and total MMI score contributed to the variance explained by 9.2%, .2%, 3.4%, 0.8%, 0.1%, 0.4% and 0.4%, respectively. However, this was not statistically significant. See table 57 for further details.

Table 56: Total in-course academic performance score hierarchical regression model summary-2015

Cohort 2015							
Total of in-course academic performance							
	Model 1 (Gender)	Model 2 (Ethnicity)	Model 3 (A2L)	Model 4 (Maturity)	Model 5 (Total PS score)	Model 6 (Total BMAT)	Model 7 (Total MMI)
R square	0.034	0.057	0.209	0.209	0.235	0.306	0.341
R square change	0.034	0.022	0.153	0.000	0.026	0.070	0.035
F change	1.308	0.854	6.754	0.000	1.129	3.241	1.655
Sig. F change	0.260	0.362	**0.014**	0.992	0.296	0.081	0.208

Table 57: Total in-course academic performance score hierarchical regression model summary-2016

	Cohort 2016							
	Total of in-course academic performance							
	Model 1 (Gender)	Model 2 (Ethnicity)	Model 3 (A2L)	Model 4 (Maturity)	Model 5 (Qualification level)	Model 6 (Total PS score)	Model 7 (Total BMAT score)	Model 8 (Total MMI score)
R square	0.092	0.094	0.129	0.292	0.300	0.301	0.305	0.308
R square change	0.092	0.002	0.034	0.163	0.008	0.001	0.004	0.004
F change	2.847	0.060	0.492	5.532	0.259	0.024	0.121	0.103
Sig. F change	0.103	0.808	0.617	0.027	0.615	0.878	0.731	0.752

3- Hierarchical regressions for the 3rd year OSCE total score

This hierarchical multiple regression was run to determine if the addition of ethnicity, then Access to Leeds eligibility then maturity, then qualification level, then total personal statement score, then BMAT score and then MMI score improved the prediction of 3rd year OSCE score over and above the Gender of the student.

2015 cohort

The full model of gender, ethnicity, A2L, maturity, total personal statement score, total BMAT score and total MMI score to predict total OSCE 3 score (Model 8) was statistically significant R square= 0.4 F (9, 39) = 2.893, p= 0.01, adjusted R square= 0.262.

By comparing the models, it was noted that R square value keeps increasing by the addition of each predictor variable. Which means that the amount of explained variance in the student's performance in 3rd year OSCE keeps increasing by the addition of each predictor variable except for the qualification level variable which added no difference in the R square value. Which means it did not add an explanation to the student's performance in 3rd year OSCE. The addition of ethnicity variable and BMAT total score contributed the most in adding a change of 0.112 and 0.166, respectively, which was also the only statistically significant change. This means that the variance explained in OSCE performance increased by 11.2% and then by 16.6% due to the inclusion of ethnicity variable and then by BMAT score. This increase was of statistical significance of 0.016 and 0.002, respectively. In other words, ethnicity and BMAT total score were the only predictor variables that added a statistically significant difference to the prediction of total 3rd year OSCE score. In fact, looking at the coefficients of model 8 revealed a significant B coefficient value of BMAT of 6.876, which indicates that a score increase in the BMAT score leads to 6.876 scores increase in the predicted OSCE score. On the other hand, the remaining variables, gender, maturity, qualification level, total personal statement score and total MMI score contributed to the variance explained by 6.2%, 4.6%, 0.3%, 0%, 0.2% and 1%, respectively. However, this was not statistically significant. See table 58 for further details.

2016 cohort

The full model of gender, ethnicity, A2L, maturity, qualification level, total personal statement score, total BMAT score and total MMI score to predict total OSCE 3 score (model 8) was statistically significant. R square= 0.569, F (9,16) =2.349, p= 0.035, Adjusted R square= 0.327

By comparing the models, it was noted that R square value keeps increasing by the addition of each predictor variable. Which means that the amount of explained variance in the student's performance in 3rd year OSCE keeps increasing by the addition of each predictor variable. The addition of ethnicity variable contributed the most in adding a change of 0.213, which was also the only statistically significant change. This means that the variance explained in OSCE performance increased by 21.3% due to the inclusion of ethnicity variable. This increase was of statistical significance of 0.017. In other words, ethnicity was the only predictor variable that added a statistically significant difference to the prediction of total 3rd year OSCE score. In fact, looking at the coefficients of model 8 revealed a significant B coefficient value of ethnicity of 7.097, which indicates that a score increase in the BMAT score leads to 7.097 scores increase in the predicted OSCE score. On the other hand, the remaining variables, gender, maturity, qualification level, total personal statement score and total MMI score contributed to the variance explained by 4.6%, 9.5%, 3.2%, 5.6%, %7, 1.3% and 4.4%, respectively. However, this was not statistically significant. See table 59 for further details.

Table 58: Total 3rd year OSCE score hierarchical regression model summary-2015

Cohort 2015								
OSCE 3 total score								
	Model 1 (Gender)	Model 2 (Ethnicity)	Model 3 (A2L)	Model 4 (Maturity)	Model 5 (Qualification level)	Model 6 (Total PS score)	Model 7 (Total BMAT score)	Model 8 (Total MMI score)
R square	.062	.174	.220	.223	.223	.225	.390	.400
R square change	.062	.112	.046	.003	.000	.002	.166	.010
F change	3.101	6.247	1.291	.170	. 006	.093	10.866	.646
Sig. F change	.085	.016	.285	.682	.938	.762	.002	.426

Table 59: Total 3rd year OSCE score hierarchical regression model summary-2016

Cohort 2016								
OSCE 3 total score								
	Model 1 (Gender)	Model 2 (Ethnicity)	Model 3 (A2L)	Model 4 (Maturity)	Model 5 (Qualification level)	Model 6 (Total PS score)	Model 7 (Total BMAT score)	Model 8 (Total MMI score)
R square	.046	.260	.354	.386	.442	.512	.525	.569
R square change	.046	.213	.095	.032	.056	.070	.013	.044
F change	1.169	6.623	1.541	1.033	1.900	2.569	.483	1.641
Sig. F change	.290	.017	.238	.322	.184	.126	.496	.218

4- Hierarchical regressions for the 4th year OSCE total score

This hierarchical multiple regression was run to determine if the addition of ethnicity, then Access to Leeds eligibility, then maturity, then qualification level, then total personal statement score, then BMAT score and then MMI score improved the prediction of 4th year OSCE score over and above the Gender of the student.

2015 cohort

The full model of gender, ethnicity, A2L, maturity, total personal statement score, total BMAT score and total MMI score to predict total OSCE 4 score (Model 8) was statistically significant R square= 0.602, F (9,37) =6.229, p=0.000, adjusted R square= 0.506.

By comparing the models, it was noted that R square value keeps increasing by the addition of each predictor variable. Which means that the amount of explained variance in the student's performance in 4th year OSCE keeps increasing by the addition of each predictor variable. Gender followed by the addition of ethnicity variable, then Access to Leeds eligibility, then BMAT total score contributed the most in adding a change of 0.192, 0.169, 0.084 and 0.080, respectively, which were also the only statistically significant changes. This means that the variance explained in OSCE performance is increased by 19.2%, then by 16.9% then by 8.4% and then by 8% due to the inclusion of these variables. This increase was of statistical significance of 0.002 and 0.001, 0.05 and 0.01 respectively. In other words, these variables were the only predictor variables that added a statistically significant difference to the prediction of total 4th year OSCE score. In fact, looking at the coefficients of the variables in model 8 revealed a significant B coefficient value of BMAT score of 6.576, which indicates that a score increase in the BMAT score leads to 6.576 scores increase in the predicted OSCE score. On the other hand, the remaining variables, gender, maturity, total personal statement score and total MMI score contributed to the variance explained by 1.7%, 3.6%, 0.7% and 1.8% respectively. However, this was not statistically significant. See table 60 for further details.

2016 cohort

The full model of gender, ethnicity, A2L, maturity, qualification level, total personal statement score, total BMAT score and total MMI score to predict total OSCE 4 score (Model 8) was statistically significant. R square= 0.318, F (9,14) = 0.04, p= 0.05, Adjusted R square= 0.295

By comparing the models, it was noted that R square value keeps increasing by the addition of each predictor variable. Which means that the amount of explained variance in the student's performance in 4th year OSCE keeps increasing by the addition of each predictor variable except for the (ethnicity) variable which added no difference in the R square value. Which means it did not add an explanation to the student's performance in 4th year OSCE score. None of the factors added a statistically significant change to the variance in the 4th year OSCE scores, However, the variance explained in OSCE performance is increased by 0%, then by 1.6%, then by 8.6% then by 6.8%, then by 3.1%, then by 0.2% then by 0.2%, due to the sequential inclusion of ethnicity, Access to Leeds eligibility, maturity, qualification level, total personal statement score, total BMAT score and total MMI score, respectively. See table 61 for further details.

Table 60: Total 4th year OSCE score hierarchical regression model summary-2015

Cohort 2015								
OSCE 4 total score								
	Model 1 (Gender)	Model 2 (Ethnicity)	Model 3 (A2L)	Model 4 (Maturity)	Model 5 (Qualification level)	Model 6 (Total PS score)	Model 7 (Total BMAT score)	Model 8 (Total MMI score)
R square	.192	.361	.444	.462	.497	.504	.584	.602
R square change	.192	.169	.084	.017	.036	.007	.080	.018
F change	10.712	11.599	3.160	1.305	2.840	.553	7.335	1.671
Sig. F change	.002	.001	.05	.26	.1	.46	.01	.204

Table 61: Total 4th year OSCE score hierarchical regression model summary-2016

Cohort 2016								
OSCE 4 total score								
	Model 1 (Gender)	Model 2 (Ethnicity)	Model 3 (A2L)	Model 4 (Maturity)	Model 5 (Qualification level)	Model 6 (Total PS score)	Model 7 (Total BMAT score)	Model 8 (Total MMI score)
R square	.002	.002	.018	.104	.172	.203	.205	.208
R square change	.002	.000	.016	.086	.068	.031	.002	.002
F change	.034	.007	.154	1.737	1.397	.625	.037	.039
Sig. F change	.856	.934	.859	.204	.253	.441	.850	.845

5- Hierarchical regressions for the OSCE 3 average of communication stations score

This hierarchical multiple regression was run to determine if the addition of ethnicity, then Access to Leeds eligibility, then maturity, then qualification level, then total personal statement score, then BMAT score and then MMI score improved the prediction of average of communication stations score of 3rd year OSCE over and above the Gender of the student.

2015 cohort

The full model of gender, ethnicity, A2L, maturity, total personal statement score, total BMAT score and total MMI score to predict average of OSCE 3 communication stations score (Model 8) was statistically significant R square= 0.362, F (9,39) = 2.458, p= 0.02, adjusted R square= 0.215.

By comparing the models, it was noted that R square value keeps increasing by the addition of each predictor variable. Which means that the amount of explained variance in the student's performance in the average communication score keeps increasing by the addition of each predictor variable except for the qualification level variable and total personal statement score which added no difference in the R square value. Which means they did not add an explanation to the student's performance the communication stations. The addition of ethnicity variable and BMAT total score contributed the most in adding a change of 0.138 and 0.126, respectively, which were also the only statistically significant change. This means that the variance explained in the communication stations score increased by 13.8% and then by 12.6% due to the inclusion of ethnicity variable and then by BMAT score. This increase was of statistical significance of 0.008 and 0.009, respectively. In other words, ethnicity and BMAT total score were the only predictor variables that added a statistically significant difference to the prediction of communication stations performance. In fact, looking at the coefficients of model 8 revealed a significant B coefficient value of BMAT of 0.719, which indicates that a score increase in the BMAT score leads to 0.719 scores increase in the predicted communication stations scores. On the other hand, the remaining variables, gender, maturity, qualification level, total personal statement score and total MMI score contributed to the variance explained by 4.1%, 0.2%, 3.6%, 0%, 0% and 1.9%, respectively. However, this was not statistically significant. See table 62 for further details.

2016 cohort

The full model of gender, ethnicity, A2L eligibility, maturity, qualification level, total personal statement score, total BMAT score and total MMI score to predict average of OSCE 3 communication stations score (Model 8) was statistically significant. R square= 0.364, F (9,16) =1.016, p= 0.05, Adjusted R square= 0.298.

By comparing the models, it was noted that R square value keeps increasing by the addition of each predictor variable. Which means that the amount of explained variance in the student's performance in the average communication score keeps increasing by the addition of each predictor variable. The addition of ethnicity variable contributed the most in adding a change of 0.230, which was also the only statistically significant change. This means that the variance explained in the communication stations score increased by 23% due to the inclusion of ethnicity variable. This increase was of statistical significance of 0.015. In other words, ethnicity was the only predictor variables that added a statistically significant difference to the prediction of communication stations performance. On the other hand, the remaining variables, gender, Access to Leeds eligibility, maturity, qualification level, total personal statement score, total BMAT score and total MMI score contributed to the variance explained by 0.1%, 2.2%, 6.9%, 1.9%, 1.7%, 0.1% and 0.5%, respectively. However, this was not statistically significant. See table 63 for further details.

Table 62: Average of OSCE 3 communication stations score hierarchical regression model summary-2015

Cohort 2015								
Average of OSCE 3 communication stations score								
	Model 1 (Gender)	Model 2 (Ethnicity)	Model 3 (A2L)	Model 4 (Maturity)	Model 5 (Qualification level)	Model 6 (Total PS score)	Model 7 (Total BMAT score)	Model 8 (Total MMI score)
R square	0.041	0.179	0.181	0.217	0.217	0.217	0.342	0.362
R square change	0.041	0.138	0.002	0.036	0.000	0.000	0.126	0.019
F change	2.003	7.718	0.062	1.968	0.003	0.000	7.638	1.188
Sig. F change	0.164	0.008	0.94	0.168	0.955	0.984	0.009	0.282

Table 63: Average of OSCE 3 communication stations score hierarchical regression model summary-2016

Cohort 2016								
Average of OSCE 3 communication stations score								
	Model 1 (Gender)	Model 2 (Ethnicity)	Model 3 (A2L)	Model 4 (Maturity)	Model 5 (Qualification level)	Model 6 (Total PS score)	Model 7 (Total BMAT score)	Model 8 (Total MMI score)
R square	0.001	0.231	0.253	0.322	0.341	0.358	0.359	0.364
R square change	0.001	0.230	0.022	0.069	0.019	0.017	0.001	0.005
F change	0.033	6.883	0.303	2.029	0.554	0.481	0.019	0.122
Sig. F change	0.857	0.015	0.742	0.170	0.466	0.497	0.892	0.731

6- Hierarchical regressions for the OSCE 3 average of fine motor stations score

This hierarchical multiple regression was run to determine if the addition of ethnicity, then Access to Leeds eligibility, then maturity, then qualification level, then total personal statement score, then BMAT score and then MMI score improved the prediction of average of fine motor stations score of 3rd year OSCE over and above the Gender of the student.

2015 cohort

The full model of gender, ethnicity, A2L, maturity, total personal statement score, total BMAT score and total MMI score to predict average of OSCE 3 fine motor stations score (Model 8) was statistically significant R square= 0.313 F (9,39) = 1.977, p= 0.04, adjusted R square= 0.255.

By comparing the models, it was noted that R square value keeps increasing by the addition of each predictor variable. Which means that the amount of explained variance in the fine motor stations score keeps increasing by the addition of each predictor variable. The addition of Maturity and total BMAT score contributed the most in adding a change of 0.086 and 0.091, respectively. This means that the variance explained increased by 8.6% and 9.1% which was due to the inclusion of maturity variable and total BMAT score, and this increase was statistically significant. In other words, maturity variable and total BMAT score were the only predictor variables that added a statistically significant difference to the prediction of fine motor stations score. In fact, BMAT significant B coefficient value of 0.527 indicates that a score increase in the BMAT scores leads to 0.527 scores increase in the predicted fine motor stations score. On the other hand, the remaining variables, gender, ethnicity, A2L, qualification level, total personal statement score and total MMI score contributed to the variance explained by 2.5%, 5.9%, 2.3%, 0.1%, 0.2% and 2.7%, respectively. However, this was not statistically significant. See table 64 for further details.

2016 cohort

The full model of gender, ethnicity, A2L, maturity, qualification level, total personal statement score, total BMAT score and total MMI score to predict average of OSCE 3 fine motor stations score (Model 8) was statistically significant. R square= 0.655, F (9,16) =3.371, p= 0.017, Adjusted R square= 0.461

By comparing the models, it was noted that R square value keeps increasing by the addition of each predictor variable. Which means that the amount of explained variance in the fine motor stations score keeps increasing by the addition of each predictor variable except for the maturity variable which added no difference in the R square value. Which means they did not add an explanation to the student's performance the fine motor stations. The addition of Access to Leeds eligibility variable contributed the most in adding a change of 0.271, which were also the only statistically significant change. This means that the variance explained in the fine motor stations score increased by 27.1% due to the inclusion of this variable. This increase was of statistical significance of 0.015. In other words, Access to Leeds variable was the only predictor variable that added a statistically significant difference to the prediction of fine motor stations performance. On the other hand, the remaining variables, gender, maturity, qualification level, total personal statement score, total BMAT score and total MMI score contributed to the variance explained by 7.9%, 9.4%, 0%, 4.9%, 8%, 2.6% and 5.5%, respectively. However, this was not statistically significant. See table 65 for further details.

Table 64: Average of OSCE 3 fine motor stations score hierarchical regression model summary-2015

Cohort 2015								
Average of OSCE 3 fine motor stations score								
	Model 1 (Gender)	Model 2 (Ethnicity)	Model 3 (A2L)	Model 4 (Maturity)	Model 5 (Qualification level)	Model 6 (Total PS score)	Model 7 (Total BMAT score)	Model 8 (Total MMI score)
R square	0.025	0.085	0.108	0.194	0.194	0.196	0.287	0.313
R square change	0.025	0.059	0.023	0.086	0.001	0.002	0.091	0.027
F change	1.221	2.977	0.567	4.584	0.048	0.080	5.086	1.508
Sig. F change	0.275	0.091	0.571	0.038	0.827	0.779	0.030	0.227

Table 65: Average of OSCE 3 fine motor stations score hierarchical regression model summary-2016

Cohort 2016								
Average of OSCE 3 fine motor stations score								
	Model 1 (Gender)	Model 2 (Ethnicity)	Model 3 (A2L)	Model 4 (Maturity)	Model 5 (Qualification level)	Model 6 (Total PS score)	Model 7 (Total BMAT score)	Model 8 (Total MMI score)
R square	0.079	0.174	0.445	0.445	0.494	0.573	0.600	0.655
R square change	0.079	0.094	0.271	0.000	0.049	0.080	0.026	0.055
F change	2.069	2.620	5.123	0.000	1.848	3.357	1.111	2.559
Sig. F change	0.163	0.119	0.015	0.990	0.190	0.084	0.307	0.129

7- Hierarchical regressions for the OSCE 4 average of communication stations score

This hierarchical multiple regression was run to determine if the addition of ethnicity, then Access to Leeds eligibility, then maturity, then qualification level, then total personal statement score, then BMAT score and then MMI score improved the prediction of average of communication stations score of 4^{th} year OSCE over and above the Gender of the student.

2015 cohort

The full model of gender, ethnicity, A2L, maturity, total personal statement score, total BMAT score and total MMI score to predict average of OSCE 4 communication stations score (Model 8) was statistically significant R square= 0.635 F (9,38) = 7.348, p= 0.000, adjusted R square= 0.549

By comparing the models, it was noted that R square value keeps increasing by the addition of each predictor variable. Which means that the amount of explained variance in the communication stations score keeps increasing by the addition of each predictor variable. The addition of gender, ethnicity, Access to Leeds variable, qualification level variable and total BMAT score contributed the most in adding a change of 0.155, 0.170, 0.095, 0.058 and 0.095, respectively. This means that the variance explained increased by 15.5%, 17%, 9.5%, 5.8% and 9.5%, which was due to the inclusion of these variables sequentially, and this increase was statistically significant. On the other hand, the remaining variables, maturity, total personal statement score and total MMI score contributed to the variance explained by 1.8%, 0.9%, and 3.3%, respectively. However, this was not statistically significant. See table 66 for further details.

2016 cohort

The full model of gender, ethnicity, A2L eligibility, maturity, qualification level, total personal statement score, total BMAT score and total MMI score to predict average of OSCE 4 communication stations score (Model 8) was statistically significant R square= 0.379, F (9,14) = 0.217, p= 0.04, Adjusted R square= 0.211

By comparing the models, it was noted that R square value keeps increasing by the addition of each predictor variable. Which means that the amount of explained variance in the student's performance in the 4th year OSCE communication stations keeps increasing by the addition of each predictor variable. None of the variables added a statistically significant change to the variance in scores. However, the variance explained in the communication stations performance is increased by 0%, then by 2.8%, then by 1.8% then by 5%, then by 1.1%, then by 0.3% then by 0.8%, then by 0.4% due to the sequential inclusion of gender, ethnicity, Access to Leeds eligibility, maturity, qualification level, total personal statement score, total BMAT score and total MMI score, respectively. See table 67 for further details.

Table 66: Average of OSCE 4 communication stations score hierarchical regression model summary-2015

	Cohort 2015							
	Average of OSCE 4 communication stations score							
	Model 1 (Gender)	Model 2 (Ethnicity)	Model 3 (A2L)	Model 4 (Maturity)	Model 5 (Qualification level)	Model 6 (Total PS score)	Model 7 (Total BMAT score)	Model 8 (Total MMI score)
R square	0.155	0.326	0.421	0.439	0.497	0.506	0.602	0.635
R square change	0.155	0.170	0.095	0.018	0.058	0.009	0.095	0.033
F change	8.467	11.366	3.541	1.333	4.732	0.763	9.341	3.469
Sig. F change	0.006	0.002	0.038	0.255	0.035	0.388	0.004	0.07

Table 67: Average of OSCE 4 communication stations score hierarchical regression model summary-2016

Cohort 2016								
Average of OSCE 4 communication stations score								
	Model 1 (Gender)	Model 2 (Ethnicity)	Model 3 (A2L)	Model 4 (Maturity)	Model 5 (Qualification level)	Model 6 (Total PS score)	Model 7 (Total BMAT score)	Model 8 (Total MMI score)
R square	0.000	0.028	0.046	0.097	0.108	0.110	0.119	0.122
R square change	0.000	0.028	0.018	0.050	0.011	0.003	0.008	0.004
F change	0.007	0.596	0.184	1.002	0.208	0.051	0.144	0.056
Sig. F change	0.934	0.449	0.833	0.330	0.654	0.824	0.710	0.816

8- Hierarchical regressions for the OSCE 4 average of fine motor stations score

This hierarchical multiple regression was run to determine if the addition of ethnicity, then Access to Leeds eligibility, then maturity, then qualification level, then total personal statement score, then BMAT score and then MMI score improved the prediction of average of fine motor stations score of 4th year OSCE over and above the Gender of the student.

2015 cohort

The full model of gender, ethnicity, A2L, maturity, total personal statement score, total BMAT score and total MMI score to predict average of OSCE 4 fine motor stations score (Model 8) was not statistically significant R square= 0.280 F (9,38) = 1.642, p= 0.138, adjusted R square= 0.109

By comparing the models, it was noted that R square value keeps increasing by the addition of each predictor variable. Which means that the amount of explained variance in the student's performance in fine motor stations keeps increasing by the addition of each predictor variable except for the maturity variable which added no difference in the R square value. Which means it did not add an explanation to the student's performance in fine motor stations. Gender variable contributed the most in a change of 0.090, which was also the only statistically significant change. This means that the variance explained in fine motor stations performance increased by 9% due to the gender variable. This increase was of statistical significance of 0.038. In other words, gender was the only predictor variable that added a statistically significant difference to the prediction of the students' performance in the stations. On the other hand, the remaining variables, ethnicity, maturity, qualification level, total personal statement score, total BMAT score and total MMI score contributed to the variance explained by 2.2%, 6.6%, 0%, 5%, 0.1%, 3.4 and 1.6%, respectively. However, this was not statistically significant. See table 68 for further details.

2016 cohort

The full model of gender, ethnicity, A2L, maturity, qualification level, total personal statement score, total BMAT score and total MMI score to predict average of OSCE 4 fine motor stations score (Model 8) was statistically significant. R square= 0.395, F (9,14) =1.017, p= 0.47, Adjusted R square= 0.301.

By comparing the models, it was noted that R square value keeps increasing by the addition of each predictor variable. Which means that the amount of explained variance in the student's performance in fine motor stations keeps increasing by the addition of each predictor variable. Ethnicity variable contributed the most in a change of 0.271, which was also the only statistically significant change. This means that the variance explained in fine motor stations performance increased by 27% due to the ethnicity variable. This increase was of statistical significance of 0.01. On the other hand, the remaining variables, gender, maturity, qualification level, total personal statement score, total BMAT score and total MMI score contributed to the variance explained by 0.9%, 0.8%, 2.5%, 5%, 1.3%, 0.4% and 1.5%, respectively. However, this was not statistically significant. See table 69 for further details.

Table 68: Average of OSCE 4 fine motor stations score hierarchical regression model summary-2015

Cohort 2015								
Average of OSCE 4 fine motor stations score								
	Model 1 (Gender)	Model 2 (Ethnicity)	Model 3 (A2L)	Model 4 (Maturity)	Model 5 (Qualification level)	Model 6 (Total PS score)	Model 7 (Total BMAT score)	Model 8 (Total MMI score)
R square	.090	.112	.178	.178	.228	.230	.264	.280
R square change	.090	.022	.066	.000	.050	.001	.034	.016
F change	4.545	1.111	1.734	.000	2.671	.067	1.823	.837
Sig. F change	.038	.297	.189	.987	.110	.797	.185	.366

Table 69: Average of OSCE 4 fine motor stations score hierarchical regression model summary-2016

Cohort 2016								
Average of OSCE 4 fine motor stations score								
	Model 1 (Gender)	Model 2 (Ethnicity)	Model 3 (A2L)	Model 4 (Maturity)	Model 5 (Qualification level)	Model 6 (Total PS score)	Model 7 (Total BMAT score)	Model 8 (Total MMI score)
R square	.009	.280	.288	.314	.364	.376	.380	.395
R square change	.009	.271	.008	.025	.050	.013	.004	.015
F change	.205	7.914	.108	.667	1.326	.321	.107	.343
Sig. F change	.655	.010	.898	.425	.265	.579	.748	.567

4.3.2.2 Does the predictive validity of the admission assessments vary across the years?

To further analyse the predictive validity of the admission assessments. A series of multiple regressions were conducted to determine whether the significance of predictions changes as the student progresses in the course. The dependent variables were the average of academic modules from the first to the fifth year and clinical practise scores from the first to the fifth year. The independent variables were total personal statement score, total BMAT score and total MMI score. The cohorts considered in this analysis were the 2015 and 2016 cohorts. A total of ten multiple regression models were ran for each cohort.

For 2015 cohort, the academic performance regression models for the second and third year of the course were statistically significant. As for the 1^{st}, 4^{th} and 5^{th} years of the course, the models were not statistically significant. However, the models explained 3.9%, 21.3%, 18.1%, 0.2% and 2.5% of the variance explained in the students' academic performance in the 1^{st}, 2^{nd}, $3^{rd,}$ 4^{th} and 5^{th} years, respectively. However, for the 2016 cohort, no models were statistically significant. However, the models explained 6.6%, 0.7%, 2%, 7.6% and 9.8% of the variance explained in the students' academic performance in the 1^{st}, 2^{nd}, 3^{rd} , 4^{th} and 5^{th} years respectively.

As for the clinical performance, regression models for the third, fourth and fifth years of the course for the 2015 cohort were statistically significant. As for the 1^{st} and 2^{nd} years of the course, the models were not statistically significant. However, the models explained 1.8%, 8.2%, 33.9, 35.3% and 29.8% of the variance explained in the students' clinical performance in the 1^{st}, 2^{nd}, $3^{rd,}$, 4^{th} and 5^{th} years, respectively. However, for the 2016 cohort, no models were statistically significant. However, the models explained 5.8%, 2.7%, 6.7%, 9% and 8.2% of the variance explained in the students' clinical performance in the 1^{st}, 2^{nd}, $3^{rd,}$ 4^{th}, and 5^{th} years, respectively.

The 2015 academic performance regression models revealed a significant B coefficient value of BMAT of 0.997 and 0.931 for the second and third year of the course, respectively. This indicates that a 0.997, 0.931 score increase in the BMAT score leads to a scores increase in the predicted academic score. Regarding the MMI, a significant B coefficient value of 0.689 for the third year of the course was found. This indicates that a 0.689 score increase in the total MMI score leads to a scores increase in the predicted academic score. As for the 2016 academic performance regression models, none of the assessed variables had statistically significant coefficients. See table 70 for a summary of the significant coefficients of the regressions.

The 2015 clinical performance regression models revealed a significant B coefficient value of BMAT of 1.753, 1.753 and 1.561 for the third, fourth and fifth year of the course, respectively. This indicates that a 1.753, 1.753 and 1.561 score increase in the BMAT score leads to a scores increase in the predicted clinical score. Regarding the MMI, a significant B coefficient values of 0.882 and 0.871 for the third and fourth year of the course was found, respectively. This indicates that a 0.882 and 0.871 score increase in the total MMI score leads to a scores increase in the predicted clinical score. Additionally, a significant B coefficient value of personal statement of 0.304 for the 5th year of the course was found, which suggests that a 0.304 score increase in the personal statement score leads to a score increase in the predicted clinical score. As for the 2016 clinical performance regression models, none of the assessed variables had statistically significant coefficients.

Table 70: Significant coefficients of the multiple regressions of students' performance across the years-2015

	Cohort 2015									
	Academic performance					Clinical performance				
	Year 1	Year 2	Year 3	Year 4	Year 5	CP 1	CP2	CP3	CP4	CP5
Total personal statement score	-	-	-	-	-	-	-	-	-	B=0.304 p =0.005
Total BMAT score	-	B= 0.997 p = 0.050	B=0.931 p =0.042	-	-	-	-	B=1.753 p =0.001	B=1.753 p =0.001	B=1.561 p =0.001
Total MMI score	-	-	B=0.689 p =0.042	-	-	-	-	B=0.882 p =0.017	B=0.871 p =0.023	B=0.384 p =0.219

4.3.2.3 Which section of the BMAT has the most predictive validity?

As BMAT was found to add significant prediction in multiple variables in the hierarchical regression, further analysis of the BMAT sections against all the previously considered outcome variables was assessed using series of multiple regressions. This was carried out to determine if certain section in the BMAT was more predictive than another. A total of eight multiple regressions were carried out for each cohort. See table 71 for full details of the variables considered in each model.

Table 71: Variables used in the multiple regressions – BMAT sections

Cohort	Multiple regression	Dependent (outcome) variables	Independent (predictor) variable
		2015 & 2016	
2015 & 2016	1	Total CP score	BMAT Section 1 BMAT Section 2 BMAT Section 3
	2	Total academic performance	
	3	Total of 3rd year OSCE score	
	4	Average of communication stations score / 3rd year OSCE	
	5	Average of fine motor stations score / 3rd year OSCE	
	6	Total of 4th year OSCE score	
	7	Average of communication stations score / 4th year OSCE	
	8	Average of fine motor stations score / 4th year OSCE	

1- Total of CP scores

2015 Multiple regression

The model was statistically significant R square = 0.259, F (3,40) = 4.654, p= 0.007, Adjusted R square = 0.203. This indicates that the model explains 20.3% of the variance in the CP performance. The model revealed a significant B coefficient value of BMAT section 3 of 9.457, p= 0.037. This indicates that a 9.457 score increase in the section 3 score leads to a scores increase in the predicted CP score. As for sections 2 and 3, none of the coefficients was of statistical significance. See table 72 for further details.

2016 Multiple regression

The model was not statistically significant. R square= 0.015, F (3,42) = 0.214, p= 0.886, Adjusted R square= 0.105. None of the BMAT sections had statistically significant B coefficients.

Table 72: Coefficients of the multiple regressions (BMAT/CP)- 2015

Cohort 2015			
Total CP			
	Model 1 (BMAT section 1)	Model 2 (BMAT section 2)	Model 3 (BMAT section 3)
Unstandardized coefficient B	1.691	6.650	9.457
Sig.	0.623	0.129	0.037

2- Total of academic score

2015 Multiple regression

The model was statistically significant R square = 0.143, F (3,37) = 2.055, p= 0.045, Adjusted R square= 0.077. None of the BMAT sections had statistically significant B coefficients.

2016 Multiple regression

The model was statistically significant. R square= 0.034, F (3,42) = 0.044, p= 0.043, Adjusted R square= 0.075. None of the BMAT sections had statistically significant B coefficients.

3- Total of OSCE 3 score

2015 Multiple regression

Model was statistically significant R square= 0.247, F (3,48) = 5.251, p= 0.003, Adjusted R square= 0.2. This indicates that the model explains 20% of the variance in the 3rd year OSCE performance. None of the BMAT sections had statistically significant B coefficients.

2016 Multiple regression

The model was statistically significant. R square= 0.015, F (3,38) = 0.196, p= 0.051, Adjusted R square= 0.076. None of the BMAT sections had statistically significant B coefficients.

4- Total of OSCE 4 score

2015 Multiple regression

The model was statistically significant R square= 0.186, F (3,46) = 3.494, p= 0.023, Adjusted R square= 0.132. This indicates that the model explains 13.2% of the variance in the total OSCE 4 score. The model revealed a significant B coefficient value of BMAT section 3 of 16.67. This indicates that a 16.67 score increase in the section 3 score leads to a scores increase in the predicted total OSCE 4 score. See table 73 for further details.

2016 Multiple regression

The model was not statistically significant. R square= 0.39, F (3,34) = 0.525, p= 0.668, Adjusted R square = 0.21 None of the BMAT sections had statistically significant B coefficients.

Table 73: Coefficients of the multiple regressions (BMAT/4th year OSCE performance)-2015

Cohort 2015			
Average of OSCE 3 communication stations score			
	Model 1 (BMAT section 1)	Model 2 (BMAT section 2)	Model 3 (BMAT section 3)
Standardized coefficient B	12.980	1.403	16.671
Sig.	0.064	0.877	0.048

5- OSCE 3 Average of communication stations score

2015 Multiple regression

The model was statistically significant R square= 0.234, F (3,48) = 4.895, p= 0.005, Adjusted R square= 0.186. This indicates that the model explains 18.6% of the variance in the average of communication stations score. The model revealed a significant B coefficient value of BMAT section 3 of 1.412. This indicates that a 1.412 score increase in the section 3 score leads to a scores increase in the predicted average of communication stations score. See table 74 for further details.

2016 Multiple regression

The model was statistically significant. R square= 0.213, F (3,38) = 0.396, p= 0.041, Adjusted R square= 0.106. None of the BMAT sections had statistically significant B coefficients.

Table 74: Coefficients of the multiple regressions (BMAT/3rd year OSCE communication stations performance)-2015

Cohort 2015			
OSCE 4 Total score			
	Model 1 (BMAT section 1)	Model 2 (BMAT section 2)	Model 3 (BMAT section 3)
Unstandardized coefficient B	.541	.471	1.412
Sig.	.248	.430	.012

6- OSCE 3 Average of fine motor stations score

2015 Multiple regression

The model was statistically significant R square= 0.467, F (3,47) = 4.371, p= 0.009, Adjusted R square= 0.168. This indicates that the model explains 16.8% of the variance in the OSCE fine motor stations performance. The model revealed a significant B coefficient value of BMAT section 2 of 0.993. This indicates that a 0.993 score increase in the section 2 score leads to a scores increase in the predicted communication stations score. See table 75 for further details.

2016 Multiple regression

The model was statistically significant. R square= 0.225, F (3,38) = 0.066, p= 0.007, Adjusted R square= 0.099. None of the BMAT sections had statistically significant B coefficients.

Table 75: Coefficients of the multiple regressions (BMAT/3rd year OSCE fine motor stations performance)-2015

Cohort 2015			
Average of OSCE 3 fine motor stations score			
	Model 1 (BMAT section 1)	Model 2 (BMAT section 2)	Model 3 (BMAT section 3)
Unstandardized coefficient B	0.410	0.993	0.055
Sig.	0.249	0.033	0.895

7- OSCE 4 average of communication stations score

2015 Multiple regression

The model was not statistically significant R square= 0.141, F (3,46) =2.468, p= 0.046, Adjusted R square= 0.083. None of the BMAT sections had statistically significant B coefficients.

2016 Multiple regression

The model was not statistically significant. R square= 0.01, F (3,34) = 0.110, p= 0.954, Adjusted R square= 0.078. None of the BMAT sections had statistically significant B coefficients.

8- OSCE 4 average of fine motor stations score

2015 Multiple regression

The model was not statistically significant R square= 0.022, F (3,46) = 0.349, p= 0.79, Adjusted R square= 0.041. None of the BMAT sections had statistically significant B coefficients.

2016 Multiple regression

The model was not statistically significant. R square= 0.056, F (3,34) = 0.673, p= 0.575, Adjusted R square= 0.069. None of the BMAT sections had statistically significant B coefficients.

4.3.2.4 MMI versus OSCE multiple regressions

Although the MMI did not seem to add significant incremental predictive validity in the hierarchical regressions, further analysis of the MMI stations and components was carried out using series of multiple regressions to assess if any predictive validity exists when considering the attributes as assessed by stations. The outcome variables chosen were the 3rd and 4th year OSCE communication and fine motor stations averages. OSCE stations were picked as they resemble the setting in which the MMI is held. See the table 76 for full details of the variables considered in each model.

For each model, linearity was assessed by partial regression plots and a plot of studentized residuals against the predicted values. Independence of residuals was assessed using Durbin-Watson test. Homoscedasticity was assessed by visual inspection of a plot of studentized residuals versus unstandardized predicted values. No evidence of multicollinearity was confirmed by tolerance values greater than 0.1. There were no studentized deleted residuals greater than ±3 standard deviations, no leverage values greater than 0.2, and values for Cook's distance above 1. The assumption of normality was confirmed by Q-Q plot.

Table 76: Variables used in the multiple regressions – MMI versus OSCE

Cohort	Multiple regression	Dependent (outcome) variables		Independent (predictor) variable
		2015	2016	
2015 & 2016	1	Average of communication stations score / OSCE 3		-MMI station 1 -MMI station 2 -MMI station 3 -MMI station 4 -MMI station 5 -MMI station 6 -MMI station 7 -MMI station 8 -Perception of the examiner score, subject to availability -MMI components, each added separately.
	2	Average of fine motor stations score / OSCE 3		
	3	Average of communication stations score / OSCE 4		
	4	Average of fine motor stations score / OSCE 4		

1- MMI versus OSCE 3 average of communication stations score

2015 regression model

The model was statistically significant R square= 0.374, F (9,48) = 3.181, p= 0.004, Adjusted R square= 0.256. This indicates that the model explains 25.6% of the variance in the OSCE communication stations performance. The model revealed only one significant B coefficient value of station 6 (empathy and communication) of 0.046. This indicates that a 0.046 score increase in the station 6 score leads to a scores increase in the predicted communication stations score. None of the remaining stations or components had significant coefficient values.

2016 regression model

The model was statistically significant R square= 0.165, F (8,59) = 1.456, p= 0.043, Adjusted R square= 0.081. Analysis revealed a significant B coefficient value of station 5 (Insight) of 0.027. This indicates that a 0.0*27* score increase in the station 5 score leads to a scores increase in the predicted communication stations score.

2- MMI versus OSCE 3 average of fine motor stations score

2015 regression model

The model was not statistically significant R square= 0.193, F (9,48) =1.274, p= 0.275, Adjusted R square= 0.041. None of the MMI stations or components had statistically significant B coefficients.

2016 regression model

The model was statistically significant. R square= 0.163, F (8,59) =1.414, p= 0.05, Adjusted R square= 0.069. However, it revealed a significant B coefficient value of station 3 (presentation) of 2.339. This indicates that a 2.339 score increase in station 3 score leads to a score increase in the predicted average of fine motor stations score.

3- **MMI versus OSCE 4 average of communication stations score**

2015 regression model

The model was statistically significant R square= 0.540, F (9,46) = 6.008, p= 0.000, Adjusted R square= 0.540. This indicates that the model explains 54% of the variance in the OSCE communication stations performance. The model revealed only one significant B coefficient value of station 6 (empathy and communication) of 1.331. This indicates that a 1.331 score increase in the station 6 score leads to a scores increase in the predicted communication stations score. None of the remaining stations or components had significant coefficient values.

2016 regression model

The model was not statistically significant. R square= 0.155, F (8,50) =1.149, p= 0.348, Adjusted R square= 0.020. None of the MMI stations or components had statistically significant B coefficients.

4- **MMI versus OSCE 4 average of fine motor stations score**

2015 regression model

The model was statistically significant. R square= 0.369, F (9,46) =2.987, p= 0.007, Adjusted R square= 0.245. This indicates that the model explains 24.5% of the variance in the OSCE fine motor stations performance. The model revealed two significant B coefficient values of station 3 (presentation) of 3.229 and perception of assessors score of .981. This indicates that a 3.229 score increase in station 3 score leads to a score increase in the predicted average of fine motor stations score. As for the perception of assessors score, a 0.981 score increase in their score leads to a scores increase in the predicted fine motor stations score. None of the remaining stations or components had significant coefficient values.

2016 regression model

The model was not statistically significant. R square= 0.217, F (8,50) = 0.649, p= 0.733, Adjusted R square= 0.102 None of the MMI stations or components had statistically significant B coefficients.

Summary: Can admission assessments predict a student's performance in the course? (Multivariate analysis)

a) **Which admission variables added a significant incremental validity in predicting students' performance?**

Outcome	Admission variables of significant incremental validity
Total CP score	Total BMAT score
Total academic performance score	Access to Leeds eligibility Maturity
Total OSCE 3 score	Total BMAT score Ethnicity
Total OSCE 4 score	Total BMAT score Access to Leeds eligibility Ethnicity Gender
Average of communication stations score / OSCE 3	Total BMAT score Ethnicity
Average of fine motor stations score / OSCE 3	Total BMAT score Access to Leeds eligibility Maturity
Average of communication stations score / OSCE 4	Total BMAT score Access to Leeds eligibility Ethnicity Qualification level Gender
Average of fine motor stations score / OSCE 4	Ethnicity Gender

Continued summary: Can admission assessments predict a student's performance in the course? (Multivariate analysis)

c) Does the predictive validity of the admission assessments vary across the years?

Admission assessment	Its predictive validity across the years of the course
Total personal statement score	Predicted clinical performance in a single year (CP5)
Total BMAT score	Predicted early years of academic performance (Years 2 & 3) and clinical performance of CP3, CP4 & CP5.
Total MMI score	Predicted academic performance of one year (Year 3) and clinical performance of CP3 & CP4.

d) Which section of the BMAT has the most predictive validity?

Outcome	BMAT section
Total CP score	Section 3
Total academic performance score	None of the BMAT sections had statistically significant coefficients.
Total OSCE 3 score	None of the BMAT sections had statistically significant coefficients.
Total OSCE 4 score	Section 3
Average of communication stations score / OSCE 3	Section 3
Average of fine motor stations score / OSCE 3	Section 2
Average of communication stations score / OSCE 4	None of the BMAT sections had statistically significant coefficients.
Average of fine motor stations score / OSCE 4	None of the BMAT sections had statistically significant coefficients.

Continued summary: Can admission assessments predict a student's performance in the course? (Multivariate analysis)

e) MMI versus OSCE : Which station of the MMI has the most predictive validity

Outcome	MMI station/s
Average of communication stations score / OSCE 3	Empathy and communication station Insight station
Average of fine motor stations score / OSCE 3	Presentation station
Average of communication stations score / OSCE 4	Empathy and communication station
Average of fine motor stations score / OSCE 4	Presentation station

4.3.2.5 Risk of failure

Initial plan was to assess the prediction of failure in clinical practice and academic modules using binary logistic regression, however, it was not statistically suitable to run the regression analysis. Therefore, univariate analysis was used to assess the association between these categorical variables and the predictor variables.

1- **CP Failure**

2015 cohort

There were seven students who had at least one failure in clinical practise assessments. A fisher's exact and chi square tests were conducted between the categorical predictor variables and failure in clinical practice. There was no statistically significant association between gender, Access to Leeds eligibility, maturity, qualification level or ethnicity and failure in clinical practice.

ANOVA test was conducted between the continuous predictor variables and failure in clinical practice. There was no statistically significant association between total personal statement score, total BMAT score or total MMI score and failure in clinical practice.

2016

There were nine students who had at least one failure in clinical practise assessments. A fisher's exact and chi square tests were conducted between the categorical predictor variables and failure in clinical practice. There was no statistically significant association between gender, Access to Leeds eligibility, maturity, qualification level or ethnicity and failure in clinical practice.

ANOVA test was conducted between the continuous predictor variables and failure in clinical practice. There was no statistically significant association between total personal statement score or total BMAT score and failure in clinical practise. However, there was a significant association between total MMI score and failure in clinical practise ($p= 0.017$).

In summary, among all the socio-demographic factors and admission assessments considered, only total MMI score was found to be significantly associated with failure in clinical practise.

1- Academic failure

2015

There were eighteen students who had at least one failure in academic assessments. A fisher's exact test was conducted between the categorical predictor variables and failure in academic assessments. There was no statistically significant association between gender, Access to Leeds eligibility, maturity, qualification level or ethnicity and failure in academic assessments.

Anova test was conducted between the continuous predictor variables and failure in academic assessments. There was no statistically significant association between total personal statement score, total BMAT score or total MMI score and academic assessments failure.

2016

There were thirty students who had at least one failure in academic assessments. A fisher's exact test was conducted between the categorical predictor variables and failure in academic assessments. There was no statistically significant association between gender, Access to Leeds eligibility, maturity, qualification level or ethnicity and failure in academic assessments.

Anova test was conducted between the continuous predictor variables and failure in academic assessments. There was no statistically significant association between total personal statement score, total BMAT score or total MMI score and failure in academic assessments.

In summary, none of the socio-demographic factors and admission assessments considered had a significant association with academic failure.

2- Unprofessional behaviour

2015

There were 2 students with reported professionalism breach. A fisher's exact test was conducted between the categorical predictor variables and professionalism breach. There was no statistically significant association between gender, Access to Leeds eligibility, maturity, qualification level or ethnicity and professionalism breach. Anova test was conducted between the continuous predictor variables and professionalism breach. There was no statistically significant association between total personal statement score, total BMAT score or total MMI score and professionalism breach.

2016

There were fourteen students with reported professionalism breach. A fisher's exact test was conducted between the categorical predictor variables and professionalism breach. There was a statistically significant association between gender (male) and Access to Leeds eligibility and professionalism breach. On the other hand, no statistically significant association between maturity, qualification level or ethnicity and professionalism breach. Anova test was conducted between the continuous predictor variables and professionalism breach. There was no statistically significant association between total personal statement score, total BMAT score or total MMI score and professionalism breach.

In summary, among all the socio-demographic factors and admission assessments considered, gender (male) and Access to Leeds eligibility were found to be significantly associated with professionalism breaches. The type of professionalism breach was not specified in the data provided for analysis. If this had been known, we could have made an attempt to understand the reasons behind the breach by these groups and recommend strategies to prevent it in the future.

Summary: Risk of failure and professionalism breaches

Which admission variables were significantly associated with failure?

	Number of CP failure	**Number of academic failure**
Admission variable/s	Total MMI score	None

Which admission variables were significantly associated with unprofessional behaviour?

Gender and Access to Leeds eligibility were found to be significantly associated with professionalism breaches.

Chapter 5 Discussion

5.1 Overview

The overall goal of this thesis was to investigate the predictive validity of admission assessments in predicting future performance of dental students and whether any of the used assessments are biased towards or against a certain personal characteristic. The findings can be parsed into two themes: (i) the predictive validity of admissions assessments, and (ii) the fairness of admissions assessments. The following section provides a discussion of these themes, informed by the results of the data analysis described in the preceding chapter.

5.2 The predictive validity of admission assessments

The admission assessments were personal statement scores, BMAT scores and MMI scores. Firstly, the correlation between these admissions assessments and the in-course performance of students was investigated. Then, the incremental validity of the admissions assessments was studied in an attempt to understand the variance, if any, added by each assessment. Further analysis was conducted as addressed by the preceding analysis's findings. This was explained in depth in the preceding chapter. In the section that follows, findings about the predictive validity of each admissions assessment will be briefly described.

5.2.1 Personal statement

Starting with the 2021 cohort, the use of personal statements in admissions has been abandoned at the school of dentistry. However, because it was considered in the admissions process of 2015 and 2016 cohorts, its correlations with students' performance in addition to its potential to predict student achievement in those cohorts was assessed. When its correlations were assessed, personal statement total score did not show any significant correlation with any of the outcome measures considered. However, its sub-scores of reflective skills and achievement & interests showed positive correlations with academic in-course performance and OSCE procedure scores. Surprisingly, life experience & social awareness in addition to motivation & insight scores showed negative correlations with OSCE procedure and gross motor stations scores. When its predictive validity across the years of the course was assessed, results showed that the personal statement total score had only one significant predictive value with clinical practice performance in the fifth year. However, our investigation of the incremental validity of the admission assessments showed that personal statement did not add any statistically significant value in explaining the variance in students' performance with any of the considered outcome measures. This is in agreement with Ferguson et al study, in which they found that neither the categories of information contained in personal statements nor the quantity of information contained in personal statements were shown to be predictive of future students' performance (Ferguson et al., 2000).

5.2.2 BMAT performance

Multiple positive correlations were found between both BMAT total and sections scores with academic and clinical aspects of the course. Both sections 1 and 2 demonstrated correlations with OSCE scores. However, section 3, showed correlations with only OSCE and clinical scores. However, these correlations demonstrate an association rather than causality.

When the predictability of students' performance across the years of the course was assessed, total BMAT score showed statistically significant coefficients with multiple academic and clinical outcomes of the course. For instance, total BMAT score had significantly predicted academic performance of second and third years of the course in addition to clinical performance of third, fourth and fifth years of the course. To further investigate which section of the BMAT had the most predictive validity, series of multiple regressions were run to assess this.

As for section 1, it was not found that it significantly predicted any of the outcome measures considered in our study. However, multiple positive correlations with individual modules in the first, third and fourth year of the course were found. On the other hand, BMAT section 3 (writing task) had significant coefficients with total CP score, total score of fourth year OSCE and average score of communication stations of third year OSCE. This is similar to finding in Davies et al study who found that section 3 scores have predicted fifth year clinical assessment performance at one of the institutions included in their study (Davies et al., 2022). It was also found that BMAT section 2 (scientific knowledge and application) had a significant coefficient with only average score of fine motor stations of third year OSCE. However, in Davies et al. study they found that section 2 predicted all written assessments in both institutions. In fact, their multivariate analysis confirmed that section 2 was the most predictive among BMAT sections (Davies et al., 2022). Looking at the correlation assessment that was carried out between each module score and BMAT sections, positive correlations between BMAT section 2 and multiple modules in the first, second, third and fourth years of the course were found. However, in the multiple regressions, only the total academic score in addition to the other outcome measures that we previously specified was included. So, these differences in the finding in our study and Davies study might be attributed to the different outcome assessment utilised in the regressions. This highlights a consideration of investigating the predicative validity for individual modules assessment to further understand the predictability of section 2. Additionally, in Emery and Bell study in which they assessed the predictive validity of the BMAT for the students' performance by examining the data of four cohorts of students at the medical course at the University of Cambridge. They found that section 2 was shown to have a stronger correlation with exam scores and with achieving the highest examination class, however this was in the pre-clinical examinations score only (Emery and Bell, 2009a). This is not surprising as both are assessments of scientific knowledge. Although BMAT does not assess motor skills, it assesses the ability to apply scientific knowledge (section 2) in addition to problem solving and critical thinking skills (section 1) which can contribute to the clinical reasoning ability which is needed when performing dental procedures. In addition, BMAT section 3 demonstrate the capacity to consider different aspects of a proposition, and to communicate them effectively in writing. This could explain BMAT's predictive validity of OSCE communication stations. In fact, in a recent study carried out by Paton et al, to assess if BMAT and UCAT scores are able to predict performance on the postgraduate Membership of the Royal Colleges of Physicians (MRCP) examination, including the clinical examination Practical Assessment of Clinical Examination Skills (PACES). The found that various subtest scores of both BMAT and UCAT had significant incremental validity for predicting performance on the written sections of the MRCP. While only aptitude and skills on BMAT and verbal reasoning on UCAT had incrementally predicted passing PACES. Based on these findings, they concluded that the cognitive abilities assessed by aptitude and skills and verbal reasoning may be the best predictive of future clinical performance among those commonly assessed at selection (Paton et al., 2022). Although BMAT will be discontinued, evidence regarding which component of BMAT is predictive could contribute to the selection of a future admissions test or perhaps in the future weighting of different admissions assessments.

Moreover, the addition of BMAT in the hierarchical regression models showed multiple significant contributions in explaining the variance in different outcome measures. For example, in 2015 cohort, total BMAT score added 21.9% explanation to the variance of CP total score. However, there was no significant contribution in explaining the variance in the total academic score. Investigating BMAT's contribution to the variance explained of OSCE performance, data revealed that BMAT had added a statistically significant value in the explanation of variance of total third year OSCE score, total fourth year OSCE performance, average of communication stations in third year OSCE score, average of fine motor stations scores in third year OSCE and average of communication stations in fourth year OSCE of 16.6%, 8%, 12.6%, 9.1% and 9.5%, respectively. However, this significance was not noted in 2016 cohort.

In 2021 and 2022 cohorts, in which the applicants' GCSE and level 3 scores was available, multiple correlations between BMAT scores and both GCSE and Level 3 scores were identified, as well as linear regressions demonstrating that GCSE and level 3 scores can significantly predict BMAT scores. However, this does not undermine the value of such admission tests, since it is certainly a good practice for all applicants to take a standardized admission test, particularly when the applicant pool has high previous academic scores to increase the granularity of data used to rank candidates. Unfortunately, the GCSE and Level 3 scores of cohorts 2015 and 2016 were not available for analysis, so it was not possible to assess the incremental validity of BMAT over GCSE and Level 3 scores. However, of all the admissions assessments evaluated in this project, BMAT appears to be the most capable of explaining some of the student performance variation.

Furthermore, multiple correlations between MMI and BMAT scores were observed. Interestingly, only in 2021 and 2022 cohorts did the total BMAT score predict the total MMI score. This could be explained by the different designs of the MMI, as the origami and tangrams stations were not included in 2021 and 2022.This could indicate that these stations are measuring distinct attributes, however neither station demonstrated predictive validity of students' performance. This finding does not necessarily imply that BMAT and MMI are measuring similar skills as this might also be due to student profile being individuals who perform highly on the BMAT also score highly on the MMI. This may also be attributed to the fact that some of the BMAT sections such as sections 1 & 3 may be associated with MMI performance, such as the correlation noted between BMAT section 3 and the communication station in the MMI. However, even in 2021 and 2022, when the BMAT was predictive of the MMI, it only explained 2.4% and 3.1% of the variation in the MMI total score.

Therefore, we believe that BMAT was significant source of additional admissions information that can predict the student's future performance. This is in agreement with Emery and Bell who suggested that BMAT serves as a valuable source of extra admissions information especially when the previous academic achievements of the applicants are high (Emery and Bell, 2009b).

5.2.3 MMI

There is little evidence in the dental literature that evaluates the underlying skills assessed in the MMI. One study by Mirghani et al. (2019b) was found that assessed the underlying skills assessed in the MMI in a single cohort at the University of Leeds, School of Dentistry. Statistically evaluating the admission assessments will allow evidence informed improvements in the admission process. In this project, the underlying skills being captured in the MMI were investigated in four cohorts using the principal component analysis.

In 2015 cohort, it was found that, despite that eight stations were designed to assess different skills, most of the variance in performance could be attributed to four underlying components. The first related to one station (presentation) which reflects the candidate presentation skills. Thus, component one was labelled “presentation skills”. The second component related to two stations, ethics & professionalism and empathy. Therefore, this component was labelled “ethics and professionalism”. The third component related to three stations, data analysis & interpretation, insight and tangrams. In the insight station, students were provided with a picture and were asked to discuss barriers or issues that the individuals in the picture might have if they had to access/get healthcare according to the picture provided, this could explain why this station loaded with the interpretation and tangrams stations. This component was labelled “analytical and visual-spacial awareness”. The fourth component related to two stations, origami and observation & memory. Multiple skills can be captured by these stations. Origami requires mental concentration to follow the instructions in addition to motor skills, however considering that these stations load together questions how much origami assesses the motor skills of an applicant. This component was labelled “visuomotor component”.

In 2016 cohort, it was found that most of the variance in performance in the eight stations could be attributed to three underlying components. The first related to three stations (insight, ethics & professionalism and presentation stations). Presentation station assesses communication skills in addition to the candidate’s understanding of the topic. The topic of the presentation for this cohort has an ethical component. This could be a rationale for the loading pattern and station scoring profile of the candidates. Thus, component one was labelled “Ethics and professionalism”. The second component related to two stations, (origami and data analysis & interpretation stations). Therefore, this component was labelled “analytical and visuomotor skills”. In this cohort origami station loaded with the interpretation station while as noted in the previous cohort, it loaded with observation and memory. This might indicate that this station is reflecting an applicant’s soft skill more than their motor skill. The third component related to two stations, (tangrams and observation & memory). This component was labelled “visual-spacial awareness”. When comparing the cohorts, it is noted that tangrams, origami, observation & memory and data analysis & interpretation stations are interchangeably loading together, this might indicate that they are measuring similar underlying constructs related to analytical and visual-spacial awareness.

In 2021 cohort, it was found that all the variance in performance in the five stations attributed to one underlying components, which reflects the candidate soft skills. Thus, this component was labelled “soft skills”. Given that dental education needs more than soft skills, the design of the MMI stations should be reviewed so that they measure various skills that are crucial for prospective dental students.

In 2022 cohort, it was found that all the variance in performance in the five stations attributed to three underlying components. The first related to two stations (Resilience and social awareness). Thus, component one was labelled “self and social awareness”. However, this social awareness station includes an element of analytical skills as the candidate was provided with a graph to interpret. Therefore, this station requires a skill other than the one intended to be measured. This observation suggests that there is a need to evaluate the scenarios used in each station to ensure that the stations are measuring what they are designed to measure. The second component related to one station, (Motivation). Therefore, this component was labelled “Motivation”. The third component related to two stations, (ethics and professionalism). This component was labelled “ethics and professionalism”.

In Mirghani’s et al study, it was found that all 10 stations loaded in two components: soft skills and motor skills. CKAT station, simodont station, origami station, and tangrams stations loaded in the motor skills component. While the remaining stations loaded in the soft skills component (Mirghani et al., 2019b). However, in our evaluation, the majority of the stations measured soft skills, with the exception of origami. However, origami did not load solely on a motor component. This might be due to the fact that origami measures skills other than motor skills that loaded with other stations. This may highlight the need to re-evaluate the test used to evaluate motor skills of the applicants. Moreover, it appears that several stations loaded in the same component, such as ethics & professionalism and empathy. This information may be beneficial for lowering the number of stations that assess the same underlying skill and replacing them with other stations to cover more assessment domains.

All scorings of MMI including total score, component scores, stations scores and perception of assessors scores showed positive correlations with various academic and clinical aspects of the course including OSCE total score, average of communication stations scores and average of motor stations scores. These were summarized in the preceding chapter. However, correlations are only an indication of an association. When the predictability of students' performance across the years of the course was assessed, MMI showed statistically significant coefficients with third year and fourth year clinical performance in addition to third year academic performance. The corelations between this year's modules and MMI were further assessed. It was found that MMI total score had a significantly positive weak correlation with personal and professional development module, in which 40% of the score is attributed to a reflective log and oral presentation, which could explain the correlation. As for 3rd and 4th year clinical performance, it's worth noting that 60% of CP3 score is attributed to OSCE performance while 50% of CP4 score is attributed to OSCE 4 score. The remaining score of CP4 is attributed to an online assessment (40%) and case presentation (10%) while the remaining score of CP3 is attributed to a report on clinical cases (40%). Multiple correlations were found between MMI stations and OSCE performance, therefore, series of multiple regressions were conducted to assess if certain stations are able to predict OSCE performance. These results demonstrated that the MMI empathy & communication station and insight station had significant coefficients with average of communication stations in both 3rd and 4th year OSCE, thus they may be useful predictors of these. Moreover, the presentation station had significant positive relationship with fine motor stations scores in the 3rd and 4th year OSCE. The skills assessed in the fine motor stations and the presentation stations are different, however, this finding could be attributed to student's profiling being those who do well in this station also perform well in fine motor stations. In contrast, the stations aimed to assess visuomotor skills had no significant coefficients with OSCE fine motor stations. Therefore, this re-emphasizes the need to evaluate the test used to assess the motor skills MMI. Various tests have been used to assess motor skills and so could be considered. These include block carving (Gansky et al., 2004), the tremometer test, the two-hand coordination machine (Luck et al., 2000), the O'Connor Tweezer Dexterity Test (Lundergan et al., 2007) (Lugassy et al., 2018) and the Purdue Pegboard Test (Wilson et al., 1991, Lugassy et al., 2018). However, there is no agreement on the test with best predictive validity. Some findings such as (Foley and Hijazi, 2013) support the correlation between assessment of motor skills at admission level and future performance, while others such as (Giuliani et al., 2007, Oudshoorn, 2003) found them as poor predictors of future performance. It is important to consider positive transfer theory, which is defined as a condition in which practicing one motor task significantly improves performance on another. This transfer is contingent on the existence of identical elements between two performances (i.e., for transfer to occur, the two performances should be as similar as possible) (Lugassy et al., 2018). Therefore, if motor skills are to be tested at the admissions level, it is crucial that the tests are relevant to the needs of the dental field and have shown evidence of good predictive validity.

However, looking into the hierarchical regression models, there was no significant contribution of MMI total score in explaining the variance in the total CP score, total academic score, nor in any of the OSCE scores.

Nonetheless, MMI is a process rather than a single instrument, hence its psychometric features will change based on the stations, the alignment between the stations and the attributes an institution values, and the outcomes used (Eva and Macala, 2014). Therefore, careful MMI design is crucial as it enables the psychometric features of the MMI to be examined and the design to be modified to enhance the admissions process.

5.3 Fairness of the admission assessments

5.3.1 The association between the socio-demographic characteristics of the applicant/student and their performance in the admission assessments

5.3.1.1 Previous academic achievement (GCSE & Level 3 scores)

When the previous academic performance was analysed, the results revealed that females performed significantly better than males in total GCSE score and

English score. This is similar to the finding of Bramley et al, in which they found that females outperformed males across all subject areas (Bramley et al., 2015). As for Access to Leeds eligible group, they performed significantly lower than non-eligible group in total GCSE and level 3 score. This is similar to the findings in Cleland's report which indicate the bias of A levels examination in favour of those from higher social classes (Cleland et al., 2012b). In fact, it was found that Access to Leeds eligibility had statistically significant coefficient in predicting both GCSE and Level 3 score. While gender proved to significantly predict total GCSE score only. This is why contextualized admissions schemes, such as Access to Leeds, have been implemented. These schemes enable applicants from widening participation backgrounds who have the potential to succeed to enrol in the program with a lower academic profile.

5.3.1.2 Personal statement

Mature students were found to perform significantly better in personal statement total score and personal statement life experience score. Likewise, students holding a degree scored significantly higher in the personal statement total score, life experience and social awareness score in addition to interests and achievement score. On the other hand, Access to Leeds eligible group scored significantly lower in personal statement total score, life experience and social awareness score and reflective skills score. However, they performed higher in achievement and interests score. Albanese et al, surveyed enrolling medical students for three years. 41% to 44% of respondents reported that they received input from others in the preparation of their personal statements. Of this reported input, 15% to 51% was in the content of the statement and 2% to 6% was received from professional services (Albanese et al., 2003). This could explain the lower personal statement scores of candidates of lower socioeconomic status as they lack the resources and networks (Cleland et al., 2012b). However, none of the personal characteristics reached a statistically significant coefficient to predict their performance in the personal statement score. These concerns regarding the integrity of the personal statement as an admissions tool have resulted in its exclusion from the admissions shortlisting procedures at the School of Dentistry, University of Leeds.

5.3.1.3 BMAT

Data analysis revealed that school leavers have performed significantly better in total BMAT score, BMAT section 1 and BMAT section 2. On the other hand, A2L eligible students and students with a degree scored significantly lower in total BMAT score, section 1 score and section 2 score. This is similar to the finding of Emery et al in which they found that applicants from independent and grammar school, and those from highly experienced centres scored considerably better on both Sections 1 and 2 of the BMAT than their baseline comparison groups (Emery et al., 2011). Moreover, student's ethnicity has also been associated with differences in total BMAT score, BMAT section 2 and BMAT section 3. For instance, Asian British Pakistani had significantly lower BMAT scores than white and Asian other ethnicities. In fact, qualification level, ethnicity and maturity had statistically significant coefficients that predicts the BMAT score.

5.3.1.4 MMI

As for gender, it was found that females performed better than males in certain stations such as presentation and insight stations. Also, mature students performed better in communication and resilience stations. On the other hand, Access to Leeds eligible applicants scored lower in MMI total score and in multiple stations such as origami, communication, motivation & insight and resilience stations. Student's ethnicity also had been associated with MMI total score, perception of assessor score and multiple stations such as empathy & communication, data analysis & interpretation, ethics & professionalism, presentation and insight stations. For instance, Asian other ethnic group performed significantly lower that other ethnic groups. As for multiple regression results, it was found that qualification level had statistically significant coefficient predict an MMI score that is 4.37 less for a student with a degree qualification than another with A level or equivalent qualification. However, none of the remaining variables had a coefficient that reached statistical significance. There is conflicting evidence in literature regarding the impact of different socio-demographic factors on MMI scores. For instance, some researchers found that female candidates performed better than male candidates in MMI total score

(Barbour and Sandy, 2014a, Jerant et al., 2012, Alaki et al., 2016). This is similar to our research finding. However, other researchers reported no significant association between gender and performance in MMIs (Eva et al., 2004c, O'Brien et al., 2011, Uijtdehaage et al., 2011). As for age, some studies were in agreement with our finding. For instance, some researchers found that older applicants performed better than their younger counterparts in MMI. It was justified by being older applicants more likely to have had more life experiences in comparison to younger applicants (O'Brien et al., 2011, Jerant et al., 2012, Leduc et al., 2017). However, O’Brien et al, found no correlation between age and MMI score (O'Brien et al., 2011). In regard to socioeconomic status, Uijtdehaage et al found no difference in MMI score for self-reported economically or educationally disadvantaged applicants (Uijtdehaage et al., 2011). However, Leduc et al reported that candidates with a higher family income had better MMI scores (Leduc et al., 2017). Moreover, Jerant et al investigated several factors, including parents’ education level, whether the applicant had contributed to family income, and whether the applicant was in receipt of income support. They found that candidates from a more deprived background had a significantly lower MMI score (Jerant et al., 2015). In our investigations, there was significant difference found in MMI performance between different ethnic groups. For instance, Asian other performed lower in MMI than white, Asian British Pakistani, Asian British Indian and Asian Chinese. On the other hand, Asian British Pakistani performed higher on data analysis and interpretation station compared to white candidates. However, Leduc et al, found that applicants who reported themselves as Chinese or Southeast Asian performed significantly worse than all other ethnic groups (Leduc et al., 2017). It was also found in their study that White/Caucasian applicants performed significantly better than other ethnic groups ($p=0.012$). On the other hand, Jerant et al found no association between race and MMI performance (Jerant et al., 2015).

5.3.2 The association between the socio-demographic characteristics of the student and their in-course performance

5.3.2.1 Gender

In our investigation, females were found to score higher in different aspects of the course. For instance, they scored higher than males in total CP, CP 1, CP3 and CP4 scores. In addition, they scored higher in 3rd and 5th year academic modules average, OSCE 4 total score and OSCE 4 average of communication and procedure scores. In fact, gender added a significant variance of 19.2%, 15.5% and 9% in total OSCE 4 performance, 4th year average of communication stations scores and OSCE 4 fine motor stations score. This indicates that admission assessments, such as the MMI, in which females demonstrated better performance, may not indicate a sign of bias. In fact, it could be measuring a true difference in performance between genders. This is in agreement with Foley and Hijazi study in which they found a significant correlation between gender and CAS in which female students achieved greater CAS scores in comparison to male students (Foley and Hijazi, 2013). However, other studies found no significant correlation between gender and in-course performance (Lala et al., 2013, Foley and Hijazi, 2015, McAndrew et al., 2017).

5.3.2.2 Maturity

Despite that the data revealed that maturity added a significant variance of 8.6% and 16.3% in explaining the performance in 3rd year average of fine motor stations and total academic score respectively, there was no statistically significant difference noted between mature and school leaver students in clinical or academic in-course performance in the assessed cohorts. This could be attributed to the fact that in the assessment of incremental validity, all factors are considered together, and maturity seems to explain some of the variance in this situation. This also highlights the need of continuing to assess additional cohorts to gain a better understanding of how age can influence success. If it was consistently found that there was no difference in in-course performance between the groups, while it still exists in some of the admission assessments as found in this research in MMI, BMAT and personal statement scores, this might indicate a sign of bias. Students' age was assessed by Foley and Hijazi in two papers. They reported no significant association between age and CAS scores in their 2013 study. However, they reported age as a significant predictor of CAS scores in their 2015 study (Foley and Hijazi, 2013, Foley and Hijazi, 2015).

5.3.2.3 Qualification level

In 2015 cohort, qualification level added a significant value of 5.8% in explaining the variance in 4th year OSCE average of communication stations score. Moreover, students with degree level scored higher in CP1 scores in 2016 cohort. Qualification level was found to have a significant association with applicants' performance in MMI and BMAT in which they performed lower than their counterparts in BMAT which might indicate a sign of bias. However, this needs to be further evaluated on larger numbers and different cohorts to be able to judge bias in assessment.

5.3.2.4 Access to Leeds eligibility

A2L eligible students were found to score lower in different aspect of the course. For example, they scored lower in 2nd and 3rd academic modules averages, total OSCE 4 score, average of procedure and gross motor stations in OSCE 4, CP1 and CP2 scores. Moreover, in 2016 cohort, A2L added a significant variance of 27.1% in 3rd year average of fine motor stations score. Additionally in 2015 cohort, A2L added a significant variance of 8.4%, 15.3% and 9.5% in total OSCE 4 score, total academic score and in 4th year average of communication stations score, respectively. This could indicate that the difference in admission assessments performance between this group and the non-eligible one is a true difference and not a sign of bias. However, these finding also highlights the need of providing further ongoing support throughout the course to this group beside the support provided on admission level.

5.3.2.5 Ethnicity

In 2015 cohort, ethnicity added a significant variance of 16,9%, 17% in total OSCE 4 score and average of communication stations scores, respectively. Moreover, ethnicity added a significant variance of 13.8% and 23% in 3rd year average of communication stations score in both 2015. & 2016 cohorts, respectively. In addition to a significant variance of 11.2% and 21.3% in total OSCE 3 score in both 2015 & 2016, respectively. As for fine motor stations average score, ethnicity had also added a significant variance of 27.1% in 4th year OSCE of 2016 cohort. In fact, white ethnicity performed significantly higher than multiple ethnic groups in different in-course assessment. The disparities in dental school performance among different ethnicities can be influenced by various factors. These factors may include socio-economic background, access to educational resources, cultural factors, discrimination or bias, language barriers, and varying levels of prior educational opportunities. It is essential to recognize that individual experiences and circumstances can significantly impact academic performance. Further research and analysis are needed to better understand the complex interplay of these factors and their effects on dental school performance across different ethnicities. Similar to what is discussed in A2L, difference in admission assessment performance, such as in BMAT, between different ethnic groups might reflect a true difference in future performance rather than bias.

Nonetheless, diversity between students is crucial. It is found that presence of diversity among students increases the educational outcome and improves discussions (Gurin et al., 2002, Whitla et al., 2003). It is also suggested that diversity may improve the health care provision for minority populations, as research has shown that the under-represented minority physicians are more likely to serve minority populations (Whitla et al., 2003). Therefore, in addition to the universities' responsibilities to assess their admissions procedures in order to guarantee a fair to access higher education, there must be enough support to ensure that groups at risk of poor performance make adequate progress during the course. An example of this support was in the extended medical degree programme (EMDP) at King’s College London, which was aimed to widen participation in medicine, the training takes six years instead of five, to ensure a gradual increase of the workload. From the start, EMDP students are taught alongside the conventional counterparts, however, in their extra available time they are provided with small-group tutorials. An induction week, student mentors, dedicated study and socializing rooms, small group teaching sessions; personalized learning programmes; an annual prize-giving ceremony; and (optional) informal discussions on cultural values are other examples of the supportive features offered at EMDP. They found that 10% of EMDP students get merit awards for finishing in the top 15% of their year group when they take identical exams to conventional classmates at the end of their second year on the programme. They concluded that students have the ability to succeed without AAB at A level if these results were obtained from a low-achieving school. This study may indicate students of a similar background may succeed at their highest level when assistance is provided (Garlick and Brown, 2008).

However, it is worth mentioning that bias and fairness are not synonymous. Perspectives on what is fair may differ even if unbiased selection tools are used. It is definitely unacceptable that an admissions tool demonstrates bias with regard to school type, socio-economic status, gender, or ethnic origin as it is concerning if appropriately competent applicants from specific groups are unfairly rejected owing to biased selection methods. As for fairness, one viewpoint holds that the admissions process should prioritise success in the course of study independent of group membership. Others may suggest that once minimal competency has been met, minorities should be taken into account. Another point of view is that admissions ought to be proportional to the number of applicants from each group that submits an application (Emery et al., 2011). Yet, according to Schwartz review, the admissions process should not be held responsible to compensate for socioeconomic disadvantages or educational inadequacies elsewhere in the educational system (Schwartz, 2004). However, each institutions has its approach to widen participation such as Access to Leeds scheme which guarantees special consideration for applicants whose specific circumstances may have affected their academic grades (Access to Leeds, 2020). Different schemes are expected to assess the talent and potential of candidates as talent and potential may not be fully exhibited by only exams outcomes. Instead, selection should be for merit of previous performance, potential and diversity. This may require additional assessment such as interviews and consideration of the educational context of the applicant. In addition, ensuring a fair admission process requires transparency as well as a valid and reliable assessments (Schwartz, 2004).

So, who will succeed and who is likely not to? What are the predictors of this success?

What can admission assessments tell us?

Who are the higher achievers in academic and clinical performance?

-Higher achievers in total BMAT score (incremental and predictive validity)

-Higher achievers in total MMI score (predictive validity)

Were we able to predict clinical failure? It was found to be associated with lower MMI total scores

Were we able to predict academic failure? No

Which skills assessed in MMI that showed predictive validity of students communication and fine motor skills when mapped to OSCE?

Empathy and communication

Insight

Presentation skills

Who do we know at risk of lower in-course performance by looking at personal characteristics?

A2L eligible students

Male students

Certain ethnic groups

Who do we know at risk of demonstrating unprofessional behaviour by looking at personal characteristics?

A2L eligible students

Male students

Certain ethnic groups

Figure 13: Summary: Predictors of students' success

5.4 Recommendations

Recommendations for admissions

1- On the basis of these findings, we recommend that admissions committee continue to review admissions data on a frequent basis to assist in the development and refinement of the admission process.

2- We also suggest a more organized storage system for complete admissions data at the admissions office. This will allow and facilitate a more precise review of the process. If more data from several cohorts are accessible and available, the external validity of the research will certainly increase.

3- We also recommend re-considering the MMI stations based on the evidence provided in this research and the evidence available in literature. For example:

- Stations with significant predictive validity, such as the empathy and communication station and the insight station, could be retained.
- Stations with no predictive validity may be eliminated or replaced. In addition, stations that loaded in the same MMI component, indicating that they are measuring a similar underlying construct, could be eliminated. This will allow for a reduction in the number of stations or for the substitution of these stations with others that measure skills that have been demonstrated to have significant predictive ability in the literature such as emotional intelligence (EI) and motivation. In a recent review, researchers found that emotional intelligence (EI) may be an essential tool for managing stress and negative emotions. In addition, they found that EI had a strong impact on the academic performance of dental students throughout their clinical years (Jahan et al., 2022). As for motivation, it is becoming increasingly crucial in health education due to its important effect on the student's performance and well-being that has been shown in research (Orsini et al., 2016). In another study carried out by Orsini et al to investigate the association between the dental students' motivational profiles with their study styles, academic performance and self-esteem. They found that the high intrinsic

motivation groups were deeper rather than surface learners and that they showed higher academic performance and higher scores for self-esteem than low intrinsic motivation groups (Orsini et al., 2018).

- In stations that aim to assess motor skills, alternative tests that better reflect the motor skills required in dentistry should be considered.
- Careful consideration of the task used to assess each skill. As noted in the insight station of 2015 MMI, the station did not load with the component measuring the targeted skill. This might be attributable to the fact that the task used to evaluate the skill required both visual and analytical reasoning to answer the question.

4- Integrating personality tests into academic admissions processes could be considered. A variety of personality measures have been used, however, one of the most popular taxonomies for classifying personality traits used is the five-factor model (FFM), referred to earlier as the 'Big-Five'. Multiple studies have been carried out to investigate the predictive validity of the facets assessed in the test. For instance, Poole et al found that conscientiousness predicted both clinical and academic performance to different degrees throughout a 4-year dental programme in four Canadian dental school (Poole et al., 2007). Similarly, other studies found that conscientiousness predicted various dental school performance. (Chamberlain, 2004, Evans and Dirks, 2001). In regard to agreeableness, Evans & Dirks found a positive significant association with students' performance (Evans and Dirks, 2001). On the other hand, high 'neuroticism' showed a negative impact on academic achievement and had a negative association with their measure of students' professional behaviour in the clinic (Chamberlain, 2004, Poole et al., 2007).

5- Regarding the BMAT-related findings, sections that have shown significant predictive validity can be taken into account while selecting the future admissions test.

Recommendations for assessment

Given the identification of certain groups being at risk of lower in-course achievement, it becomes necessary to identify and minimize the barriers that these specific groups may face during the admissions process and throughout their academic journey. It is crucial to undertake comprehensive measures aimed at recognizing, understanding, and ultimately minimizing the barriers encountered by these individuals, ensuring that they receive the necessary support to thrive. By actively identifying and addressing these barriers, we can foster an equitable educational environment that enables all students to reach their full potential. Such efforts contribute to the creation of a diverse and enriched academic community, where individuals from all backgrounds can excel and succeed.

Recommendations for future research

1- We suggest collaboration between institutions to provide a more comprehensive investigation of the predictive validity of different admissions assessments.
2- Additional research is required to identify students who are at a high risk for failure or poor performance and provide the necessary support for them. Admission and demographic variables may explain part of the student achievement. However, many other variables, such as psychological factors, learning-related daily habits, and the learning environment, impact students' performance (Meepradit et al., 2022).
3- In addition, we suggest studying the incremental and predictive validity of the admission assessments on 2021 cohort, 2022 cohort and future cohorts, wherein the A level and GCSE data is available. Such a study will provide valuable insights and enable us to offer evidence-based recommendations regarding the grades required in A levels and GCSE for admission. By analysing the relationship between these assessment measures and future academic performance, we can enhance the efficacy of the admissions process, ensuring that the admission requirements align with the demonstrated achievement of students.

4- Furthermore, considering the observed differences in BMAT scores between mature students and school leavers despite the absence of differences in their in-course performance, it is essential to investigate this when utilising the alternative test to replace BMAT. Adequate attention should be given to ensure fair consideration of the required scores for mature students. In this regard, it may be worth exploring the possibility of recognizing the academic achievements of mature students who hold a degree, thereby allowing for different score requirements compared to school leavers. Conducting such a study will enable and aid in the establishment of a more equitable admissions process

5- In light of the importance of motor skills in the field of dentistry, it is strongly advised to conduct research aimed at identifying the best assessment method for evaluating an applicant's motor skills. Additionally, it is crucial to determine the minimum level of motor skill proficiency required from an applicant. By conducting such research, we can establish appropriate processes for assessing and selecting candidates.

5.5 Limitations

This project was conducted at a single institution, and two cohorts were used to evaluate the predictive validity of admission assessments. Although the initial goal was to evaluate the predictive validity in four cohorts, it was only possible to evaluate this in two. This is owing to the deletion of 2014 cohort admission information by the admission office and the impact of the COVID issue on the 2017 cohort's in-course assessment. This limitation affects the generalizability of the results, nonetheless the cohorts assessed still provide a decent understanding of the admissions process at the School of Dentistry of the University of Leeds. If additional research could be conducted on additional cohorts, the results would unquestionably gain greater depth. Moreover, difficulty was faced in obtaining the 2020 cohort admission data and locating some information related to the 2021 and 2022 cohorts. For example, GCSE and level 3 scores could not be located for 2015 and 2016 cohorts, therefore their predictive validity could not be evaluated. In addition, it was not possible to locate some demographic information, including gender and age for the 2022 cohort, as well as ethnicity and Access to Leeds eligibility for the 2021 and 2022 cohorts. However, this did not affect the assessment of predictive validity or assessment of bias in this project as the students' performance data for theses cohorts was not yet available at the time of data collection. Assessment of those was limited to the 2015 and 2016 cohorts as both admission data & in-course performance data were available.

Another issue arises from the availability of data solely for candidates who successfully enrolled in the course for the 2015 and 2016 cohorts, which resulted a range restriction. It was not possible to adjust for this because we lacked information on the properties of the complete distribution of applications, not only the distribution of entrants (successful applicants). Range restriction could be expected to weaken relationships between predictors and outcomes.

By delving deeper into the curriculum, more tasks could have been uncovered that could have been matched to the interview-assessed skills. Examples include group work presentations, poster presentations, spotter tests, as well as clinical crown testing. However, the OSCE involved elements of both soft and fine motor skills and resembled the MMI setting, thus this evaluation was chosen to be mapped to the MMI for assessment of predictive validity.

5.6 Conclusion

In this research the literature has been systematically reviewed for evidence of the predictive validity of admission assessments used in the United Kingdom. The predictability and fairness of the admission process at the School of Dentistry of the University of Leeds have also been investigated which is a topic that is fundamental to the dental education field.

The findings of this thesis support the discontinuation of use of personal statements as a means of selection. It has also been demonstrated that, among the assessments evaluated in this research, the BMAT total score and sections scores appear to be the best predictive of students' performance as the findings have demonstrated evidence of incremental and predictive validity of the BMAT as an admission test. Although BMAT will be discontinued, the research findings may aid in the selection of the future admission test and in selecting similar components to the BMAT sections which were found essential to be included in the next examination. The findings have also indicated that the MMI employed for the cohorts studied has poor incremental validity. However, there is a potential to re-assess the MMI's design based on evidence to improve its quality as a selection tool. Special consideration must be given to the skills assessed in the MMI and the tasks used to assess these skills.

None of the admission assessments showed evidence of bias against gender. However, further assessment of age and qualification level to investigate potential associated bias is needed. According to the findings of our research, admission assessments did not show bias against Access to Leeds eligible or certain ethnic groups, however, the findings highlighted the need to identify individuals at a greater risk of low performance and provide them with the appropriate support to ensure their progress in the course.

This thesis also highlighted the necessity for further and ongoing evaluation of the admissions process to inform optimal practice. There is a huge ethical obligation to choose the best practice for selecting future students as our selection of an admissions test is demanding for applicants in terms of cost, time, effort and stress, it even may discourage them from applying. It is likewise unethical to require candidates to pay for a test or to reject an applicant based on their score on an admissions assessment with minimal predictive value for their future performance. Therefore, it is of critical necessity that the institution adequately stores and manages all the admissions information at the University to facilitate future research. We suggest a future research agenda that includes longitudinal studies examining incremental and predictive validity and following students over the duration of their course and perhaps into their postgraduate years or professional career. Hence enhancing the evidence and informing our admission strategies with evidence for a fair admission process for all! We hope that this thesis contributes to the literature in this area of research, and we eagerly anticipate the future growth of these fields over the following years.

Appendix A Search Strategies of the systematic review

Date: 28-07-2022

Database: Ovid MEDLINEI ALL <1946 to July 27, 2022>

2 Students, Dental/ (6987)

2 Education, Dental/ (15502)

3 exp Dentistry/ (425636)

4 exp Students/ (156724)

5 3 and 4 (3629)

6 (dent* adj4 student*).tw. (9644)

7 (dent* adj4 undergraduate*).tw. (1973)

8 (dent* adj4 education*).tw. (9008)

9 (dent* adj4 applica*).tw. (5214)

10 (dent* adj4 candidate*).tw. (281)

11 (dent* adj4 program*).tw. (5558)

12 1 or 2 or 5 or 6 or 7 or 8 or 9 or 10 or 11 (36968)

13 Psychomotor Performance/ or Academic Performance/ or Work Performance/ (70911)

14 Professional Misconduct/ (3448)

15 educational measurement/ or exp academic performance/ or exp professional competence/ (158158)

16 (academic adj5 (performance or success* or achieve* or attain* or outcome* or score* or assess*)).tw. (21642)

17 (undergrad* adj5 (performance or success* or achieve* or attain* or outcome* or score* or assess*)).tw. (3165)

18 (educat* adj5 (performance or success* or achieve* or attain* or outcome* or score* or assess*)).tw. (52555)

19 (student* adj5 (performance or success* or achieve* or attain* or outcome* or score* or assess*)).tw. (43625)

20 (profession* adj4 behavio*).tw. (4065)

21 (profession* adj4 misconduct*).tw. (294)

22 professionalism.tw. (8260)

23 (unprofession* adj4 (behavio* or misconduct)).tw. (420)

24 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 (325580)

25 12 and 24 (6075)

26 college admission test/ or school admission criteria/ or test taking skills/ (6268)

27 Interviews as Topic/ (66801)

28 exp Personality/ (385364)

29 exp Cognition/ (188347)

30 personality assessment/ or aptitude tests/ or personality tests/ or psychometrics/ (102019)

31 (letter* adj3 recommendation*).tw. (516)

32 (letter* adj3 reference*).tw. (169)

33 psychomotor performance/ or motor skills/ (91182)

34 Forecasting/ (90503)

35 (admission* adj3 (criteria or test* or requirement* or select* or assessment* or entrance* or method* or tool*)).tw. (9282)

36 (select* adj3 (criteria or test* or requirement* or assessment* or entrance* or student* or undergraduate* or method* or tool*)).tw. (131265)

37 interview*.tw. (421597)

38 (cogniti* adj2 (factor* or skill* or abilit* or domain* or dimension*)).tw. (41168)

39 (non-cogniti* adj2 (factor* or skill* or abilit* or domain* or dimension*)).tw. (222)

40 motor skill*.tw. (9985)

41 soft skill*.tw. (346)

42 manual dexterity.tw. (1836)

43 (recruit* adj3 (student* or undergraduate* or candidate* or applicant*)).tw. (4125)

44 (personal* adj3 (domain* or measure* or test* or assessment* or type* or attribute* or trait* or qualities)).tw. (36648)

45 (predict* adj3 (validity or performance* or outcome* or success* or behavio* or score* or attainment* or grade* or achievement*)).tw. (216355)

46 emotional intelligence.tw. (2745)

47 (test* adj3 (ability or aptitude or judgement)).tw. (26357)

48 or/26-47 (1567217)

49 12 and 24 and 48 (1743)

Date: 28-07-2022

Database: Embase Classic + Embase <1947 to 2022 July 27>

2 dental student/ (8885)

2 dental education/ (24284)

3 exp dentistry/ (137708)

4 student/ or exp health student/ or undergraduate student/ or university student/ (270887)

5 3 and 4 (2515)

6 (dent* adj4 student*).tw. (10895)

7 (dent* adj4 undergraduate*).tw. (2209)

8 (dent* adj4 education*).tw. (9099)

9 (dent* adj4 applica*).tw. (5398)

10 (dent* adj4 candidate*).tw. (293)

11 (dent* adj4 program*).tw. (5726)

12 1 or 2 or 5 or 6 or 7 or 8 or 9 or 10 or 11 (44717)

13 motor performance/ or task performance/ or psychomotor performance/ or performance/ (288598)

14 achievement/ or exp academic achievement/ or exp competence/ or performance/ (250352)

15 misconduct/ or professional misconduct/ (4457)

16 education/ or academic achievement/ or “outcome of education”/ or exp school attendance/ or student retention/ (524717)

17 (academic adj5 (performance or success* or achieve* or attain* or outcome* or score* or assess*)).tw. (26733)

18 (undergrad* adj5 (performance or success* or achieve* or attain* or outcome* or score* or assess*)).tw. (3718)

19 (educat* adj5 (performance or success* or achieve* or attain* or outcome* or score* or assess*)).tw. (72212)

20 (student* adj5 (performance or success* or achieve* or attain* or outcome* or score* or assess*)).tw. (54933)

21 (profession* adj4 behavio*).tw. (4880)

22 (profession* adj4 misconduct*).tw. (326)

23 professionalism.tw. (10088)

24 (unprofession* adj4 (behavio* or misconduct)).tw. (508)

25 or/13-24 (1039150)

26 12 and 25 (15013)

27 interview/ or semi structured interview/ or structured interview/ or telephone interview/ or unstructured interview/ (311223)

28 exp personality assessment/ (14608)

29 mental function assessment/ or exp cognition assessment/ (36419)

30 exp psychometry/ (108133)

31 psychologic test/ or aptitude test/ or exp personality test/ (80393)

32 (letter* adj3 recommendation*).tw. (704)

33 (letter* adj3 reference*).tw. (232)

34 psychomotor performance/ (25072)

35 motor performance/ (88495)

36 “prediction and forecasting”/ or forecasting/ or prediction/ or predictive validity/ or predictive value/ (735326)

37 (admission* adj3 (criteria or test* or requirement* or select* or assessment* or entrance* or method* or tool*)).tw. (19985)

38 (select* adj3 (criteria or test* or requirement* or assessment* or entrance* or student* or undergraduate* or method* or tool*)).tw. (180055)

39 interview*.tw. (535548)

40 (cogniti* adj2 (factor* or skill* or abilit* or domain* or dimension*)).tw. (55207)

41 (non-cogniti* adj2 (factor* or skill* or abilit* or domain* or dimension*)).tw. (239)

42 motor skill*.tw. (14552)

43 soft skill*.tw. (440)

44 manual dexterity.tw. (2549)

45 (recruit* adj3 (student* or undergraduate* or candidate* or applicant*)).tw. (5187)

46 (personal* adj3 (domain* or measure* or test* or assessment* or type* or attribute* or trait* or qualities)).tw. (46941)

47 (predict* adj3 (validity or performance* or outcome* or success* or behavio* or score* or attainment* or grade* or achievement*)).tw. (312545)

48 emotional intelligence.tw. (3048)

49 (test* adj3 (ability or aptitude or judgement)).tw. (33497)

50 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 (2090081)

51 26 and 50 (1973)

Date: 28-07-2022

Database: APA PsycInfo <1806 to July Week 3 2022>

2 dental students/ (316)

2 dental education/ (217)

3 exp dentistry/ (478)

4 education/ or higher education/ or school attendance/ or school enrollment/ or school retention/ or student admission criteria/ or student records/ or academic achievement/ or academic aptitude/ or dropouts/ or educational administration/ or school dropouts/ or student attitudes/ or students/ (195119)

5 3 and 4 (18)

6 (dent* adj4 student*).tw. (711)

7 (dent* adj4 undergraduate*).tw. (75)

8 (dent* adj4 education*).tw. (356)

9 (dent* adj4 applica*).tw. (73)

10 (dent* adj4 candidate*).tw. (9)

11 (dent* adj4 program*).tw. (297)

12 1 or 2 or 5 or 6 or 7 or 8 or 9 or 10 or 11 (1279)

13 test performance/ or performance/ (28698)

14 motor performance/ or motor processes/ or motor control/ or motor coordination/ (46965)

15 achievement/ or exp academic achievement/ or exp achievement potential/ or exp failure/ or exp achievement measures/ or “awards (merit)”/ or exp competence/ or exp performance/ or exp productivity/ (209628)

16 ability/ or ability level/ or academic aptitude/ or exp cognitive ability/ or exp communication skills/ or exp competence/ or exp learning ability/ or exp nonverbal ability/ or social skills/ or exp achievement potential/ or creativity/ or exp intelligence/ or exp performance/ (359849)

17 “awards (merit)”/ or exp achievement/ or exp professional recognition/ or exp rewards/ (122192)

18 professional competence/ or competence/ or professional development/ or professionalism/ or professional standards/ (57065)

19 (academic adj5 (performance or success* or achieve* or attain* or outcome* or score* or assess*)).tw. (61493)

20 (undergrad* adj5 (performance or success* or achieve* or attain* or outcome* or score* or assess*)).tw. (6545)

21 (educat* adj5 (performance or success* or achieve* or attain* or outcome* or score* or assess*)).tw. (55740)

22 (student* adj5 (performance or success* or achieve* or attain* or outcome* or score* or assess*)).tw. (109311)

23 (profession* adj4 behavio*).tw. (4119)

24 (profession* adj4 misconduct*).tw. (192)

25 professionalism.tw. (5370)

26 (unprofession* adj4 (behavio* or misconduct)).tw. (146)

27 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 (634058)

28 12 and 27 (335)

29 exp student admission criteria/ (1961)

30 entrance examinations/ or educational measurement/ or college entrance examination board scholastic aptitude test/ (16652)

31 prediction/ or academic achievement prediction/ or “predictability (measurement)”/ or predictive validity/ (34094)

32 exp Interviews/ (18336)

33 exp personality/ (501715)

34 exp cognition/ (41713)

35 personality measures/ or exp psychological assessment/ or california psychological inventory/ or neo personality inventory/ or state trait level measures/ (115863)

36 aptitude measures/ or cognitive assessment/ (8825)

37 (letter* adj3 recommendation*).tw. (298)

38 (letter* adj3 reference*).tw. (108)

39 exp motor skills/ (4787)

40 exp cognitive ability/ (136847)

41 (admission* adj3 (criteria or test* or requirement* or select* or assessment* or entrance* or method* or tool*)).tw. (3540)

42 (select* adj3 (criteria or test* or requirement* or assessment* or entrance* or student* or undergraduate* or method* or tool*)).tw. (30682)

43 interview*.tw. (370509)

44 (cogniti* adj2 (factor* or skill* or abilit* or domain* or dimension*)).tw. (53401)

45 (non-cogniti* adj2 (factor* or skill* or abilit* or domain* or dimension*)).tw. (461)

46 motor skill*.tw. (9218)

47 soft skill*.tw. (610)

48 manual dexterity.tw. (988)

49 (recruit* adj3 (student* or undergraduate* or candidate* or applicant*)).tw. (3873)

50 (personal* adj3 (domain* or measure* or test* or assessment* or type* or attribute* or trait* or qualities)).tw. (75123)

51 (predict* adj3 (validity or performance* or outcome* or success* or behavio* or score* or attainment* or grade* or achievement*)).tw. (98200)

52 emotional intelligence.tw. (7439)

53 (test* adj3 (ability or aptitude or judgement)).tw. (15268)

54 academic achievement/ or achievement/ or college academic achievement/ or academic aptitude/ or educational attainment level/ (84328)

55 personality traits/ (54246)

56 test validity/ (86109)

57 or/29-56 (1349619)

58 12 and 27 and 57 (163)

Date: 28-07-2022

Database

ERIC – Education Resources Information Center (EBSCO) 1966- present

British Education Index (EBSCO) 1986- present

S11	(S7 OR S8 OR S9) AND (S1 AND S6 AND S10)	134
S10	S7 OR S8 OR S9	291,744
S9	TX interview* OR TX (select* N3 (criteria or test* or requirement* or assessment* or entrance* or student* or undergraduate* or method* or tool*)) OR TX (admission* N3(criteria or test* or requirement* or select* or assessment* or entrance* or method* or tool*)) OR TX letter* N3 reference* OR TX letter* N3 recommendation*	207,102
S8	TX manual dexterity OR TX soft skill* OR TX motor skill* OR TX (non-cogniti* N2 (factor* or skill* or abilit* or domain* or dimension*)) OR TX (cogniti* N2 (factor* or skill* or abilit* or domain* or dimension*))	27,955
S7	TX (test* N3 (ability or aptitude or judgement)) OR TX emotional intelligence OR TX (predict* N3 (validity or performance* or outcome* or success* or behavio* or score* or attainment* or grade* or achievement*)) OR TX (personal* N3 (domain* or measure* or test* or assessment* or type* or attribute* or trait* or qualit*)) OR TX (recruit* N3 (student* or undergraduate* or candidate* or applicant*))	73,347

S6	S2 OR S3 OR S4 OR S5	457,230
S5	TX (academic N5 (performance or success or achieve* or attain* or outcome* or score* or assess*)) OR TX (undergrad* N5 (performance or success* or achieve* or attain* or outcome* or score* or assess*)) OR TX (educat* N5 (performance or success* or achieve* or attain* or outcome* or score* or assess*)) OR TX (student* N5 (performance or success* or achieve* or attain* or outcome* or score* or assess*)) OR TX profession* N4 behavio* OR TX profession* N4 misconduct* OR TX (unprofession* N4 (behavio* or misconduct))	335,198
S4	professionalism OR professional misconduct OR unprofessional conduct OR professional competence	8,978
S3	TX academic performance OR TX academic achievement OR TX academic success OR TX outcome OR TX academic attain* OR TX competence	295,807
S2	TX psychomotor performance OR TX motor skill* OR TX manual dexterity	5,251
S1	TX dent* N4 student* OR TX dent* N4 undergraduate* OR TX dent* N4 education* OR TX dent* N4 applica* OR TX dent* N4 candidate* OR TX dent* N4 program*	2,382

Date: 28-07-2022

Database: Web of Science Core Collection: Citation Indexes (Clarivate Analytics) 1900-present

Total number of records found: 904

9 #8 AND #4 AND #1
Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=All years

8 #7 OR #6 OR #5
Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=All years

7 **TOPIC:** (interview*) *OR* **TOPIC:** ((select* NEAR/3 (criteria or test* or requirement* or assessment* or entrance* or student* or undergraduate* or method* or tool*))) *OR* **TOPIC:** ((admission* NEAR/3(criteria or test* or requirement* or select* or assessment* or entrance* or method* or tool*))) *OR* **TOPIC:** (letter* NEAR/3 reference*) *OR* **TOPIC:** (letter* NEAR/3 recommendation*)
Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=All years

6 **TOPIC:** (manual dexterity) *OR* **TOPIC:** (soft skill*) *OR* **TOPIC:** (motor skill*) *OR* **TOPIC:** ((non-cogniti* N2 (factor* or skill* or abilit* or domain* or dimension*))) *OR* **TOPIC:** ((cogniti* N2 (factor* or skill* or abilit* or domain* or dimension*)))
Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=All years

5 **TOPIC:** ((test* NEAR/3 (ability or aptitude or judgement))) *OR* **TOPIC:** (emotional intelligence) *OR* **TOPIC:** ((predict* NEAR/3 (validity or performance* or outcome* or success* or behavio* or score* or attainment* or grade*

or achievement*))) *OR* **TOPIC:** ((personal* NEAR/3 (domain* or measure* or test* or assessment* or type* or attribute* or trait* or qualit*))) *OR* **TOPIC:** ((recruit* NEAR/3 (student* or undergraduate* or candidate* or applicant*)))

Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=All years

4 #3 OR #2

Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=All years

3 **TOPIC:** ((academic NEAR/5 (performance or success or achieve* or attain* or outcome* or score* or assess*))) *OR* **TOPIC:** ((undergrad* NEAR/5 (performance or success* or achieve* or attain* or outcome* or score* or assess*))) *OR* **TOPIC:** ((educat* NEAR/5 (performance or success* or achieve* or attain* or outcome* or score* or assess*))) *OR* **TOPIC:** ((student* NEAR/5 (performance or success* or achieve* or attain* or outcome* or score* or assess*))) *OR* **TOPIC:** (profession* NEAR/4 behavio*) *OR* **TOPIC:** (profession* NEAR/4 misconduct*) *OR* **TOPIC:** ((unprofession* NEAR/4 (behavio* or misconduct)))

Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=All years

2 **TOPIC:** (psychomotor performance OR motor skill* OR manual dexterity) *OR* **TOPIC:** (academic performance OR academic achievement OR academic success OR outcome OR academic attain* OR competence) *OR* **TOPIC:** (professionalism OR professional misconduct OR unprofessional conduct OR professional competence)

Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=All years

1 **TOPIC:** ((dent* NEAR/4 student*) OR (dent* NEAR/4 undergraduate*) OR (dent* NEAR/4 education*) OR (dent* NEAR/4 applica*) OR (dent* NEAR/4 candidate*) OR (dent* NEAR/4 program*))

Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=All years

Date: 28-07-2022

Database: BIOSIS Previews (Clarivate Analytics Web of Science) 1969-present

Total number of records found: 74

9 #8 AND #4 AND #1
Indexes=BIOSIS Previews Timespan=All years

8 #7 OR #6 OR #5
Indexes=BIOSIS Previews Timespan=All years

7 **TOPIC:** ((interview*)) *OR* **TOPIC:** ((select* NEAR/3 (criteria or test* or requirement* or assessment* or entrance* or student* or undergraduate* or method* or tool*))) *OR* **TOPIC:** ((admission* NEAR/3(criteria or test* or requirement* or select* or assessment* or entrance* or method* or tool*))) *OR* **TOPIC:** ((letter* NEAR/3 reference*)) *OR* **TOPIC:** ((letter* NEAR/3 recommendation*))
Indexes=BIOSIS Previews Timespan=All years

6 **TOPIC:** ((manual dexterity)) *OR* **TOPIC:** ((soft skill*)) *OR* **TOPIC:** ((motor skill*)) *OR* **TOPIC:** ((non-cogniti* N2 (factor* or skill* or abilit* or domain* or dimension*))) *OR* **TOPIC:** ((cogniti* N2 (factor* or skill* or abilit* or domain* or dimension*)))
Indexes=BIOSIS Previews Timespan=All years

5 **TOPIC:** ((test* NEAR/3 (ability or aptitude or judgement))) *OR* **TOPIC:** ((emotional intelligence)) *OR* **TOPIC:** ((predict* NEAR/3 (validity or performance* or outcome* or success* or behavio* or score* or attainment* or grade* or achievement*))) *OR* **TOPIC:** ((personal* NEAR/3 (domain* or measure* or test* or assessment* or type* or

attribute* or trait* or qualit*))) *OR* **TOPIC:** ((recruit* NEAR/3 (student* or undergraduate* or candidate* or applicant*)))
Indexes=BIOSIS Previews Timespan=All years

4 #3 OR #2
Indexes=BIOSIS Previews Timespan=All years

3 **TOPIC:** ((academic NEAR/5 (performance or success or achieve* or attain* or outcome* or score* or assess*))) *OR* **TOPIC:** ((undergrad* NEAR/5 (performance or success* or achieve* or attain* or outcome* or score* or assess*))) *OR* **TOPIC:** ((educat* NEAR/5 (performance or success* or achieve* or attain* or outcome* or score* or assess*))) *OR* **TOPIC:** ((student* NEAR/5 (performance or success* or achieve* or attain* or outcome* or score* or assess*))) *OR* **TOPIC:** ((profession* NEAR/4 behavio*)) *OR* **TOPIC:** ((profession* NEAR/4 misconduct*)) *OR* **TOPIC:** ((unprofession* NEAR/4 (behavio* or misconduct)))
Indexes=BIOSIS Previews Timespan=All years

2 **TOPIC:** ((psychomotor performance OR motor skill* OR manual dexterity)) *OR* **TOPIC:** ((academic performance OR academic achievement OR academic success OR outcome OR academic attain* OR competence)) *OR* **TOPIC:** ((professionalism OR professional misconduct OR unprofessional conduct OR professional competence))
Indexes=BIOSIS Previews Timespan=All years

1 **TOPIC:** (((dent* NEAR/4 student*) OR (dent* NEAR/4 undergraduate*) OR (dent* NEAR/4 education*) OR (dent* NEAR/4 applica*) OR (dent* NEAR/4 candidate*) OR (dent* NEAR/4 program*)))
Indexes=BIOSIS Previews Timespan=All years

Date: 28-07-2022

Database: Scopus (Elsevier B.V.) 1823 – Present

Total number of records found: 918

17 ((TITLE-ABS-KEY (test* OR assessment* OR inteview* OR personal OR personality OR cognition OR cognitive OR aptitude OR psychometric* OR skill* OR admission OR criteria OR (letter W/3 recommendation*) OR (letter W/3 reference))) OR (TITLE-ABS-KEY (predict* OR forecast*)) OR (TITLE-ABS-KEY (“manual dexterity”)) OR (TITLE-ABS-KEY (emotional AND intelligence)) OR (TITLE-ABS-KEY ((select* W/3 (requirement* OR entrance* OR student* OR undergraduate* OR method* OR tool*)))) OR (TITLE-ABS-KEY ((non-cogniti* W/2 (factor* OR skill* OR abilit* OR domain* OR dimension*)))) OR (TITLE-ABS-KEY ((recruit* W/3 (student* OR undergraduate* OR candidate* OR applicant*))))) AND ((TITLE-ABS-KEY ((academic W/5 (perform* OR success* OR achieve* OR attain* OR outcome* OR score* OR assess*)))) OR (TITLE-ABS-KEY ((undergraduate* W/5 (perform* OR success* OR achieve* OR attain* OR outcome* OR score* OR assess*)))) OR (TITLE-ABS-KEY ((educat* W/5 (perform* OR success* OR achieve* OR attain* OR outcome* OR score* OR assess*)))) OR (TITLE-ABS-KEY ((student* W/5 (perform* OR success* OR achieve* OR attain* OR outcome* OR score* OR assess*)))) OR (TITLE-ABS-KEY ((profession* W/4 behavio*) OR (profession* W/4 misconduct*) OR professionalism OR (unprofession* W/4 (behavio* OR misconduct*)))) OR (TITLE-ABS-KEY (“academic performance” OR “psychomotor performance” OR “clinical competence” OR “academic achievement” OR “clinical achievement” OR “educational measurement” OR “professional competence”))) AND (TITLE-ABS-KEY (dent* W/4 student* OR dent* W/4 undergraduate* OR dent* W/4 education* OR dent* W/4 applica* OR dent* W/4 candidate* OR dent* W/4 program*)

16 (TITLE-ABS-KEY (test* OR assessment* OR inteview* OR personal OR personality OR cognition OR cognitive OR aptitude OR psychometric* OR skill* OR admission OR criteria OR (letter W/3 recommendation*) OR (letter W/3 reference))) OR (TITLE-ABS-KEY (predict* OR forecast*)) OR (TITLE-ABS-KEY (“manual dexterity”)) OR (TITLE-ABS-KEY (emotional AND intelligence)) OR (TITLE-ABS-KEY ((select* W/3 (requirement* OR entrance* OR student* OR undergraduate* OR method* OR tool*)))) OR (TITLE-ABS-KEY ((non-cogniti* W/2 (factor* OR skill* OR abilit* OR domain* OR dimension*)))) OR (TITLE-ABS-KEY ((recruit* W/3 (student* OR undergraduate* OR candidate* OR applicant*)))))

15 TITLE-ABS-KEY ((recruit* W/3 (student* OR undergraduate* OR candidate* OR applicant*)))

14 TITLE-ABS-KEY ((non- cogniti* W/2 (factor* OR abilit* OR domain* OR dimension*)))

13 TITLE-ABS-KEY ((select* W/3 (requirement* OR entrance* OR student* OR undergraduate* OR method* OR tool*)))

12 TITLE-ABS-KEY (emotional AND intelligence)

11 TITLE-ABS-KEY (“manual dexterity”)

10 TITLE-ABS-KEY (predict* OR forecast*)

9	TITLE-ABS-KEY (test* OR assessment* OR inteview* OR personal OR personality OR cognition OR cognitive OR aptitude OR psychometric* OR skill* OR admission OR criteria OR (letter W/3 recommendation*) OR (letter W/3 reference))
8	(TITLE-ABS-KEY ((academic W/5 (perform* OR success* OR achieve* OR attain* OR outcome* OR score* OR assess*)))) OR (TITLE-ABS-KEY ((undergraduate* W/5 (perform* OR success* OR achieve* OR attain* OR outcome* OR score* OR assess*)))) OR (TITLE-ABS-KEY ((educat* W/5 (perform* OR success* OR achieve* OR attain* OR outcome* OR score* OR assess*)))) OR (TITLE-ABS-KEY ((student* W/5 (perform* OR success* OR achieve* OR attain* OR outcome* OR score* OR assess*)))) OR (TITLE-ABS-KEY ((profession* W/4 behavio*) OR (profession* W/4 misconduct*) OR professionalism OR (unprofession* W/4 (behavio* OR misconduct*)))) OR (TITLE-ABS-KEY (“academic performance” OR “psychomotor performance” OR “clinical competence” OR “academic achievement” OR “clinical achievement” OR “educational measurement” OR “professional competence”))
7	TITLE-ABS-KEY (“academic performance” OR “psychomotor performance” OR “clinical competence” OR “academic achievement” OR “clinical achievement” OR “educational measurement” OR “professional competence”)
6	TITLE-ABS-KEY ((profession* W/4 behavio*) OR (profession* W/4 misconduct*) OR professionalism OR (unprofession* W/4 (behavio* OR misconduct*)))
5	TITLE-ABS-KEY ((student* W/5 (perform* OR success* OR achieve* OR attain* OR outcome* OR score* OR assess*)))

4 TITLE-ABS-KEY ((educat* W/5 (perform* OR success* OR achieve* OR attain* OR outcome* OR score* OR assess*)))

3 TITLE-ABS-KEY ((undergraduate* W/5 (perform* OR success* OR achieve* OR attain* OR outcome* OR score* OR assess*)))

2 TITLE-ABS-KEY ((academic W/5 (perform* OR success* OR achieve* OR attain* OR outcome* OR score* OR assess*)))

1 TITLE-ABS-KEY (dent* W/4 student* OR dent* W/4 undergraduate* OR dent* W/4 education* OR dent* W/4 applica* OR dent* W/4 candidate* OR dent* W/4 program*)

Date: 25-02-2020

Database: Proquest

S4	2 and 3 and 4	141
S3	noft(((dental or dentist or dentists or dentistry) NEAR/4 (student or students OR undergraduate or undergraduates or education or educational OR application or applicant or applicants OR candidate or candidates OR program or programs or programme or programmes)))	1,390
S	noft(((test* NEAR/3 (ability or aptitude or judgement))) OR (emotional intelligence) OR ((predict* NEAR/3 (validity or performance* or outcome* or success* or behavio* or score* or attainment* or grade* or achievement*))) OR ((personal* NEAR/3 (domain* or measure* or test* or assessment* or type* or attribute* or trait* or qualit*))) OR ((recruit* NEAR/3 (student* or undergraduate* or candidate* or applicant*)))) OR noft((manual dexterity) OR (soft skill*) OR (motor skill*) OR ((non-cogniti* N2 (factor* or skill* or abilit* or domain* or dimension*))) OR ((cogniti* N2 (factor* or skill* or abilit* or domain* or dimension*)))) OR noft((interview*) OR ((select* NEAR/3 (criteria or test* or requirement* or assessment* or entrance* or student* or undergraduate* or method* or tool*))) OR ((admission* NEAR/3(criteria or test* or requirement* or select* or assessment* or entrance* or method* or tool*))) OR (letter* NEAR/3 reference*) OR (letter* NEAR/3 recommendation*))	419,079

S1	noft((psychomotor performance OR motor skill* OR manual dexterity) OR (academic performance OR academic achievement OR academic success OR outcome OR academic attain* OR competence) OR (professionalism OR professional misconduct OR unprofessional conduct OR professional competence)) OR noft(((academic NEAR/5 (performance or success or achieve* or attain* or outcome* or score* or assess*))) OR ((undergrad* NEAR/5 (performance or success* or achieve* or attain* or outcome* or score* or assess*))) OR ((educat* NEAR/5 (performance or success* or achieve* or attain* or outcome* or score* or assess*))) OR ((student* NEAR/5 (performance or success* or achieve* or attain* or outcome* or score* or assess*))) OR (profession* NEAR/4 behavio*) OR (profession* NEAR/4 misconduct*) OR ((unprofession* NEAR/4 (behavio* or misconduct))))

Appendix B Medical Education Research Study Quality Instrument (MERSQI)

Table 77: MERSQI domains, item scores and operational definitions

(Reed et al., 2007, Cook and Reed, 2015)

Domain	MERSQI Item	Item score	Maximum domain score	Operational definitions
Study design	1. Study design		3	• Survey studies are cross-sectional. • Case–control and cohort studies (2 or more defined cohorts) are considered 2-group nonrandomized.
	Single group cross-sectional or single group post-test only	1		
	Single group pre-test and post-test	1.5		
	Non-randomized, 2 group	2		
	Randomized controlled trial	3		
Sampling	2. Number of institutions studied		3	Number of institutions refers to origin of study participants (not study authors).
	1	0.5		
	2	1		
	>2	1.5		

Table 77: MERSQI domains, item scores and operational definitions, continued

	3. Response rate, %			• Response rate is the proportion of those eligible who completed the posttest or survey. For intervention studies, this is the proportion of those enrolled who completed the intervention evaluation. • Use "not applicable" only if a response rate truly does not apply (e.g., data obtained from a medical record or professional organization database).
	Not applicable			
	<50 or not reported	0.5		
	50-74	1		
	75	1.5		
Type of data	4. Type of data		3	• Observer ratings are considered objective.
	Assessment by study participant	1		
	Objective measurement	3		
Validity of evaluation instrument	5.Internal structure		3	• Relevant content evidence would include using theory, guidelines, experts, and existing instruments to identify or refine the instrument. • Relevant internal structure evidence would include all reliability (internal consistency, interrater, interstation, and test–retest) and factor analysis. • Relevant evidence of relationships to other variables would include expert–novice comparisons and concurrent or predictive correlation with other variables. • Use “not applicable” only if the study does not measure a psychological construct *and* there is no instrument to rate (e.g., gender as the sole outcome); should be used very rarely.
	Not applicable			
	Not reported	0		
	Reported	1		
	6.Content			
	Not applicable			
	Not reported	0		
	Reported	1		

Table 77: MERSQI domains, item scores and operational definitions, continued

	7.Relationships to other variables			
	Not applicable			
	Not reported	0		
	Reported	1		
Data analysis	8. Appropriateness of analysis		3	• Considered “no” if there is a statistical error or if authors failed to analyze data at all.
	Data analysis inappropriate for study design or type of data	0		
	Data analysis appropriate for study design and type of data	1		
	9. Complexity of analysis			• Descriptive analyses include frequency, mean, and median. • Any test of statistical inference is considered “beyond descriptive.”
	Descriptive analysis only	1		
	Beyond descriptive analysis	2		
Outcomes	10. Outcomes		3	• General facts include participant demographics. • Knowledge/skills are in a test setting (paper, computer, simulation, or patients in a nonauthentic setting). • Behaviours are physician actions with real patients in a clinical context, or other activities in a real context. • Patient/health care outcomes are actual effects on real patients, programs, or society.
	Satisfaction, attitudes, perceptions, opinions, general facts	1		
	Knowledge, skills	1.5		
	Behaviors	2		
	Patient/health care outcome	3		
Total score			18	

Appendix C Details of MERSQI scoring

Table 78: Details of MERSQI scoring

Study	Study Design score	Sampling scores		Type of data score	Validity evidence of evaluation instrument			Data analysis scores		Outcome score				Total score
		Number of Institutions	Response rate		Internal structure	Content	Relationship to other variables	Appropriateness	Complexity	Satisfaction, attitudes, perception, opinions, general facts	Knowledge, skills	Behaviours	Patient/health care outcome	
(Kay et al., 2010)	1	0.5	0.5	3	0	1	1	1	2	0	1.5	0	0	11.5
(Lala et al., 2013)	2	0.5	1.5	3	0	1	1	1	2	1	1.5	0	0	14.5
(Foley and Hijazi, 2013)	2	0.5	0.5	3	0	0	1	1	2	1	1.5	0	0	12.5

Table 78: Details of MERSQI scoring, continued

(Foley and Hijazi, 2015)	2	0.5	0.5	3	0	1	1	1	2	1	1.5	0	0	13.5
(Lambe et al., 2018)	1	0.5	1.5	3	0	1	1	1	2	1	1.5	0	0	13.5
(McAndrew et al., 2017)	2	1	1.5	3	0	0	1	1	2	1	1.5	0	0	14
(Patterson et al., 2017)	2	1.5	0.5	3	0	1	1	1	2	1	1.5	0	0	14.5
(Mirghani, 2020a)	1	0.5	0.5	3	1	1	1	1	2	1	1.5	1	1	15.5

Appendix D Ethical Approval

Phase I application form

UNIVERSITY OF LEEDS RESEARCH ETHICS COMMITTEE APPLICATION FORM

Please read each question carefully, taking note of instructions and completing all parts. If a question is not applicable please indicate so. The superscripted numbers (eg[8]) refer to sections of the guidance notes, available at http://ris.leeds.ac.uk/uolethicsapplication. Where a question asks for information which you have previously provided in answer to another question, please just refer to your earlier answer rather than repeating information. Research ethics training courses: http://www.sddu.leeds.ac.uk/research-innovation/research-ethics-training-and-guidance

To help us process your application enter the following reference numbers, if known and if applicable:

Ethics reference number:	**090320/EA/297**
Student number and/ or grant reference:	**201291130**

PART A: Summary

A.1 Which Faculty Research Ethics Committee would you like to consider this application?[2]

- ○ Arts, Humanities and Cultures (PVAR)
- ○ Biological Sciences (BIOSCI)
- ○ ESSL/ Environment/ LUBS (AREA)
- ○ MaPS and Engineering (MEEC)
- ○ Medicine and Health (Please specify a subcommittee):
  - ◉ School of Dentistry (DREC)
  - ○ School of Healthcare (SHREC)
  - ○ School of Medicine (SoMREC)
  - ○ School of Psychology (SoPREC)

A.2 Title of the research[3]
Assessment of the Undergraduate Admissions Process for Dental Surgery: Predictability and Fairness: Phase I

A.3 Principal investigator's contact details[4]	
Name *(Title, first name, surname)*	**Eman Alsharafi**
Position	**PhD student**
Department/ School/ Institute	**School of Dentistry**
Faculty	**Medicine and Health**
Work address *(including postcode)*	**University of Leeds, Leeds, LS2 9LU**
Telephone number	**+44749 2239526**
University of Leeds email address	**dnea@leeds.ac.uk**

A.4 Purpose of the research:[5] (Tick as appropriate)

- [x] Research
- [x] Educational qualification: ***Please specify:*** **Postgraduate degree, PhD**
- [x] Educational Research & Evaluation[6]
- [ ] Medical Audit or Health Service Evaluation[7]
- [ ] Other

A.5 Select from the list below to describe your research: (You may select more than one)

☑ Research on or with human participants

☐ Research which has potential adverse environmental impact.[8] ***If yes, please give details:***

____

☑ Research working with data of human participants

- ☐ New data collected by qualitative methods
- ☑ New data collected by quantitative methods
- ☐ New data collected from observing individuals or populations
- ☑ Routinely collected data or secondary data
- ☐ Research working with aggregated or population data
- ☐ Research using already published data or data in the public domain

☐ Research working with human tissue samples (*Please inform the relevant Persons Designate if the research will involve human tissue*)[9]

A.6 Will the research involve NHS staff recruited as potential research participants (by virtue of their professional role) or NHS premises/ facilities?

☐ Yes ☑ No

If yes, ethical approval must be sought from the University of Leeds. Note that approval from the NHS Health Research Authority may also be needed, please contact FMHUniEthics@leeds.ac.uk for advice.

A.7 Will the research involve any of the following:[10] (You may select more than one)

*If your project is classified as research rather than service evaluation or audit and involves any of the following an application must be made to the NHS Health Research Authority via IRAS www.myresearchproject.org.uk as NHS ethics approval will be required. **There is no need to complete any more of this form**. Further information is available at* *http://ris.leeds.ac.uk/NHSethicalreview and at http://ris.leeds.ac.uk/HRAapproval. You may also contact **governance-ethics@leeds.ac.uk** for advice.*

- ☐ Patients and users of the NHS (including NHS patients treated in the private sector)[11]
- ☐ Individuals identified as potential participants because of their status as relatives or carers of patients and users of the NHS
- ☐ Research involving adults in Scotland, Wales or England who lack the capacity to consent for themselves[12]
- ☐ A prison or a young offender institution in England and Wales (and is health related)[14]
- ☐ Clinical trial of a medicinal product or medical device[15]
- ☐ Access to data, organs or other bodily material of past and present NHS patients[9]
- ☐ Use of human tissue (including non-NHS sources) where the collection is not covered by a Human Tissue Authority licence[9]
- ☐ Foetal material and IVF involving NHS patients
- ☐ The recently deceased under NHS care
- ☑ None of the above

You must inform the Research Ethics Administrator of your NHS REC reference and approval date once approval has been obtained.

The HRA decision tool to help determine the type of approval required is available at http://www.hra-decisiontools.org.uk/ethics. If the University of Leeds is not the Lead Institution, or approval has been granted elsewhere (e.g. NHS) then you should contact the local Research Ethics Committee for guidance. The UoL Ethics Committee needs to be assured that any relevant local ethical issues have been addressed.

A.8 Will the participants be from any of the following groups? (Tick as appropriate)

- [ ] Children under 16[16] ***Specify age group:*** ______________________________
- [ ] Adults with learning disabilities[12]
- [ ] Adults with other forms of mental incapacity or mental illness
- [ ] Adults in emergency situations
- [ ] Prisoners or young offenders[14]
- [ ] [x] Those who could be considered to have a particularly dependent relationship with the investigator, e.g. members of staff, students[17]
- [ ] Other vulnerable groups
- [ ] No participants from any of the above groups

Please justify the inclusion of the above groups, explaining why the research cannot be conducted on non-vulnerable groups.

This study will assess the association between the undergraduate admission process and the students' in-course performance. Therefore, the cohorts studied will be the undergraduate students. As the research supervision team includes members of staff at the University, students could feel that they have a dependent relationship. The information sheets will reassure students that their involvement (or not) in the study will have no bearing on their current or future studies and that their data will be anonymised.

It is the researcher's responsibility to check whether a DBS check (or equivalent) is required and to obtain one if it is needed. See also http://www.homeoffice.gov.uk/agencies-public-bodies/dbs and http://store.leeds.ac.uk/browse/extra_info.asp?modid=1&prodid=2162&deptid=34&compid=1&prodvarid=0&catid=243.

A.9 Give a short summary of the research[18]

Selection of students with the highest potential of success in an undergraduate programme in Dental Surgery is a very challenging process. This is due to the fact that the selection is carried out among a highly academically-qualified pool of applicants that exceed the number of places available. Furthermore, little is known about which personal attributes significantly predict a student's subsequent performance.

Therefore, we plan to conduct cross-sectional studies to comprehensively assess the admission process at the Dental Surgery Programme at the School of Dentistry. This project is essential as it assesses the effectiveness and fairness of the selection process. The project aims to:

1- Assess if the current admissions process at the Dental Surgery Programme at the School of Dentistry predicts students' future performance.
2- Assess if the attributes evaluated at the Multiple Mini Interviews (MMIs) held at the School of Dentistry do predict students' subsequent performance (academic and clinical)
3- Assess if an association exists between the socio-demographic characteristics of a student and the student's performance at the admission process and in-course performance

This application is to approve the research team to conduct this work over the next three years (2020-2023) to avoid multiple applications to the ethics committee.

The first study of the research will aim to assess the predictability of the admission process.

In this study, the admission criterion considered for the Dental Surgery Programme and the socio-demographic characteristics of the registered students (predictor variables) will be assessed for prediction of the students' in-course performance (outcome variables). Both predictor variables and outcome variables are specified later in this section.

- Participants of the study will be the students registered at the Dental surgery programme in the academic sessions of 2014, 2015, 2016 and 2017.
- Performance of the students (outcome variables) will be assessed with regard to their academic and clinical in-course performance, attendance and any unprofessional behavior record. This will involve tracking students' academic performance across their undergraduate degree in the dental surgery programme. They include the following data:

1- Academic in-course performance
2- Clinical in-course performance
3- Attendance

4- Any unprofessional behavior records (Professionalism Committee) or disciplinary proceedings (Fitness to Practice)

The predictor variables required are as follows:

1- Age
2- Gender
3- Self-identified ethnicity
4- Socio-economic status
5- Widening participation indices
6- A-level (individual subject scoring) or predicted where appropriate
7- GCSE scores (Number of subjects – Score achieved-Dual award or single subjects)
8- Presence of a previous degree
9- Personal statement total scores
10- Personal statement sub-scores
11- Biomedical Admission Test (BMAT) score
12- MMI total score
13- Individual MMI station score

The data required for this study are existing data and routinely collected as part of the admission process and in-course evaluation. The students will only be asked to provide their A-level scores, GCSE details and information about their previous degrees, if present, via an electronic form that will be sent by email. This is due to the difficulty encountered to obtain this data from the admission office. Otherwise, the study does not require any further active involvement from the students. In other words, they will not be asked to do above and beyond the tasks necessary to satisfy the requirements of their undergraduate degree.

After obtaining ethical approval from DREC and consenting the students (Opt-out consent), tracking of students' performance during the application cycles of 2014, 2015, 2016 and 2017 as they progress through their programme is planned. The performance measures, admission assessments scores and socio-demographic data will be extracted from student's records. An email will also be sent to the participants to request their A-level scores, GCSE details and their previous degrees, if present, as explained above. The aim is to use the data generated as part of the typical degree process (assessed summative marks, practical and clinical performance data) alongside their performance on the admission assessments and their socio-demographic characteristics. This will help us to identify patterns that will allow us to build statistical models identifying the predictors of student performance during the programme of study.

-Ensuring data anonymity will be a key priority and personal identifiers of the students will be removed. Students will be informed that they will be able to withdraw from the study for 2 weeks from when they receive the opt out consent email. At this point the data will be anonymised and amalgamated and therefore the data will be unable to be extracted. These ethical issues are further described in section (A.10) Another opt out consent form will be also sent along with the electronic form and an information sheet. This is to be signed by the student if they wish not to provide the data via the electronic form. If the student opted out from providing the data or did not respond to the email within a two-week period, further attempts to obtain the data from the students' records held at the university will be made as the students have already been consented for participation in the research.

-The data statistical analysis will be carried out in several phases to assess the association of the predictor variables and the outcome variables. Detailed description of the data analysis is written in section (C.2).

The second phase of this research will be described in a separate application form, as requested.

A.10 **What are the main ethical issues with the research and how will these be addressed?**[19]

There are important ethical issues surrounding data management and confidentiality for work that requires correlation of admissions performance with socio-demographic data, students' academic and clinical attainment records, attendance and any reports of unprofessional behaviour. In order to address these concerns, data collected from students will be anonymised. Students will only be identifiable to the research team who are involved in the data analysis by a unique participant identification number (UPN); there will be no record linking UPNs to personal details kept by any of the researchers responsible for the data analysis. A member of staff who is not involved in the data analysis at the University of Leeds will retain a record of student's UPNs linked to their name; this will be kept separate from the researcher analysing the data. Arrangements will be made for an independent third party to perform the encoding. This will be a PGR student from the School of Psychology. Keeping of this record is precautionary (in the event if a student asks to view their data or we needed to add their progress through the programme).

Prior to data collection, an opt-out consent form will be emailed by an SES member, who has access to the student contact details, to the registered students of admission cycles 2016 and 2017 along with an information sheet. Students will be given an opportunity to respond to the email for 2 weeks from when they receive the opt out consent email. The Alumni Office will email the opt out consent form along with the information sheet to the graduated students of admission cycle 2014 and 2015. They will also be given an opportunity to respond to the email for 2 weeks from when they receive the opt out consent email.

Participants will be provided with contact details of Prof Michael Manogue and the researcher, Eman Alsharafi, to send their withdrawal consents if they choose not to be included in the study. This will be explained in the information sheet and consent form. They can also use these contact details should they have any enquiries about the research.

Data will be then collected and anonymised as previously explained unless the student dissents this by signing and emailing the opt-out consent form. It will be highlighted in the information sheet that their participation is voluntary and that their withdrawal from the study is optional for 2 weeks from when they receive the opt out consent email.

As previously explained, there were difficulties obtaining some data from the admission office, therefore, this data will be requested to be completed by the students in an electronic form that will be sent by email along with an opt out consent form and an information sheet. The email will be sent by an SES member, who has access to the student contact details, to the registered students of admission cycles 2016 and 2017. The Alumni Office will be asked to send the email to the graduated students of admission cycle 2014 and 2015. The students will be given an opportunity to respond to the email for 2 weeks from when they receive the email. The opt out consent is to be signed by the student if they wish not to provide the data via the electronic form. If the student opted out from providing the data or did not respond to the email in 2 weeks period, further attempts to obtain the data from the students' records held at the university will be made as the students have already been consented for participation in the research.

Electronic data related to academic performance will be password protected. All computers used for data collection, storage or analysis will be encrypted.

PART B: About the research team

B.1 To be completed by students only[20]	
Qualification working towards (e.g. Masters, PhD)	**PhD**
Supervisor's name (Title, first name, surname)	**Prof Michael Manogue**

Department/ School/ Institute	**School of Dentistry**
Faculty	**Faculty of Medicine and Health**
Work address (including postcode)	**Worsley Building, University of Leeds, LS2 9LU**
Supervisor’s telephone number	**0113 343 6173**
Supervisor’s email address	**m.manogue@leeds.ac.uk**
Module name and number	

B.2 Other members of the research team (e.g.co-supervisors) [21]	
Name *(Title, first name, surname)*	**Dr Jennifer Hallam**
Position	**Educational Psychometrician**
Department/ School/ Institute	**School of Medicine**
Faculty	**Faculty of Medicine and Health**
Work address *(including postcode)*	**Worsley Building, University of Leeds, LS2 9LU**
Telephone number	**0113 343 4378**
Email address	**j.l.hallam@leeds.ac.uk**

Name (Title, first name, surname)	**Dr Gail Nicholls**
Position	**Head of Admissions**
Department/ School/ Institute	**School of Medicine**
Faculty	**Faculty of Medicine and Health**

Work address (including postcode)	**Room 7.09, Worsley Building, University of Leeds, LS2 9LU**
Telephone number	**0113 343 7579**
Email address	**g.c.nicholls@leeds.ac.uk**

Part C: The research

C.1 What are the aims of the study?[22]

The overarching aim of this research project is to evaluate the current admissions process at the Dental Surgery Programme at the School of Dentistry, University of Leeds (predictability and fairness) by:

1- Assessing if the current admissions process at the Dental Surgery Programme at the School of Dentistry predicts students' future performance.

2- Assessing if the attributes evaluated at the multiple mini-interviews (MMIs) held at the School of Dentistry do predict students' subsequent performance

3- Assessing if an association exists between the socio-demographic characteristics of a student and the student's performance at the admission process and in-course performance.

C.2 Describe the design of the research. Qualitative methods as well as quantitative methods should be included.

The work largely involves a quantitative methodology. Data will be analysed using IBM SPSS version 23. The analysis will be exploratory in nature and will aim to identify the predictive factors of dental school performance and to assess the association between the socio-demographic factors and the students' performance at the admission process and in-course performance. The statistical analysis will be conducted in stages due to the exploratory nature, and each stage will inform the next.

The following analysis will be carried out:

- Stage I: Initial analysis

Initial analysis will be carried out to explore the students' pre-admission achievements and to describe the MMI procedure, focusing on the attributes assessed at each of the admission cycles included in the study. Data will be explored to assess the distribution to determine the type of tests to be used at the exploration stages.

- Stage II: Univariate analysis

The association between each of the student's entry level achievements (predictor variables) and the defined outcome measures will be assessed using univariate analysis tests. Analyses will include exploring mean scores (with standard deviations) in order to explore the relationships between the different variables. This analysis will result in the identification of variables that warrant further investigation using more advanced analysis techniques at stage III.

- Stage III: Logistic regression

Statistical modelling will be then carried out to explore the extent to which the scores achieved at the admission assessments is predictive, over and above, of each of the outcome measures. The analysis will also explore moderation and mediation effects between the different variables.

A conventional p-value <0.05 will be the criteria to reject the null hypothesis but effect sizes and confidence intervals will also be used to explore the strength of the relationships identified.

C.3 What will participants be asked to do in the study?[23]

When ethical approval is obtained, an information sheet and an opt-out consent form will be sent to the participants by email as previously explained in section A.10. They will be given 2 weeks to respond to the email. Data will be then collected and anonymised as previously explained in sections A.9 and A.10 unless the participant dissents this by signing and emailing the opt-out consent form.

The students will also be asked to provide their A-level scores, GCSE details and information about their previous degrees, if present, via an electronic form that will be sent by email as previously explained in section A.10. This is due to the difficulty encountered to obtain this data from the admission office.

Participants will not be asked to do anything further as the data will be retrospectively collected from the students' records.

C.4 Does the research involve an international collaborator or research conducted overseas:[24]

☐ Yes ☑ No

If yes, describe any ethical review procedures that you will need to comply with in that country:

Describe the measures you have taken to comply with these:
Include copies of any ethical approval letters/ certificates with your application.

C.5 Proposed study dates and duration
Research start date (DD/MM/YY): **20 October 2020** Research end date (DD/MM/YY): **31 January 2023**
Fieldwork start date (DD/MM/YY): **02 November 2020** Fieldwork end date (DD/MM/YY): **31 August 2021**

C.6. Where will the research be undertaken? (i.e. in the street, on UoL premises, in schools)[25]
The research will be carried out at the School of Dentistry.

RECRUITMENT & CONSENT PROCESSES

C.7 How will potential participants in the study be:

(i) identified?

Participants are:

All registered undergraduate dental students for the admission cycles 2014, 2015, 2016 and 2017 (369 registered student) at the Dental Surgery Programme at the School of Dentistry, Faculty of Medicine and Health, University of Leeds will be included in the study. Number of students in each admission cycle is as follows: 2014=87 student, 2015= 91 student, 2016= 100 student, 2017=91 student.

(ii) approached?

Once the ethical approval is obtained, an opt-out consent form will be emailed by a member of the SES team to the registered students of admission cycles 2016 and 2017 along with an information sheet. Students will be given an opportunity to respond to the email for 2 weeks from when they receive the opt out consent email. The Alumni Office will email the opt out consent form along with the information sheet to the graduated students of admission cycle 2014 and 2015. They will also be given an opportunity to respond to the email for 2 weeks from when they receive the opt out consent email.

Participants will also be provided with contact details of Prof Michael Manogue and the researcher, Eman Alsharafi, to send their consents if they decided to withdraw from the study. This will be explained in the information sheet and

consent form. They can also use these contact details should they have any enquiries about the research.
Data will be then collected and anonymised as previously explained in sections A.9 and A.10 unless the student dissents this by signing and emailing the opt-out consent form. It will be highlighted in the information sheet that their participation is voluntary and that their withdrawal from the study is optional for 2 weeks from when they receive the opt out consent email.

The students will also be asked to provide their A-level scores, GCSE details and information about their previous degrees, if present, via an electronic form that will be sent by email as previously explained in section A.10. This is due to the difficulty encountered to obtain this data from the admission office. The email will be sent by an SES member, who has access to the student contact details, to the registered students of admission cycles 2016 and 2017. The Alumni Office will be asked to send the email to the graduated students of admission cycle 2014 and 2015. The students will be given an opportunity to respond to the email for 2 weeks from when they receive the email. When the student fills the form, it will automatically be forwarded to Prof Michael Manogue. The data will be then forwarded to an independent third party to link the data provided with the rest of the data and perform the encoding. The opt out consent is to be signed by the student if they wish not to provide the data via the electronic form. The students will be provided with the contact details of Prof Michael Manogue and the researcher, Eman Alsharafi, to send their consents if they decided to not to provide their data in the electronic form. This will be explained in the information sheet and consent form. If the student opted out from providing the data or did not respond to the email in 2 weeks period, further attempts to obtain the data from the students' records held at the university will be made as the students have already been consented for participation in the research.

(iii) recruited?[26]

Explained above.

C.8 Will you be excluding any groups of people, and if so what is the rationale for that?[27]

Students who have dropped out of the programme, as we will not be able to consent them.

C.9 How many participants will be recruited and how was the number decided upon?[28]

To have a fully representative sample, data of all the registered cohort at the School of Dentistry for the admission cycles 2014, 2015, 2016 and 2017 (369 registered student). Number of registered students in each admission cycle is as follows: 2014=87 student, 2015= 91 student, 2016= 100 student, 2017=91 student.

C10 Will the research involve any element of deception?[29]

If yes, please describe why this is necessary and whether participants will be informed at the end of the study.

No

C.11 Will <u>informed consent</u> be obtained from the research participants?[30]

☑ Yes ☐ No

If yes, <u>give details</u> of how it will be done. Give details of any particular steps to provide information (in addition to a written information sheet) e.g. videos, interactive material. If you are not going to be obtaining informed consent you will need to justify this.

If ***participants are to be recruited from any of potentially vulnerable groups, <u>give details of extra steps</u> taken to assure their protection. Describe any arrangements to be made for obtaining consent from a legal representative.***

For the enrolled students of admission cycles 2016 and 2017 opt-out consents will be emailed by a member of the SES, who has access to the students' contact details, and they will be provided with a description of the project with the aims and study plans explained. Students will be given 2 weeks from when they receive the opt out consent email to respond to the email. Data will be then collected and anonymised as previously explained in sections A.9 and A.10 unless the student dissents this by signing and emailing the opt-out consent form. Participants will also be given contact details of the researchers and the opportunity to ask questions at any point over the next 3 years.

Participants will also be provided with contact details of Prof Michael Manogue and the researcher, Eman Alsharafi, to send their consents if they decided to withdraw from the study. This will be explained in the information sheet and

consent form. They can also use these contact details should they have any enquiries about the research. An information sheet will also be provided with details about what each study involves. It will be made clear that information will be anonymous and that participants are free to withdraw from the study at any time without consequence for 2 weeks from when they receive the opt out consent email. Participants will also be given the opportunity to ask questions before agreeing to participate and throughout the procedure. For admission cycle 2014 and 2015, the Alumni Office will email the opt out consent form along with the information sheet. They will also be given an opportunity to respond to the email for 2 weeks from when they receive the opt out consent email. Participants will also be provided with contact details of the researchers should they have any enquiries about the research. Another opt out consent form will be sent along with an information sheet and an electronic form to collect the A-level, GCSE and information regarding the students' previous degrees, if present. The email will be sent by an SES member, who has access to the student contact details, to the registered students of admission cycles 2016 and 2017. The Alumni Office will be asked to send the email to the graduated students of admission cycle 2014 and 2015. The students will be given an opportunity to respond to the email for 2 weeks from when they receive the email. The opt out consent is to be signed by the student if they wish not to provide the data via the electronic form. If the student opted out from providing the data or did not respond to the email in 2 weeks period, further attempts to obtain the data from the students' records held at the university will be made as the students have already been consented for participation in the research.
***Copies of any written consent form, written information and all other explanatory material should accompany this application**. The information sheet should make explicit that participants can withdraw from the research at any time, if the research design permits. Remember to use meaningful file names and version control to make it easier to keep track of your documents.* *Sample information sheets and consent forms are available from the University ethical review webpage at* http://ris.leeds.ac.uk/InvolvingResearchParticipants.

C.12 Describe whether participants will be able to withdraw from the study, and up to what point (e.g. if data is to be anonymised). If withdrawal is not possible, explain why not.

Any limits to withdrawal, e.g. once the results have been written up or published, should be made clear to participants in advance, preferably by specifying a date after which withdrawal would not be possible. Make sure that the information provided to participants (e.g. information sheets, consent forms) is consistent with the answer to C12.

Participants are free to opt out from the study for 2 weeks from when they receive the opt out consent email, without consequences. As for providing the data via the electronic form, the students will also be given a two-week period to opt out from providing the previously specified data by email. It will be made clear to the students that in order to opt out from the study they should send their consent form signed to Prof Michael Manogue or the researcher, Eman Alsharafi. This will be explained in the information sheet and consent form.

C.13 How long will the participant have to decide whether to take part in the research?[31]

The risks involved in taking part in this research are very low, and therefore it is anticipated that participants will not need to take long before deciding whether they are comfortable to take part. After emailing the opt-out consent forms on, students will be given 2 weeks to respond to the email.

C.14 What arrangements have been made for participants who might have difficulties understanding verbal explanations or written information, or who have particular communication needs that should be taken into account to facilitate their involvement in the research?[32]

No problems with language are foreseen.

C.15 Will individual or group interviews/ questionnaires discuss any topics or issues that might be sensitive, embarrassing or upsetting, or is it possible that criminal or other disclosures requiring action could take place during the study (e.g. during interviews or group discussions)?[33]
The information sheet should explain under what circumstances action may be taken.

☐ Yes ☑ No *If yes, give details of procedures in place to deal with these issues.*

C.16 Will individual research participants receive any payments, fees, reimbursement of expenses or any other incentives or benefits for taking part in this research?[34]

☐ Yes ☑ No

If Yes, please describe the amount, number and size of incentives and on what basis this was decided.

RISKS OF THE STUDY

C.17 What are the potential benefits and/ or risks for research participants in both the short and medium-term?[35]

Benefits: By allowing access to anonymised student data, participants will help us to analyse and improve the admission system to promote fair access and ensure the appropriate selection of our students. We are aiming to identify the predictive validity of different components of the selection process and to use this to determine whether or not the current admissions processes should be altered. Additionally, by analysing the demographic data we will be able to determine whether there is any unidentified bias to certain cohort groups.

Risks: No identified risks for participants.

C.18 Does the research involve any risks to the researchers themselves, or people not directly involved in the research? *E.g. lone working*[36]

☐ Yes ☑ No

If yes, please describe:

Is a risk assessment necessary for this research?

☐ Yes ☑ No If yes, please include a copy of your risk assessment form with your application.

NB: If you are unsure whether a risk assessment is required visit http://ris.leeds.ac.uk/HealthAndSafetyAdvice or contact your Faculty Health and Safety Manager for advice.

RESEARCH DATA

C.19 Explain what measures will be put in place to protect personal data. E.g. anonymisation procedures, secure storage and coding of data. Any potential for re-identification should be made clear to participants in advance.[37] Refer to http://ris.leeds.ac.uk/ConfidentialityAnonymisation and http://ris.leeds.ac.uk/ResearchDataManagement for guidance.

The terms of GDPR will be adhered to and all information will be securely stored. The data will be anonymised at all stages of the research and will not be associated with the student's name or ID for the researcher carrying out the data analysis, as previously explained in section A.10. The data will be stored on password protected PC and backed up on the University M drive. Any personal data will be stored securely and separately from the anonymised data.

C.20 How will you make your research data available to others in line with: the University's, funding bodies' and publishers' policies on making the results of publically funded research publically available. Explain the extent to which anonymity will be maintained. *(max 200 words)* Refer to http://ris.leeds.ac.uk/ConfidentialityAnonymisation and http://ris.leeds.ac.uk/ResearchDataManagement for guidance.

Where relevant, we will make the anonymised, analysed dataset publicly available through an online research depository. All data will be kept strictly confidential and any individual data in write-ups/publications will be referred to by code-name only and will not be associated with the participant's name or student ID. Only anonymous data will be used.

C.21 Will the research involve any of the following activities at any stage (including identification of potential research participants)? (Tick as appropriate)

- [x] Examination of personal records by those who would not normally have access
- [ ] Access to research data on individuals by people from outside the research team
- [ ] Electronic surveys, please specify survey tool: ________________________________ (further guidance)
- [x] Other electronic transfer of data

☑ Use of personal addresses, postcodes, faxes, e-mails or telephone numbers

☐ Use of audio/ visual recording devices (NB this should usually be mentioned in the information for participants)

☐ FLASH memory or other portable storage devices

Storage of personal data on, or including, any of the following:

☑ University approved cloud computing services (Microsoft Office 365 for email (Exchange online) and Microsoft OneDrive for Business)

☐ Other cloud computing services

☑ Manual files

☐ Private company computers

☐ Laptop computers

☐ Home or other personal computers (not recommended; data should be stored on a University of Leeds server such as your M: or N: drive where it is secure and backed up regularly: http://ris.leeds.ac.uk/ResearchDataManagement.)

C.22 How do you intend to share the research data? (Indicate with an 'X)
Refer to http://library.leeds.ac.uk/research-data-deposit for guidance.

☐ Exporting data outside the European Union

☐ Sharing data with other organisations

☐ Publication of direct quotations from respondents

☐ Publication of data that might allow identification of individuals to be identified

☑ Submitting to a journal to support a publication

☑ Depositing in a self-archiving system or an institutional repository

- [x] Dissemination via a project or institutional website
- [ ] Informal peer-to-peer exchange
- [x] Depositing in a specialist data centre or archive
- [ ] Other, please state:

____.

- [ ] No plans to report or disseminate the data

C.23 How do you intend to report and disseminate the results of the study? (Indicate with an 'X) Refer to http://ris.leeds.ac.uk/ResearchDissemination and http://ris.leeds.ac.uk/Publication for guidance.

- [x] Conference presentation
- [x] Peer reviewed journals
- [x] Publication as an eThesis in the Institutional repository
- [x] Publication on website
- [ ] Other publication or report, please state:

____

- [x] Submission to regulatory authorities
- [ ] Other, please state:

____.

- [ ] No plans to report or disseminate the results

C.24 For how long will data from the study be stored? Please explain why this length of time has been chosen.[38] Refer to the RCUK Common Principles on Data Policy and http://ris.leeds.ac.uk/info/71/good_research_practice/106/research_data_guidance/5.

Students: *It would be reasonable to retain data for at least 2 years after publication or three years after the end of data collection, whichever is longer.*

______5____ years, __________ months (For publication following completion of the research)

CONFLICTS OF INTEREST

C.25 Will any of the researchers or their institutions receive any other benefits or incentives for taking part in this research over and above normal salary or the costs of undertaking the research?[39]
☐ **Yes** ☑ **No**
If yes, indicate how much and on what basis this has been decided

C.26 Is there scope for any other conflict of interest?[40] *For example, could the research findings affect the any ongoing relationship between any of the individuals or organisations involved and the researcher(s)? Will the research funder have control of publication of research findings? Refer to http://ris.leeds.ac.uk/ConflictsOfInterest.*
☐ Yes ☑ No
If so, please describe this potential conflict of interest, and outline what measures will be taken to address any ethical issues that might arise from the research.

C.27 Does the research involve external funding? (Tick as appropriate)
☐ Yes ☑ No ***If yes, what is the source of this funding?***
NB: If this research will be financially supported by the US Department of Health and Human Services or any of its divisions, agencies or programmes please ensure the additional funder requirements are complied with. Further guidance is available at http://ris.leeds.ac.uk/FWAcompliance and you may also contact your FRIO for advice.

Phase II application form

UNIVERSITY OF LEEDS RESEARCH ETHICS COMMITTEE APPLICATION FORM

Please read each question carefully, taking note of instructions and completing all parts. If a question is not applicable please indicate so. The superscripted numbers (eg[8]) refer to sections of the guidance notes, available at http://ris.leeds.ac.uk/uolethicsapplication. Where a question asks for information which you have previously provided in answer to another question, please just refer to your earlier answer rather than repeating information. Research ethics training courses: http://www.sddu.leeds.ac.uk/research-innovation/research-ethics-training-and-guidance

To help us process your application enter the following reference numbers, if known and if applicable:

Ethics reference number:	**191020/EA/308**
Student number and/ or grant reference:	**201291130**

PART A: Summary

A.1 Which Faculty Research Ethics Committee would you like to consider this application?[2]

○ Arts, Humanities and Cultures (PVAR)

○ Biological Sciences (BIOSCI)

○ ESSL/ Environment/ LUBS (AREA)

○ MaPS and Engineering (MEEC)

○ Medicine and Health (Please specify a subcommittee):

- ◉ School of Dentistry (DREC)
- ○ School of Healthcare (SHREC)
- ○ School of Medicine (SoMREC)
- ○ School of Psychology (SoPREC)

A.2 Title of the research[3]
Assessment of the Undergraduate Admissions Process for Dental Surgery: Predictability and Fairness: Phase II

A.3 Principal investigator's contact details[4]	
Name *(Title, first name, surname)*	**Eman Alsharafi**
Position	**PhD student**
Department/ School/ Institute	**School of Dentistry**
Faculty	**Medicine and Health**
Work address *(including postcode)*	**University of Leeds, Leeds, LS2 9LU**
Telephone number	**+44749 2239526**
University of Leeds email address	**dnea@leeds.ac.uk**

A.4 Purpose of the research:[5] (Tick as appropriate)

- ☑ Research
- ☑ Educational qualification: ***Please specify:*** **Postgraduate degree, PhD**
- ☑ Educational Research & Evaluation[6]
- ☐ Medical Audit or Health Service Evaluation[7]
- ☐ Other

A.5 Select from the list below to describe your research: (You may select more than one)

- [x] Research on or with human participants
- [ ] Research which has potential adverse environmental impact.[8] ***If yes, please give details:***

- [x] Research working with data of human participants
  - [ ] New data collected by qualitative methods
  - [x] New data collected by quantitative methods
  - [ ] New data collected from observing individuals or populations
  - [x] Routinely collected data or secondary data
  - [ ] Research working with aggregated or population data
  - [ ] Research using already published data or data in the public domain
- [ ] Research working with human tissue samples (*Please inform the relevant Persons Designate if the research will involve human tissue)*[9]

A.6 Will the research involve NHS staff recruited as potential research participants (by virtue of their professional role) or NHS premises/ facilities?

- [ ] Yes
- [x] No

If yes, ethical approval must be sought from the University of Leeds. Note that approval from the NHS Health Research Authority may also be needed, please contact FMHUniEthics@leeds.ac.uk for advice.

A.7 Will the research involve any of the following:[10] (You may select more than one)

If your project is classified as research rather than service evaluation or audit and involves any of the following an application must be made to the NHS Health Research Authority via IRAS www.myresearchproject.org.uk as NHS ethics approval will be required. ***There is no need to complete any more of this form****. Further information is available at* *http://ris.leeds.ac.uk/NHSethicalreview and at http://ris.leeds.ac.uk/HRAapproval. You may also contact* ***governance-ethics@leeds.ac.uk*** *for advice.*

☐ Patients and users of the NHS (including NHS patients treated in the private sector)[11]

☐ Individuals identified as potential participants because of their status as relatives or carers of patients and users of the NHS

☐ Research involving adults in Scotland, Wales or England who lack the capacity to consent for themselves[12]

☐ A prison or a young offender institution in England and Wales (and is health related)[14]

☐ Clinical trial of a medicinal product or medical device[15]

☐ Access to data, organs or other bodily material of past and present NHS patients[9]

☐ Use of human tissue (including non-NHS sources) where the collection is not covered by a Human Tissue Authority licence[9]

☐ Foetal material and IVF involving NHS patients

☐ The recently deceased under NHS care

☑ None of the above

You must inform the Research Ethics Administrator of your NHS REC reference and approval date once approval has been obtained.

The HRA decision tool to help determine the type of approval required is available at http://www.hra-decisiontools.org.uk/ethics. If the University of Leeds is not the Lead Institution, or approval has been granted elsewhere (e.g. NHS) then you should contact the local Research Ethics Committee for guidance. The UoL Ethics Committee needs to be assured that any relevant local ethical issues have been addressed.

A.8 Will the participants be from any of the following groups? (Tick as appropriate)

☐ Children under 16[16] ***Specify age group:***

____

☐ Adults with learning disabilities[12]

☐ Adults with other forms of mental incapacity or mental illness

☐ Adults in emergency situations

☐ Prisoners or young offenders[14]

☐ Those who could be considered to have a particularly dependent relationship with the investigator, e.g. members of staff, students[17]

☐ Other vulnerable groups

☐ No participants from any of the above groups

Please justify the inclusion of the above groups, explaining why the research cannot be conducted on non-vulnerable groups.

This study will assess the association of the socio-demographic characteristics and widening participation indices with both the performance in the undergraduate admission process, for all applicants, and the students' in-course performance, for those accepted. Therefore, the cohorts studied will be the applicants to the Dental Surgery Programme and the undergraduate students. As the research supervision team includes members of staff at the University, students could feel that they have a dependent relationship. The information sheets will reassure students that their involvement (or not) in the study will have no bearing on their admission assessment or on their future studies, if they were offered a place in Leeds University, and that all their data will be anonymised.

It is the researcher's responsibility to check whether a DBS check (or equivalent) is required and to obtain one if it is needed. See also http://www.homeoffice.gov.uk/agencies-public-bodies/dbs and http://store.leeds.ac.uk/browse/extra_info.asp?modid=1&prodid=2162&deptid=34&compid=1&prodvarid=0&catid=243.

A.9 Give a short summary of the research[18]

Selection of students with the highest potential of success in an undergraduate programme in Dental Surgery is a very challenging process. This is due to the fact that the selection is carried out among a highly academically-qualified pool of applicants that exceed the number of places available. Furthermore, little is known about which personal attributes significantly predict a student's subsequent performance.

Therefore, we plan to conduct cross-sectional studies to comprehensively assess the admission process at the Dental Surgery Programme at the School of Dentistry. This project is essential as it assesses the effectiveness and fairness of the selection process. The project aims to:

1- Assess if an association exists between the socio-demographic characteristics and widening participation indices of a student and the student's performance at the admission process and in-course performance
2- Assess if the current admissions process at the Dental Surgery Programme at the School of Dentistry predicts students' future performance.
3- Assess if the attributes evaluated at the Multiple Mini Interviews (MMIs) held at the School of Dentistry do predict students' subsequent performance (academic and clinical)

This application is to approve the research team to conduct this work over the next three years (2020-2023) to avoid multiple applications to the ethics committee.

This study (The second phase of the research) aims to assess the fairness of the admission process.

In this study, the following information is required:

- the socio-demographic data and widening participation indices of the (accepted) students only of admission cycle 2020 as we will not be able to consent the rejected ones in this admission cycle.
- the socio-demographic data and widening participation indices of the applicants (both accepted and rejected) at the Dental Surgery Programme during the application cycles 2021 and 2022. Consent is further discussed later in this section and section C.11
- performance of all the above-mentioned cohorts in the admission assessments
- (registered/accepted) students' in-course performance.

The association between the socio-demographic characteristics and widening participation indices with the following data will be evaluated.

1- the admission assessment scores of all applicants of admission cycles 2020, 2021 and 2022 except the rejected ones in admission cycle 2020 as we will not be able to consent the rejected ones in this admission cycle.
2- and in-course performance of the registered ones.

This is done to evaluate if any of the socio-demographic characteristics or widening participation indices of the applicants are affecting their performance in the admission assessments used or the in-course performance of the registered ones.

- The participants will only be asked to provide their A-level scores, GCSE details and information about their previous degrees, if present, via an electronic form that will be sent by email. This is due to the difficulty encountered to obtain this data from the admission office. Otherwise, the study does not require any further active involvement from the participants as these data are existing data and routinely collected as part of the admission process, access to Leeds application forms, UCAS forms and in-course evaluation. In other words, they will not be asked to do above and beyond the usual admission process and the tasks necessary to satisfy the requirements of their undergraduate degree.

-The data required are as follows:

Predictor variables will be recorded for each applicant included in the study:

1- Year of application
2- Age
3- Gender
4- Self-identified ethnicity
5- Socio-economic status
6- Widening participation indices

Outcome measures will be recorded for each applicant as follows:

1- Whether an offer was made to the applicant
2- If the applicant was rejected, the stage of the admission process at which he/she was rejected will be recorded.
3- Achieved scores in the A level exam (predicted where appropriate), GSCE, Personal statement total score, Personal statement sub-scores, BMAT score, MMI total score and MMI individual stations scores

Outcome measures will be recorded for each enrolled student as follows:

1- Academic in-course performance
2- Clinical in-course performance
3- Attendance
4- Any unprofessional behavior record or disciplinary proceedings
5- Year and reason of drop out, if present.

After obtaining ethical approval from DREC, opt out consent forms will be emailed to registered students of admission cycle 2020 and they will be given 2 weeks from when they receive the opt out consent email to withdraw from the study. Applicants of admission cycles 2021 and 2022 will be consented after the BMAT exam in November 2020 and November 2021 respectively. They will also be given 2 weeks from when they receive the opt out consent email to withdraw from the study. After consenting the students (Opt-out consent), the performance measures, admission assessments scores, socio-demographic data and widening participation indices of the applicants will be collected. Additionally, tracking of the enrolled students' performance as they progress through the early years of the programme is planned. An email will also be sent to the participants to request their A-level scores, GCSE details and their previous degrees, if present, as explained above. The aim is to use the data generated as part of the typical degree process (assessed summative marks, practical and clinical performance data) alongside their performance on the admission assessments and their socio-demographic characteristics. This will help us to identify patterns that will allow us to build statistical models identifying the predictors of applicants' performance in the admission process used at Leeds University and predictors of enrolled students' performance during the early years of the programme of study.

-Ensuring data anonymity will be a key priority and personal identifiers of the applicants and enrolled students will be removed. They will be free to withdraw from the study during the period specified above and in the consent forms. These ethical issues are further described in section (A.10) Another opt out consent form will be also sent along with the electronic form and an information sheet. This is to be signed by the participant if they wish not to provide the data via the electronic form. If the participant opted out from providing this data or did not respond to the email within a two-week period, further attempts to obtain the data from the participants' records held at the university will be made as the participants have already been consented for participation in the research.

-The data statistical analysis will be carried out in several phases to assess the association of the predictor variables and the outcome variables. Detailed description of the data analysis is written in section (C.2).

The first phase of this research will be described in a separate application form, as requested.

A.10 What are the main ethical issues with the research and how will these be addressed?[19]

Indicate any issues on which you would welcome advice from the ethics committee.

There are important ethical issues surrounding data management and confidentiality for work that requires correlation of socio-demographic data and widening participation indices with admissions performance, students' academic and clinical attainment records, attendance and any record of unprofessional behaviour. In order to address these concerns, data collected from participants will be anonymised. Participants will only be identifiable to the research team who are involved in the data analysis by a unique participant identification number (UPN); there will be no record linking UPNs to personal details kept by any of the researchers responsible for the data analysis. A member of staff who is not involved in the data analysis at the University of Leeds will retain a record of participant's UPNs linked to their name; this will be kept separate from the researcher analysing the data. Arrangements will be made for an independent third party to perform the encoding. This will be a PGR student from the School of Psychology. Keeping of this record is precautionary (in the event if a participant asks to view their data or we needed to add their progress through the programme)

Prior to data collection, an opt-out consent form and information sheet will be emailed by an SES member, who has access to the student contact details, to the registered students of admission cycles 2020. The consent will be also emailed to all applicants of admission cycles 2021 and 2022 along with an information sheet after the BMAT exam on November 2020 and November 2021 respectively. Participants will be given 2 weeks from when they receive the opt out consent email to respond to the email.

Participants will be provided with contact details of Prof Michael Manogue and the researcher, Eman Alsharafi, to send their withdrawal consents if they choose not to be included in the study. This will be explained in the information sheet and consent form. They can also use these contact details should they have any enquiries about the research.

Data will be then collected and anonymised as previously explained unless the participant dissents this by signing and emailing the opt-out consent form. It will be highlighted in the information sheet that their participation is voluntary and that their withdrawal from the study is optional during the 2 weeks period following receipt of consent. Participants will also be provided with contact details of the researchers should they have any enquiries about the research.
As previously explained, there were difficulties obtaining some data from the admission office, therefore, this data will be requested to be completed by the participants in an electronic form that will be sent by email along with an opt out consent form and an information sheet. The email will be sent by an SES member, who has access to the participants contact details. The participants will be given an opportunity to respond to the email for 2 weeks from when they receive the email. The opt out consent is to be signed by the participant if they wish not to provide the data via the electronic form. If the participant opted out

from providing the data or did not respond to the email in 2 weeks period, further attempts to obtain the data from the applicants'/students' records held at the university will be made as the participants have already been consented for participation in the research. Electronic data related to academic performance will be password protected. All computers used for data collection, storage or analysis will be encrypted.

PART B: About the research team

B.1 To be completed by students only[20]	
Qualification working towards (e.g. Masters, PhD)	**PhD**
Supervisor's name (Title, first name, surname)	**Prof Michael Manogue**
Department/ School/ Institute	**School of Dentistry**
Faculty	**Faculty of Medicine and Health**
Work address (including postcode)	**Worsley Building, University of Leeds, LS2 9LU**
Supervisor's telephone number	**0113 343 6173**
Supervisor's email address	**m.manogue@leeds.ac.uk**
Module name and number (if applicable)	

B.2 Other members of the research team (e.g. co-investigators, co-supervisors) [21]	
Name *(Title, first name, surname)*	**Dr Jennifer Hallam**
Position	**Educational Psychometrician**
Department/ School/ Institute	School of Medicine
Faculty	**Faculty of Medicine and Health**

Work address *(including postcode)*	**Worsley Building, University of Leeds, LS2 9LU**
Telephone number	**01133434378**
Email address	**j.l.hallam@leeds.ac.uk**

Name (Title, first name, surname)	**Dr Gail Nicholls**
Position	**Head of Admissions**
Department/ School/ Institute	**School of Medicine**
Faculty	**Faculty of Medicine and Health**
Work address (including postcode)	**Room 7.09, Worsley Building, University of Leeds, LS2 9LU**
Telephone number	**0113 34 37579**
Email address	**g.c.nicholls@leeds.ac.uk**

Part C: The research

C.1 What are the aims of the study?[22] (Must be in language comprehensible to a lay person.)

The overarching aim of this research project is to evaluate the current admissions process in the Dental Surgery Programme at the School of Dentistry, University of Leeds for predictability and fairness by:

1- Assess if an association exists between the socio-demographic characteristics and widening participation indices of a student with the student's performance at the admission process and in-course performance
2- Assess if the current admissions process at the Dental Surgery Programme at the School of Dentistry predicts students' future performance.
3- Assess if the attributes evaluated at the Multiple Mini Interviews (MMIs) held at the School of Dentistry do predict students' subsequent performance (academic and clinical)

C.2 Describe the design of the research. Qualitative methods as well as quantitative methods should be included.

The work largely involves a quantitative methodology. Data will be analysed using IBM SPSS version 23. The analysis will be exploratory in nature and will aim and to explore the association of the socio-demographic factors and widening participation indices with the applicants' (accepted and rejected) performance at the admission process and to also explore the predictive factors of dental school performance (for the enrolled/accepted students). The statistical analysis will be conducted in stages due to the exploratory nature, and each stage will inform the next.

The following analysis will be carried out:

- Stage I: Initial analysis (Data of all applicants which includes: accepted and rejected applicants of 2021 & 2022 + data of accepted students 2020)

Initial analysis will be carried out to explore the participants' socio-demographic characteristics and widening participation indices.

This will be followed by an analysis of the participants' performance at each stage of the admission process e.g. at initial screening of A level and GSCE performance, secondly by personal statement assessment stage, followed by BMAT score assessment stage and finally by MMI assessment stage.

Additionally, before any further analysis is carried out, data will be explored to assess the distribution to determine the type of tests to be used at the exploration stages.

- Stage II: (Data of all applicants which includes: accepted and rejected applicants of 2021 & 2022 + data of accepted students 2020)

Assess the association of the socio-demographic characteristics and widening participation indices with success at each stage of the admission process using univariate analysis. In other words, each predictor variable will be assessed individually in relation to the association with each outcome measure. Logistic regression analysis (statistical modeling) will be then carried out to explore the extent to which success at each stage of the admission process is related to socio-demographic characteristics or widening participation indices of the participant.

- Stage III: (Data of all applicants which includes: accepted and rejected applicants of 2021 & 2022 + data of accepted students 2020)

Assess the association between socio-demographic characteristics and widening participation indices with the score obtained in the admission assessments. Univariate analysis will be used to explore the association between the socio-demographic variables and widening participation indices of the participants and the scores obtained at each of the admission assessments. Statistical modelling identifying prediction will then be carried out to explore the extent to which the score obtained at each of the admission assessments is related to the socio-demographic characteristics of the participants.

- Stage IV: (Data of accepted/enrolled students 2020, 2021 and 2022) Assess the association of the socio-demographic characteristics and widening participation indices with completion of the early years of the programme. Univariate analysis will be used to explore association between each of the socio-demographic variables of the participants who enrolled in the programme and completion of the early years of the programme. This will be followed by logistic regression to explore the extent of the effect, if present.

- Stage V: (Data of accepted/enrolled students 2020, 2021 and 2022) Assess the association of the socio-demographic characteristics and widening participation indices with in-course performance of the enrolled students. Univariate analysis will be used to explore the significance of association of each of the predictor variables to outcome measures (in-course performance). This will be followed by modelling each of the outcome measures with the predictor variables.

C.3 What will participants be asked to do in the study?[23] *(e.g. number of visits, time, travel required, interviews)*

When ethical approval is obtained, an information sheet and an opt-out consent form will be sent to the participants by email as previously explained in section A.10. They will be given 2 weeks to respond to the email. Data will be then collected and anonymised as previously explained in sections A.9 and A.10 unless the applicant/student dissents this by signing and emailing the opt-out consent form. They will be allowed to withdraw from the study up until the date specified in the consent forms (2 weeks following receipt of consent).

The participants will also be asked to provide their A-level scores, GCSE details and information about their previous degrees, if present, via an electronic form that will be sent by email as previously explained in section A.10. This is due to the difficulty encountered to obtain this data from the admission office.

Participants will not be asked to do anything further as the data will be retrospectively collected from the participants’ records.

C.4 Does the research involve an international collaborator or research conducted overseas:[24] (Tick as appropriate) ☐ Yes ☑ No **If yes, describe any ethical review procedures that you will need to comply with in that country:** **Describe the measures you have taken to comply with these:** Include copies of any ethical approval letters/ certificates with your application.

C.5 Proposed study dates and duration Research start date (DD/MM/YY): 20 October 2020 Research end date (DD/MM/YY): 31 January 2023 Fieldwork start date (DD/MM/YY): 02 November 2020 Fieldwork end date (DD/MM/YY): 31 December 2022

C.6. Where will the research be undertaken? (i.e. in the street, on UoL premises, in schools)[25] The research will be carried out at the School of Dentistry.

RECRUITMENT & CONSENT PROCESSES

C.7 How will potential participants in the study be: **(i) identified?** **Participants are:** All accepted students of admission cycle 2020 will be included (98 accepted student). Additionally, all applicants for the Dental Surgery Programme, both accepted and rejected, for the admission cycle 2021 and 2022 at the School of Dentistry, Faculty of Medicine and Health, University of Leeds. **(ii) approached?** When the ethical approval is obtained, an opt-out consent form will be emailed by a member of the SES team to the accepted students of admission cycle 2020. This will also be sent to all applicants of admission cycles 2021 and 2022 along with an information sheet after undertaking the BMAT exam. Students

will be given an opportunity to respond to the email for 2 weeks from when they receive the opt out consent email.

Participants will also be provided with contact details of Prof Michael Manogue and the researcher, Eman Alsharafi, to send their consents if they decided to withdraw from the study. This will be explained in the information sheet and consent form. They can also use these contact details should they have any enquiries about the research.

Data will be then collected and anonymised as previously explained in sections A.9 and A.10 unless the student dissents this by signing and emailing the opt-out consent form. It will be highlighted in the information sheet that their participation is voluntary and that their withdrawal from the study is optional for 2 weeks from when they receive the opt out consent email.

The participants will also be asked to provide their A-level scores, GCSE details and information about their previous degrees, if present, via an electronic form that will be sent by email as previously explained in section A.10. This is due to the difficulty encountered to obtain this data from the admission office. The email will be sent by an SES member, who has access to the participants contact details. The participants will be given an opportunity to respond to the email for 2 weeks from when they receive the email. When the participant fills the form, it will automatically be forwarded to Prof Michael Manogue. The data will be then forwarded to an independent third party to link the data provided with the rest of the data and perform the encoding. The opt out consent is to be signed by the participant if they wish not to provide the data via the electronic form. The participants will be provided with the contact details of Prof Michael Manogue and the researcher, Eman Alsharafi, to send their consents if they decided to not to provide their data in the electronic form. This will be explained in the information sheet and consent form. If the participant opted out from providing the data or did not respond to the email in 2 weeks period, further attempts to obtain the data from the participants' records held at the university will be made as the participants have already been consented for participation in the research.

(iii) recruited?[26]

Explained above.

C.8 Will you be excluding any groups of people, and if so what is the rationale for that?[27]

The rejected applicants of admission cycle 2020 will be excluded as we will not be able to consent them.

C.9 How many participants will be recruited and how was the number decided upon?[28]

To have a fully representative sample, data of all accepted students of admission cycle 2020 (98 student) and data of all applicants for the admission cycles 2021 and 2022 will be included.

C10 Will the research involve any element of deception?[29]

No

C.11 Will informed consent be obtained from the research participants?[30]

☑ Yes ☐ No

If yes, give details of how it will be done. Give details of any particular steps to provide information (in addition to a written information sheet) e.g. videos, interactive material. If you are not going to be obtaining informed consent you will need to justify this.

If ***participants are to be recruited from any of potentially vulnerable groups, give details of extra steps taken to assure their protection. Describe any arrangements to be made for obtaining consent from a legal representative.***

For the enrolled students for admission cycles 2020 and all applicants of admission cycle 2021 and 2022, opt-out consents will be emailed by a member of the SES, who has access to the students' contact details, and they will be provided with a description of the project with the aims and study plans explained in the information sheet. This will be sent to the enrolled students of admission cycle 2020 when the ethical approval is obtained and will be sent in November 2020 and November 2021 for all applicants of admission cycle 2021 and 2022 respectively after their BMAT exam is completed. Students will be given 2 weeks from when they receive the opt out consent email to respond to the email. Data will be then collected and anonymised as previously explained in sections A.9 and A.10 unless the student dissents this by signing and emailing the opt-out consent form. Participants will also be given contact details

of the researchers and the opportunity to ask questions at any point over the next 3 years. Participants will also be provided with contact details of Prof Michael Manogue and the researcher, Eman Alsharafi, to send their consents if they decided to withdraw from the study. This will be explained in the information sheet and consent form. They can also use these contact details should they have any enquiries about the research. An information sheet will also be provided with details about what each study involves. It will be made clear that information will be anonymous and that participants are free to withdraw from the study without consequence for 2 weeks from when they receive the opt out consent email. Participants will also be given the opportunity to ask questions before agreeing to participate and throughout the procedure. Another opt out consent form will be sent along with an information sheet and an electronic form to collect the A-level, GCSE and information regarding the participants' previous degrees, if present. The email will be sent by an SES member, who has access to the participants' contact details. The participants will be given an opportunity to respond to the email for 2 weeks from when they receive the email. The opt out consent is to be signed by the participant if they wish not to provide the data via the electronic form. If the participant opted out from providing the data or did not respond to the email in 2 weeks period, further attempts to obtain the data from the participants' records held at the university will be made as the participants have already been consented for participation in the research.
Copies of any written consent form, written information and all other explanatory material should accompany this application*. The information sheet should make explicit that participants can withdraw from the research at any time, if the research design permits. Remember to use meaningful file names and version control to make it easier to keep track of your documents.* *Sample information sheets and consent forms are available from the University ethical review webpage at* http://ris.leeds.ac.uk/InvolvingResearchParticipants.

C.12 Describe whether participants will be able to withdraw from the study, and up to what point (e.g. if data is to be anonymised). If withdrawal is not possible, explain why not.

Participants are free to opt out from the study for 2 weeks from when they receive the opt out consent email, without consequences. As for providing the data via the electronic form, the participants will also be given a two-week period to opt out from providing the previously specified data by email. It will be made clear to the participants that in order to opt out from the study they should send their consent form signed to Prof Michael Manogue or the researcher, Eman Alsharafi. This will be explained in the information sheet and consent form.

C.13 How long will the participant have to decide whether to take part in the research?[31]

The risks involved in taking part in this research are very low, and therefore it is anticipated that participants will not need to take long before deciding whether they are comfortable to take part. After emailing the opt-out consent forms on, participants will be given 2 weeks to respond to the email.

C.14 What arrangements have been made for participants who might have difficulties understanding verbal explanations or written information, or who have particular communication needs that should be taken into account to facilitate their involvement in the research?[32]

No problems with language are foreseen.

C.15 Will individual or group interviews/ questionnaires discuss any topics or issues that might be sensitive, embarrassing or upsetting, or is it possible that criminal or other disclosures requiring action could take place during the study (e.g. during interviews or group discussions)?[33]
The information sheet should explain under what circumstances action may be taken.

☐ Yes ☑ No *If yes, give details of procedures in place to deal with these issues.*

C.16 Will individual research participants receive any payments, fees, reimbursement of expenses or any other incentives or benefits for taking part in this research?[34]

☐ Yes ☑ No

If Yes, please describe the amount, number and size of incentives and on what basis this was decided.

RISKS OF THE STUDY

C.17 What are the potential benefits and/ or risks for research participants in both the short and medium-term?[35]

Benefits: By allowing access to anonymised student data, participants will help us to analyse and improve the admission system to promote fair access and ensure the appropriate selection of our students. We are aiming to assess if there is any unidentified bias to certain cohort groups and to identify the predictive validity of different components of the selection process and to use this to determine whether or not the current admissions processes should be altered.

Risks: No identified risks for participants.

C.18 Does the research involve any risks to the researchers themselves, or people not directly involved in the research? *Eg lone working*[36]

☐ Yes ☑ No

If yes, please describe:

____

Is a risk assessment necessary for this research?

☐ Yes ☑ No If yes, please include a copy of your risk assessment form with your application.

NB: If you are unsure whether a risk assessment is required visit http://ris.leeds.ac.uk/HealthAndSafetyAdvice or contact your Faculty Health and Safety Manager for advice.

RESEARCH DATA

C.19 Explain what measures will be put in place to protect personal data. E.g. anonymisation procedures, secure storage and coding of data. Any potential for re-identification should be made clear to participants in advance.[37] Refer to http://ris.leeds.ac.uk/ConfidentialityAnonymisation and http://ris.leeds.ac.uk/ResearchDataManagement for guidance.

The terms of GDPR will be adhered to and all information will be securely stored. The data will be anonymised at all stages of the research and will not be associated with the student's name or ID for the researcher carrying out the data analysis, as previously explained in section A.10. The data will be stored on password protected PC and backed up on the University M drive. Any personal data will be stored securely and separately from the anonymised data.

C.20 How will you make your research data available to others in line with: the University's, funding bodies' and publishers' policies on making the results of publically funded research publically available. Explain the extent to which anonymity will be maintained. *(max 200 words)* Refer to http://ris.leeds.ac.uk/ConfidentialityAnonymisation and http://ris.leeds.ac.uk/ResearchDataManagement for guidance.

Where relevant, we will make the anonymised, analysed dataset publicly available through an online research depository. All data will be kept strictly confidential and any individual data in write-ups/publications will be referred to by code-name only and will not be associated with the participant's name or student ID. Only anonymous data will be used.

C.21 Will the research involve any of the following activities at any stage (including identification of potential research participants)? (Tick as appropriate)

- ☑ Examination of personal records by those who would not normally have access
- ☐ Access to research data on individuals by people from outside the research team
- ☐ Electronic surveys, please specify survey tool: ______________________ (further guidance)
- ☑ Other electronic transfer of data

- [x] Use of personal addresses, postcodes, faxes, e-mails or telephone numbers

- [ ] Use of audio/ visual recording devices (NB this should usually be mentioned in the information for participants)

- [ ] FLASH memory or other portable storage devices

Storage of personal data on, or including, any of the following:

- [x] University approved cloud computing services (Microsoft Office 365 for email (Exchange online) and Microsoft OneDrive for Business)

- [ ] Other cloud computing services

- [x] Manual files

- [ ] Private company computers

- [ ] Laptop computers

- [ ] Home or other personal computers (not recommended; data should be stored on a University of Leeds server such as your M: or N: drive where it is secure and backed up regularly: http://ris.leeds.ac.uk/ResearchDataManagement.)

C.22 How do you intend to share the research data? (Indicate with an 'X)
Refer to http://library.leeds.ac.uk/research-data-deposit for guidance.

- [ ] Exporting data outside the European Union

- [ ] Sharing data with other organisations

- [ ] Publication of direct quotations from respondents

- [ ] Publication of data that might allow identification of individuals t identified

- [x] Submitting to a journal to support a publication

- [x] Depositing in a self-archiving system or an institutional repository

- [x] Dissemination via a project or institutional website
- [ ] Informal peer-to-peer exchange
- [x] Depositing in a specialist data centre or archive
- [ ] Other, please ______________________________.
- [ ] No plans to report or disseminate the data

C.23 How do you intend to report and disseminate the results of the study? (Indicate with an 'X) Refer to http://ris.leeds.ac.uk/ResearchDissemination and http://ris.leeds.ac.uk/Publication for guidance.

- [x] Conference presentation
- [x] Peer reviewed journals
- [x] Publication as an eThesis in the Institutional repository
- [x] Publication on website
- [ ] Other publication or report, please state:

____

- [x] Submission to regulatory authorities
- [ ] Other, please state:

______________________________.

- [ ] No plans to report or disseminate the results

C.24 For how long will data from the study be stored? Please explain why this length of time has been chosen.[38] Refer to the RCUK Common Principles on Data Policy and http://ris.leeds.ac.uk/info/71/good_research_practice/106/research_data_guidance/5.

Students*: It would be reasonable to retain data for at least 2 years after publication or three years after the end of data collection, whichever is longer.*

______5___ years, _________ months (For publication following completion of the research)

CONFLICTS OF INTEREST

C.25 Will any of the researchers or their institutions receive any other benefits or incentives for taking part in this research over and above normal salary or the costs of undertaking the research?[39]

☐ **Yes** ☑ **No**

If yes, indicate how much and on what basis this has been decided

C.26 Is there scope for any other conflict of interest?[40] *For example, could the research findings affect the any ongoing relationship between any of the individuals or organisations involved and the researcher(s)? Will the research funder have control of publication of research findings? Refer to http://ris.leeds.ac.uk/ConflictsOfInterest.*

☐ Yes ☑ No

If so, please describe this potential conflict of interest, and outline what measures will be taken to address any ethical issues that might arise from the research.

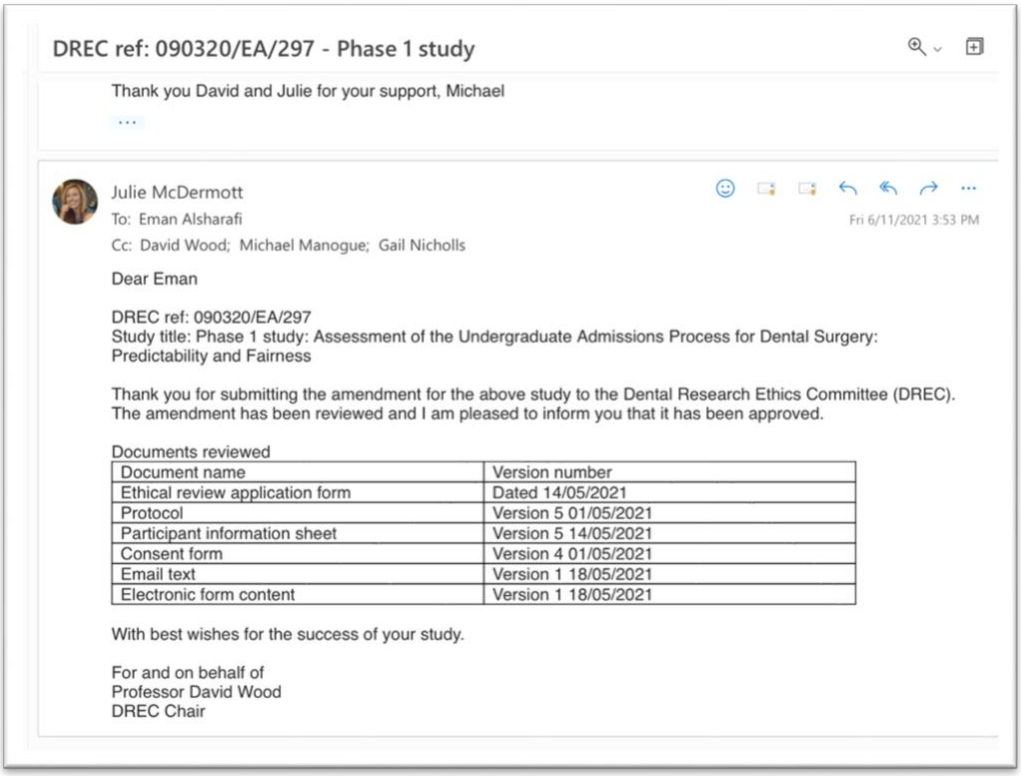
C.27 Does the research involve external funding? (Tick as appropriate)

☐ Yes ☑ No ***If yes, what is the source of this funding?***

____

NB: If this research will be financially supported by the US Department of Health and Human Services or any of its divisions, agencies or programmes please ensure the additional funder requirements are complied with. Further guidance is available at http://ris.leeds.ac.uk/FWAcompliance and you may also contact your FRIO for advice.

Confirmations of ethical approval by DREC



DREC ref: 090320/EA/297 - Phase 1 study

Thank you David and Julie for your support, Michael

...

Julie McDermott
To: Eman Alsharafi
Cc: David Wood; Michael Manogue; Gail Nicholls

Fri 6/11/2021 3:53 PM

Dear Eman

DREC ref: 090320/EA/297
Study title: Phase 1 study: Assessment of the Undergraduate Admissions Process for Dental Surgery: Predictability and Fairness

Thank you for submitting the amendment for the above study to the Dental Research Ethics Committee (DREC). The amendment has been reviewed and I am pleased to inform you that it has been approved.

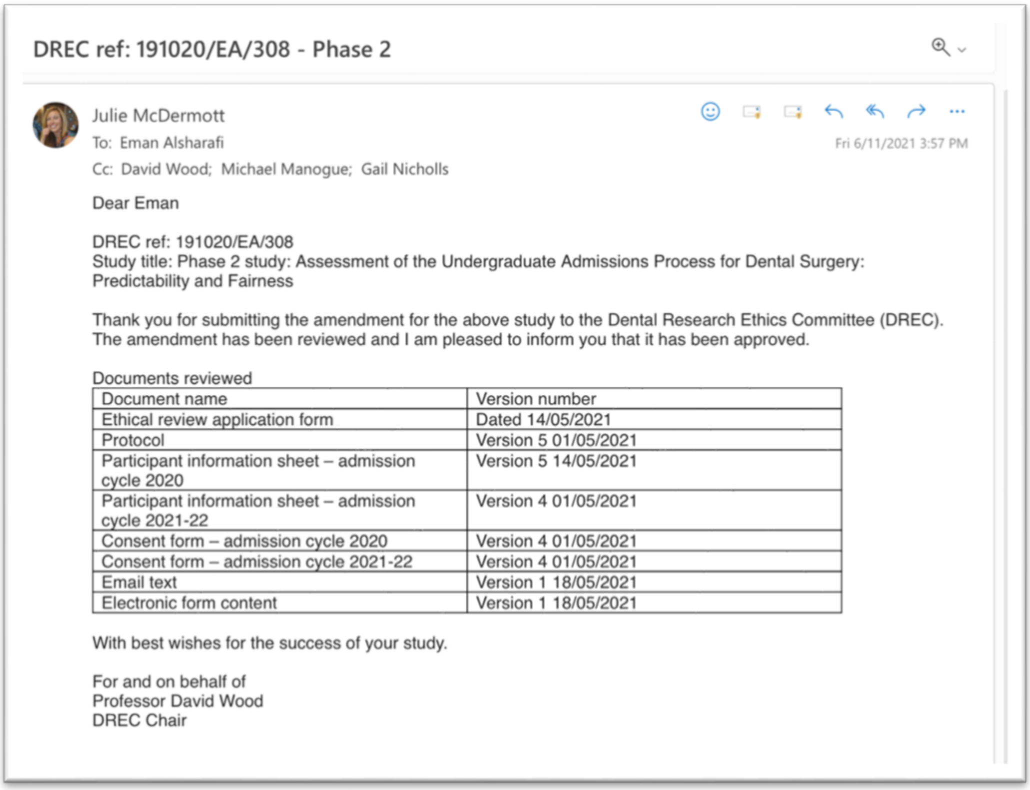
Documents reviewed

Document name	Version number
Ethical review application form	Dated 14/05/2021
Protocol	Version 5 01/05/2021
Participant information sheet	Version 5 14/05/2021
Consent form	Version 4 01/05/2021
Email text	Version 1 18/05/2021
Electronic form content	Version 1 18/05/2021

With best wishes for the success of your study.

For and on behalf of
Professor David Wood
DREC Chair

Figure 14: Confirmation of phase I ethical approval by DREC



DREC ref: 191020/EA/308 - Phase 2

Julie McDermott
To: Eman Alsharafi
Cc: David Wood; Michael Manogue; Gail Nicholls

Fri 6/11/2021 3:57 PM

Dear Eman

DREC ref: 191020/EA/308
Study title: Phase 2 study: Assessment of the Undergraduate Admissions Process for Dental Surgery: Predictability and Fairness

Thank you for submitting the amendment for the above study to the Dental Research Ethics Committee (DREC). The amendment has been reviewed and I am pleased to inform you that it has been approved.

Documents reviewed

Document name	Version number
Ethical review application form	Dated 14/05/2021
Protocol	Version 5 01/05/2021
Participant information sheet – admission cycle 2020	Version 5 14/05/2021
Participant information sheet – admission cycle 2021-22	Version 4 01/05/2021
Consent form – admission cycle 2020	Version 4 01/05/2021
Consent form – admission cycle 2021-22	Version 4 01/05/2021
Email text	Version 1 18/05/2021
Electronic form content	Version 1 18/05/2021

With best wishes for the success of your study.

For and on behalf of
Professor David Wood
DREC Chair

Figure 15: Confirmation of phase II ethical approval by DREC

Appendix E Personal statement scoring

Personal statements are evaluated for the four categories described below..

Table 79: Personal statement scoring

Domain	Description	Scoring
1.Life Experience and Social Awareness	Demonstrates commitment to activities or caring roles. Demonstrates caring attributes, team work and social awareness.	Scored 1-4, weighted x 4
2.Motivation and Insight	Demonstrates research on dentistry. Demonstrates insight into dentistry.	Scored 1-4, weighted x 2.5
3.Reflective Skills	Demonstrates understanding of what they have learned from their life experiences Explains how this learning makes them suitable for the dental profession.	Scored 1-4, weighted x 2.5
4.Interests and Achievements	Engagement in non-dental interests that would support becoming a dental professional. Achievements and awards should be able to be evidenced (eg certificates)	Scored 1-4, weighted x 1

Appendix F Details of academic modules

Table 80: Year 1 modules

Module	Credits	Assessments	% of formal assessment
Health and Health Promotion	20 credits	Coursework: Group presentation based on group project	0
		Exam	100
Introduction to the Oral Environment	20 credits	Coursework: -Practical: Log books -Computer exercise: Online tooth morphology test	0 0
		Exam	100
Anxiety and Pain Management	20 credits	Exam	100
Oral Diseases, Defence and Repair	20 credits	Coursework: In-course MCQ: Online with feedback	0
		Exam: Online time-limited assessment	100

Table 80: Year 1 modules, continued

Introduction to Clinical Skills and Practice	20 credits	Coursework: In-course Assessment: Professionalism in line with General Dental Council, Preparing for Practice, outcomes for registration This module is grading mode W and as such is pass/fail. Students will need to have successfully completed the Clinical Portfolio and to have demonstrated an appropriate level of professionalism in order to pass the module.	0
Personal and Professional Development 1	20 credits	Coursework: - Tutorial Performance: Attendance at Ethics and Professionalism Day - Tutorial Performance: Participation in Consent and Confidentiality workshop -Report: Report on observed dental disease (500 words) Formative -Report: Report on observed dental treatment (600 words) - Group presentation	0 0 0 50 50

Table 81: Year 2 modules

Module	Credits	Assessments	% of formal assessment
Personal and Professional Development 2	20 credits	Coursework: -Essay: 1,000-word essay -Poster Presentation - Reflective log: Reflective report on interaction with patient simulator (progressional)	 40 60 0
Social Sciences Related to Dentistry	10 credits	Coursework: - Essay or Dissertation: Sample exam questions made available - Oral Presentation	 0 0
		Exam: Online Time-Limited assessment	 100
Clinical Skills A	60 credits	Coursework: - Group Project: Journal article (1500 words max) - Practical: Clinical skills exercises	 0 0
		Exams: - Online Time-Limited assessment - Practical Exam / OSCE	 70 30
Introduction to Biomedical Sciences	20 credits	Coursework: In-course assessment: On-line formative MCQ exercises	 0
		Exam: Online Time-Limited assessment	 100
Clinical Practice 2	15 credits	Coursework: Practical: Practise OSCE	 0
		Exam	100

Table 82: Year 3 modules

Modules	Credits	Assessments	% of formal assessment
Undergraduate Projects	20 credits	Coursework: -Group project: completion of Search Strategy and Medline. Formative assessment. - Tutorial Performance: Participation in Research Ethics Seminar (progressional) - Completion of Annotated Bibliography 1800 words.	 0 0 25
		Exam: Online Time-Limited assessment	 75
Clinical Skills B	50 credits	Coursework: - Group Project: Treatment planning (formative) - Literature Review: Endo group presentation (formative). -Reflective log: Reflection on the key elements of the module within handbooks (progressional) -Practical: Denture design test (progressional).	 0 0 0 0

Table 82: Year 3 modules, continued

		-Practical: Continuous assessment (progressional - attendance & completion of requirements). -Practical: Endodontic skill assessment (progressional). -Practical: Crown test (progressional). -Practical: Basic Extraction (progressional).	0 0 0 0 0
		Exams: Online Time-Limited assessment	100
Child Centred Dentistry 1	10 credits	Coursework: - Practical: Simulated pulpotomy and crown preparation (progressonal). - Reflective assignment. Clinical: 2-3 structured cases 2000 words. - Tooth morphology spotter, identification of primary and permanent teeth (progressional).	0 100 0

Table 82: Year 3 modules, continued

Illness and Well-being	20 credits	Coursework: In-course Assessment: Formative	0
		Exams: Online Time-Limited assessment	100
Clinical Practice 3	20 credits	Coursework: - Clinical Experience: Clinical passport and clinical review process (progressional). - Satisfactory completion of Paediatric workbook (progressional). - 'Preparing for Practice' outcomes for registration (progressional). -Report: Clinical case report with 500 word discussion. -Reflective log: Review of clinical progress and experience(progressional).	0 0 0 40 0
		Exams: Practical Exam / OSCE	60
Personal and Professional Development 3	20 credits	Coursework: -Reflective log (progressional) - Oral Presentation	0 40
		Exam: Online Time-Limited assessment	60

Table 83: Year 4 modules

Modules	Credits	Assessments	% of formal assessment
Clinical Medical Sciences 1	30 credits	Coursework: Case study (Clinical diary, 2 clinical cases)	40
		Exam	60
Complex Adult Dentistry	35 credits	Course work: -Viva (Prosthetics viva – formative) -Practical assessment of C/C set up (progressional) -Continuous assessment of practical skills (formative)	 0 0 0
		Exams: -Online time-limited assessment -Practical exam OSCE	 50 50
Child Centred Dentistry 2	10 credits	Exams: -Exam 1 -Exam 2	 50 50
Final Year Project	30 credits	Course work: -Research proposal -Report	 20 80

Table 83: Year 4 modules, continued

Personal and Professional Development 4	10 credits	Coursework: -Reflective log -Reflective assignment (1500 words)	 0 100
Clinical Practice 4	40 credits	Coursework: -Practical: Medical Emergencies Simulation Training (progressional) -Practical: Continuous Clinical Assessment (formative & progressional sign off from tutor) -Computer exercise: Relevant online assessments (progressional) -Practical: Crown and molar endo tests - progressional -Presentation: Case presentation - Prosthetics case - progressional -Presentation: Case presentation-Perio -Reflective log: Oral surgery log book/diary (progressional) -Reflective log: Paeds/ortho logbook (progressional) -Practical: Radiography competency (formative)	 0 0 0 0 10 0 0 0 0
		Exams: -Online time-limited assessment -Practical exam/OSCE -Practical exam/OSCE	 40 25 25

Table 84: Year 5 modules

Modules	Credits	Assessments	% of formal assessment
Anxiety Management and Sedation	10 credits	Coursework:	
		-Practical: Attendance on clinics (progressional)	0
		-Reflective log: Log book – progressional	0
		-Report: Case report – Sammative 1000-1500 words	100
		-Written work: Workbook – Progressional	0
Clinical Medical Sciences 2	10 credits	Coursework:	
		-Case study: Clinical diary	20
		-Case study: Hospital attachment	0
		Exam	80
Final Year Project	30 credits	Coursework:	
		-Research proposal of 1500 words	20
		-Report: In the format of a journal article of 4,000 words submitted at the end of first semester in year 5	80

Table 84: Year 5 modules, continued

Clinical Practice 5	50 credits	Course work: -Portfolio: One long case, 2 short cases (40% Combined); one paeds case (10%) -Practical: Continuous Clinical Assessment (formative & progressional sign off from tutor) -Practical: Medical Emergencies Simulation Training Session (progressional) -Computer exercise: Relevant online NHS assessments -Practical: Radiography competency - progressional -Presentation: Case presentation - formative -Practical: Construction of a splint (formative)	50
		Exams: -Online time-limited assessment -Practical exam / OSCE	30 20
Personal and Professional Development 5 - Preparing for the World of Work	20 credits	Coursework: -Online ethics tutorial (progressional) -Written assignment (GDC)	40 60

References

ACCESS TO LEEDS, U. O. L. 2020. Access to Leeds - Widening access scheme.

ADEA 2013. ADEA Competencies for the New General Dentist:(As approved by the 2008 ADEA House of Delegates). *J Dent Educ,* 77**,** 899-902.

AL-SAUD, L. M., MUSHTAQ, F., MANN, R. P., MIRGHANI, I. A., BALKHOYOR, A., HARRIS, R., OSNES, C., KEELING, A., MON-WILLIAMS, M. A. & MANOGUE, M. 2020. Early assessment with a virtual reality haptic simulator predicts performance in clinical practice. *BMJ Simulation & Technology Enhanced Learning,* 6**,** 274.

ALAKI, S. M., YAMANY, I. A., SHINAWI, L. A., HASSAN, M. H. & TEKIAN, A. 2016. Can Multiple Mini-Interviews Predict Academic Performance of Dental Students? A Two-Year Follow-Up. *J Dent Educ,* 80**,** 1376-1383.

ALBANESE, M. A., SNOW, M. H., SKOCHELAK, S. E., HUGGETT, K. N. & FARRELL, P. M. 2003. Assessing personal qualities in medical school admissions. *Academic Medicine,* 78**,** 313-321.

ARNOLD, W., GONZALEZ, P. & GAENGLER, P. 2011. The predictive value of criteria for student admission to dentistry. *European Journal of Dental Education,* 15**,** 236-243.

BALA, L., PEDDER, S., SAM, A. H. & BROWN, C. 2022. Assessing the predictive validity of the UCAT—A systematic review and narrative synthesis. *Medical Teacher,* 44**,** 401-409.

BARBOUR, M. E. & SANDY, J. R. 2014a. Multiple mini interviews for selection of dental students: influence of gender and starting station. *Journal of Dental Education,* 78**,** 589-596.

BARBOUR, M. E. & SANDY, J. R. 2014b. Multiple mini interviews for selection of dental students: influence of gender and starting station. *J Dent Educ,* 78**,** 589-96.

BARKLEY, R. 1976. The dilemma of dental school admissions: a possible solution. *The Journal of the American College of Dentists,* 43**,** 119-126.

BEIER, U. S., KAPFERER, I., BURTSCHER, D., ULMER, H. & DUMFAHRT, H. 2012. Impact of a prior medical degree on students' dental school performance in Innsbruck, Austria. *Journal of Dental Education,* 76**,** 341-347.

BETANCOURT, J. R. 2006. Eliminating racial and ethnic disparities in health care: what is the role of academic medicine? *Academic Medicine,* 81**,** 788-792.

BOOTH, A. J., HURRY, K. J. & ABELA, S. 2022. The current dental school applicant: an overview of the admission process for UK dental schools and the sociodemographic status of applicants. *British Dental Journal,* 232**,** 172-176.

BOREHAM, N., RUSSELL, C. & WASTELL, D. 1988. Can past academic criteria predict students at risk of future failure? *Medical Education,* 22**,** 94-98.

BRAMLEY, T., VIDAL RODEIRO, C. L. & VITELLO, S. 2015. Gender differences in GCSE. Cambridge Assessment Research Report.: Cambridge, UK: Cambridge Assessment.

CHAMBERLAIN, T. 2004. Personality and a new Canadian Dental Association interview: implications for dental student selection.

CHEUNG, K., MCELWEE, S. & SHANNON, M. 2017. *The BioMedical Admissions Test as a shortlisting tool for MMIs: An examination of predictive validity in a UK dental school*.

CLEGHORN, B. M., BRILLANT, M., KRAGLUND, F., SETH, S. & GARLAND, H. W. 2018. Value of the manual dexterity test as a screening tool for dental school admissions. *Journal of Dental Education,* 82**,** 878-882.

CLELAND, J., DOWELL, J., MCLACHLAN, J., NICHOLSON, S. & PATTERSON, F. 2012a. Identifying best practice in the selection of medical students. *London: General Medical Council*.

CLELAND, J., DOWELL, J., MCLACHLAN, J., NICHOLSON, S. & PATTERSON, F. 2012b. Identifying best practice in the selection of medical students (literature review and interview survey). London: General Medical Council; 2012.

COLLINS, J., WHITE, G., PETRE, K. & WILLOUGHBY, E. 1995. A structured panel interview and group exercise in the selection of medical students. *Medical Education,* 29**,** 332-336.

COOK, D. A. & REED, D. A. 2015. Appraising the quality of medical education research methods: the medical education research study quality instrument and the Newcastle–Ottawa scale-education. *Academic Medicine,* 90**,** 1067-1076.

COWPE, J., PLASSCHAERT, A., HARZER, W., VINKKA-PUHAKKA, H. & WALMSLEY, A. D. 2010. Profile and competences for the graduating European dentist - update 2009. *Eur J Dent Educ,* 14**,** 193-202.

CURNOW, G. 2018. MMI - An unbiased approach to health education selection? *MedEdPublish,* 7**,** 43.

CURTIS, S., BLUNDELL, C., PLATZ, C. & TURNER, L. 2014. Successfully widening access to medicine. Part 2: curriculum design and student progression. *Journal of the Royal Society of Medicine,* 107**,** 393-397.

DALAYA, M., ISHAQUDDIN, S., GHADAGE, M. & HATTE, G. 2015. An interesting review on soft skills and dental practice. *J Clin Diagn Res,* 9**,** Ze19-21.

DAVIES, D. J., SAM, A. H., MURPHY, K. G., KHAN, S. A., CHOE, R. & CLELAND, J. 2022. BMAT's predictive validity for medical school performance: a retrospective cohort study. *Medical Education*.

DEPARTMENT OF EDUCATION. 2021. *Post-Qualification Admissions Reform Consultation* [Online]. Available: https://consult.education.gov.uk/he-access-and-admissions/higher-education-admissions-reform/#:~:text=This%20consultation%20follows%20the%20commitment%20from%20Government%20to,move%20to%20a%20system%20of%20post-qualification%20admissions%20%28PQA%29. [Accessed 2023].

DORE, K. L., KREUGER, S., LADHANI, M., ROLFSON, D., KURTZ, D., KULASEGARAM, K., CULLIMORE, A. J., NORMAN, G. R., EVA, K. W., BATES, S. & REITER, H. I. 2010. The reliability and acceptability of the Multiple Mini-Interview as a selection instrument for postgraduate admissions. *Acad Med,* 85**,** S60-3.

DUFF, R. E., KATCHER, P. A., DANIELS, R. M. & RAMASWAMY, V. 2020. The multiple mini interview as a dental school admission tool: can it predict noncognitive traits associated with professional behaviors? *Journal of dental education,* 84**,** 478-485.

EDWARDS, J. C., JOHNSON, E. K. & MOLIDOR, J. B. 1990. The interview in the admission process. *Acad Med,* 65**,** 167-77.

EMERY, J. L. & BELL, J. F. 2009a. The predictive validity of the BioMedical Admissions Test for pre-clinical examination performance. *Med Educ,* 43**,** 557-64.

EMERY, J. L. & BELL, J. F. 2009b. The predictive validity of the BioMedical Admissions Test for pre-clinical examination performance. *Medical education,* 43**,** 557-564.

EMERY, J. L., BELL, J. F. & VIDAL RODEIRO, C. L. 2011. The BioMedical admissions test for medical student selection: issues of fairness and bias. *Medical Teacher,* 33**,** 62-71.

EVA, K. W. 2003. On the generality of specificity. *Med Educ,* 37**,** 587-8.

EVA, K. W. & MACALA, C. 2014. Multiple mini-interview test characteristics:'Tis better to ask candidates to recall than to imagine. *Medical Education,* 48**,** 604-613.

EVA, K. W., REITER, H. I., ROSENFELD, J. & NORMAN, G. R. 2004a. The ability of the multiple mini-interview to predict preclerkship performance in medical school. *Acad Med,* 79**,** S40-2.

EVA, K. W., REITER, H. I., ROSENFELD, J., TRINH, K., WOOD, T. J. & NORMAN, G. R. 2012. Association between a medical school admission process using the multiple mini-interview and national licensing examination scores. *Jama,* 308**,** 2233-40.

EVA, K. W., ROSENFELD, J., REITER, H. I. & NORMAN, G. R. 2004b. An admissions OSCE: the multiple mini-interview. *Med Educ,* 38**,** 314-26.

EVA, K. W., ROSENFELD, J., REITER, H. I. & NORMAN, G. R. 2004c. An admissions OSCE: the multiple mini-interview. *Medical education,* 38**,** 314-326.

EVANS, J. G. & DIRKS, S. J. 2001. Relationships of admissions data and measurements of psychological constructs with psychomotor performance of dental technology students. *Journal of Dental Education,* 65**,** 874-882.

FERGUSON, E., JAMES, D. & MADELEY, L. 2002a. Factors associated with success in medical school: systematic review of the literature. *Bmj,* 324**,** 952-957.

FERGUSON, E., JAMES, D. & MADELEY, L. 2002b. Factors associated with success in medical school: systematic review of the literature. *Bmj,* 324**,** 952-7.

FERGUSON, E., MCMANUS, I., JAMES, D., O'HEHIR, F. & SANDERS, A. 2003. Pilot study of the roles of personality, references, and personal statements in relation to performance over the five years of a medical degreeCommentary: How to derive causes from correlations in educational studies. *Bmj,* 326**,** 429-432.

FERGUSON, E., SANDERS, A., O'HEHIR, F. & JAMES, D. 2000. Predictive validity of personal statements and the role of the five-factor model of personality in relation to medical training. *Journal of Occupational and Organizational Psychology,* 73**,** 321-344.

FIELDING, S., TIFFIN, P. A., GREATRIX, R., LEE, A. J., PATTERSON, F., NICHOLSON, S. & CLELAND, J. 2018. Do changing medical admissions practices in the UK impact on who is admitted? An interrupted time series analysis. *BMJ open,* 8**,** e023274.

FOLEY, J. & HIJAZI, K. 2013. The admissions process in a graduate-entry dental school: can we predict academic performance? *British dental journal,* 214**,** E4-E4.

FOLEY, J. & HIJAZI, K. 2015. Predictive value of the admissions process and the UK clinical aptitude test in a graduate-entry dental school. *British Dental Journal,* 218**,** 687-689.

GALLAGHER, J. 2019. The Future Oral and Dental Workforce for England: Liberating human resources to serve the population across the life-course. *Higher Education England*.

GANSKY, S. A., PRITCHARD, H., KAHL, E., MENDOZA, D., BIRD, W., MILLER, A. J. & GRAHAM, D. 2004. Reliability and validity of a manual dexterity test to predict preclinical grades. *Journal of Dental Education,* 68**,** 985-994.

GARLICK, P. B. & BROWN, G. 2008. Widening participation in medicine. *Bmj,* 336**,** 1111-1113.

GDC 2015. Preparing for practice: Dental team learning outcomes for registration.

GDC 2016. Student professionalism and fitness to practise.

GIULIANI, M., LAJOLO, C., CLEMENTE, L., QUERQUI, A., VIOTTI, R., BOARI, A. & MIANI, C. 2007. Is manual dexterity essential in the selection of dental students? *British Dental Journal,* 203**,** 149-155.

GREATRIX, R. & MCANDREW, R. 2022. UCAT and dental student selection in the UK-what has changed? *British Dental Journal,* 232**,** 333-338.

GREATRIX, R., NICHOLSON, S. & ANDERSON, S. 2021. Does the UKCAT predict performance in medical and dental school? A systematic review. *BMJ open,* 11**,** e040128.

GRIFFIN, B. & WILSON, I. 2012. Associations between the big five personality factors and multiple mini-interviews. *Adv Health Sci Educ Theory Pract,* 17**,** 377-88.

GURIN, P., DEY, E., HURTADO, S. & GURIN, G. 2002. Diversity and Higher Education: Theory and Impact on Educational Outcomes. *Harvard Educational Review,* 72**,** 330-367.

HAMBRICK, D. Z., OSWALD, F. L., ALTMANN, E. M., MEINZ, E. J., GOBET, F. & CAMPITELLI, G. 2014. Deliberate practice: Is that all it takes to become an expert? *Intelligence,* 45**,** 34-45.

HANSON, M. D., KULASEGARAM, K. M., WOODS, N. N., FECHTIG, L. & ANDERSON, G. 2012. Modified personal interviews: resurrecting reliable personal interviews for admissions? *Acad Med,* 87**,** 1330-4.

HARASYM, P. H., WOLOSCHUK, W., MANDIN, H. & BRUNDIN-MATHER, R. 1996. Reliability and validity of interviewers' judgments of medical school candidates. *Academic Medicine,* 71**,** S40-2.

HAYWARD, G., STURDY, S. & JAMES, S. 2005. Estimating the reliability of predicted grades. *Cheltenham: University and Colleges Admissions Service*.

HEINTZE, U., RADEBORG, K., BENGTSSON, H. & STENLAAS, A. 2004. Assessment and evaluation of individual prerequisites for dental education. *Eur J Dent Educ,* 8**,** 152-60.

HOAD-REDDICK, G. & MACFARLANE, T. 1999. An analysis of an admissions system: can performance in the first year of the dental course be predicted? *British dental journal,* 186**,** 138-142.

HOFMEISTER, M., LOCKYER, J. & CRUTCHER, R. 2009. The multiple mini-interview for selection of international medical graduates into family medicine residency education. *Med Educ,* 43**,** 573-9.

JAHAN, S. S., NERALI, J. T., PARSA, A. D. & KABIR, R. 2022. Exploring the Association between Emotional Intelligence and Academic Performance and Stress Factors among Dental Students: A Scoping Review. *Dentistry Journal,* 10**,** 67.

JAMES, D. & CHILVERS, C. 2001. Academic and non-academic predictors of success on the Nottingham undergraduate medical course 1970–1995. *Medical education,* 35**,** 1056-1064.

JAMES, D., YATES, J. & NICHOLSON, S. 2010. Comparison of A level and UKCAT performance in students applying to UK medical and dental schools in 2006: cohort study. *BMJ,* 340.

JERANT, A., FANCHER, T., FENTON, J. J., FISCELLA, K., SOUSA, F., FRANKS, P. & HENDERSON, M. 2015. How Medical School Applicant Race, Ethnicity, and Socioeconomic Status Relate to Multiple Mini-Interview-Based Admissions Outcomes: Findings From One Medical School. *Acad Med,* 90**,** 1667-74.

JERANT, A., GRIFFIN, E., RAINWATER, J., HENDERSON, M., SOUSA, F., BERTAKIS, K. D., FENTON, J. J. & FRANKS, P. 2012. Does applicant personality influence multiple mini-interview performance and medical school acceptance offers? *Acad Med,* 87**,** 1250-9.

JONES, J. G. 1979. Dental student selection—the prediction of success. *Journal of Dentistry,* 7**,** 329-338.

KAY, E., BENNETT, J., ALLISON, P. & COOMBES, L. 2010. Evidence-informed dental student recruitment techniques. *British Dental Journal,* 208**,** 127-131.

KELLY, M. E., PATTERSON, F., O'FLYNN, S., MULLIGAN, J. & MURPHY, A. W. 2018. A systematic review of stakeholder views of selection methods for medical schools admission. *BMC medical education,* 18**,** 1-26.

KIRCHNER, G. L. & HOLM, M. B. 1997. Prediction of Academic and Clinical Performance of Occupational Therapy Students in an Entry-Level Master's Program. *American Journal of Occupational Therapy,* 51**,** 775-779.

KNORR, M. & HISSBACH, J. 2014. Multiple mini-interviews: same concept, different approaches. *Med Educ,* 48**,** 1157-75.

KREITER, C. D., YIN, P., SOLOW, C. & BRENNAN, R. L. 2004. Investigating the reliability of the medical school admissions interview. *Advances in Health Sciences Education,* 9**,** 147-159.

LALA, R., WOOD, D. & BAKER, S. 2013. Validity of the UKCAT in applicant selection and predicting exam performance in UK dental students. *Journal of dental education,* 77**,** 1159-1170.

LAMBE, P., KAY, E. & BRISTOW, D. 2018. Exploring uses of the UK Clinical Aptitude Test-situational judgement test in a dental student selection process. *European Journal of Dental Education,* 22**,** 23-29.

LEDUC, J. M., RIOUX, R., GAGNON, R., BOURDY, C. & DENNIS, A. 2017. Impact of sociodemographic characteristics of applicants in multiple mini-interviews. *Med Teach,* 39**,** 285-294.

LEMAY, J. F., LOCKYER, J. M., COLLIN, V. T. & BROWNELL, A. K. 2007. Assessment of non-cognitive traits through the admissions multiple mini-interview. *Med Educ,* 41**,** 573-9.

LIEVENS, F., BUYSE, T. & SACKETT, P. R. 2005. The operational validity of a video-based situational judgment test for medical college admissions: illustrating the importance of matching predictor and criterion construct domains. *Journal of Applied Psychology,* 90**,** 442.

LIEVENS, F., PEETERS, H. & SCHOLLAERT, E. 2008. Situational judgment tests: A review of recent research. *Personnel Review*.

LIEVENS, F. & SACKETT, P. R. 2006. Video-based versus written situational judgment tests: a comparison in terms of predictive validity. *Journal of applied psychology,* 91**,** 1181.

LUCK, O., REITEMEIER, B. & SCHEUCH, K. 2000. Testing of fine motor skills in dental students. *European Journal of Dental Education,* 4**,** 10-14.

LUGASSY, D., LEVANON, Y., PILO, R., SHELLY, A., ROSEN, G., MEIROWITZ, A. & BROSH, T. 2018. Predicting the clinical performance of dental students with a manual dexterity test. *PloS one,* 13**,** e0193980.

LUNDERGAN, W. P., SODERSTROM, E. J. & CHAMBERS, D. W. 2007. Tweezer dexterity aptitude of dental students. *Journal of Dental Education,* 71**,** 1090-1097.

MCANDREW, R., ELLIS, J. & VALENTINE, R. 2017. Does a selection interview predict year 1 performance in dental school? *European Journal of Dental Education,* 21**,** 108-112.

MCANDREW, R. & GREATRIX, R. 2014. The UKCAT test: developments, research and its use by dental schools in the UK. *British Dental Journal,* 216**,** 191-194.

MCMANUS, I., POWIS, D. A., WAKEFORD, R., FERGUSON, E., JAMES, D. & RICHARDS, P. 2005. Intellectual aptitude tests and A levels for selecting UK school leaver entrants for medical school. *Bmj,* 331**,** 555-559.

MCMANUS, I. C., DEWBERRY, C., NICHOLSON, S., DOWELL, J. S., WOOLF, K. & POTTS, H. W. 2013. Construct-level predictive validity of educational attainment and intellectual aptitude tests in medical student selection: meta-regression of six UK longitudinal studies. *BMC Med,* 11**,** 243.

MEEPRADIT, K., AUAMNOY, T. & LEELAKANOK, N. 2022. FACTORS AFFECTING GPA IN HIGHER EDUCATION IN ASIA: A SYSTEMATIC REVIEW. *International Journal of Early Childhood,* 14**,** 1581-1595.

MIRGHANI, I. 2020a. *Predicting Sensorimotor and Academic Performance in Dental Students.* PhD thesis, The University of Leeds.

MIRGHANI, I., MUSHTAQ, F., BALKHOYOR, A., AL-SAUD, L., OSNES, C., KEELING, A., MON-WILLIAMS, M. A. & MANOGUE, M. 2019a. The factors that count in selecting future dentists: sensorimotor and soft skills. *Br Dent J,* 226**,** 417-421.

MIRGHANI, I., MUSHTAQ, F., BALKHOYOR, A., AL-SAUD, L., OSNES, C., KEELING, A., MON-WILLIAMS, M. A. & MANOGUE, M. 2019b. The factors that count in selecting future dentists: sensorimotor and soft skills. *British dental journal,* 226**,** 417-421.

MIRGHANI, I. A. A. 2020b. *Predicting Sensorimotor and Academic Performance in Dental Students.* The University of Leeds, Faculty of Medicine and Health, School of Dentistry.

NEWTON, J., BUCK, D., THOROGOOD, N. & SKELLY, A. 2003. Admission as a dental student to the former UMDS and its relationship to socio-demographic characteristics. *British dental journal,* 195**,** 211-217.

O'BRIEN, A., HARVEY, J., SHANNON, M., LEWIS, K. & VALENCIA, O. 2011. A comparison of multiple mini-interviews and structured interviews in a UK setting. *Med Teach,* 33**,** 397-402.

OFFICE FOR STUDENTS. 2022. *Medical and dental intakes* [Online]. Available: https://www.officeforstudents.org.uk/advice-and-guidance/funding-for-providers/health-education-funding/medical-and-dental-intakes/ [Accessed].

ORSINI, C., BINNIE, V. I. & WILSON, S. L. 2016. Determinants and outcomes of motivation in health professions education: a systematic review based on self-determination theory. *Journal of educational evaluation for health professions,* 13.

ORSINI, C. A., BINNIE, V. I. & TRICIO, J. A. 2018. Motivational profiles and their relationships with basic psychological needs, academic performance, study strategies, self-esteem, and vitality in dental students in Chile. *Journal of educational evaluation for health professions,* 15.

OUDSHOORN, W. C. 2003. The utility of Canadian DAT perceptual ability and carving dexterity scores as predictors of psychomotor performance in first-year operative dentistry. *Journal of Dental Education,* 67**,** 1201-1208.

PAPADAKIS, M. A., HODGSON, C. S., TEHERANI, A. & KOHATSU, N. D. 2004. Unprofessional behavior in medical school is associated with subsequent disciplinary action by a state medical board. *Journal of Medical Regulation,* 90**,** 16-23.

PARRY, J., MATHERS, J., STEVENS, A., PARSONS, A., LILFORD, R., SPURGEON, P. & THOMAS, H. 2006. Admissions processes for five year medical courses at English schools. *Bmj,* 332**,** 1005-1009.

PATON, L. W., MCMANUS, I. C., CHEUNG, K. Y. F., SMITH, D. T. & TIFFIN, P. A. 2022. Can achievement at medical admission tests predict future performance in postgraduate clinical assessments? A UK-based national cohort study. *BMJ open,* 12**,** e056129.

PATTERSON, F., COUSANS, F., EDWARDS, H., ROSSELLI, A., NICHOLSON, S. & WRIGHT, B. 2017. The predictive validity of a text-based situational judgment test in undergraduate medical and dental school admissions. *Academic medicine,* 92**,** 1250-1253.

PATTERSON, F., KNIGHT, A., DOWELL, J., NICHOLSON, S., COUSANS, F. & CLELAND, J. 2016. How effective are selection methods in medical education? A systematic review. *Medical education,* 50**,** 36-60.

PAU, A., JEEVARATNAM, K., CHEN, Y. S., FALL, A. A., KHOO, C. & NADARAJAH, V. D. 2013. The Multiple Mini-Interview (MMI) for student selection in health professions training - a systematic review. *Med Teach,* 35**,** 1027-41.

POOLE, A., CATANO, V. M. & CUNNINGHAM, D. 2007. Predicting performance in Canadian dental schools: the new CDA structured interview, a new personality assessment, and the DAT. *Journal of Dental Education,* 71**,** 664-676.

POWIS, D., NEAME, R., BRISTOW, T. & MURPHY, L. 1988. The objective structured interview for medical student selection. *Br Med J (Clin Res Ed),* 296**,** 765-768.

PRICE, M. D. & PARK, S. E. 2018. Can noncognitive components of admissions data predict dental student performance and postdoctoral program placement? *Journal of Dental Education,* 82**,** 1051-1058.

PROUT, R. & HOY, T. 1976. University examination performance of dental students. Correlation between entry qualifications and non-clinical examinations. *British Dental Journal,* 141**,** 141-145.

RAZACK, S., FAREMO, S., DROLET, F., SNELL, L., WISEMAN, J. & PICKERING, J. 2009. Multiple mini-interviews versus traditional interviews: stakeholder acceptability comparison. *Med Educ,* 43**,** 993-1000.

REED, D. A., COOK, D. A., BECKMAN, T. J., LEVINE, R. B., KERN, D. E. & WRIGHT, S. M. 2007. Association between funding and quality of published medical education research. *Jama,* 298**,** 1002-1009.

REES, E. L., HAWARDEN, A. W., DENT, G., HAYS, R., BATES, J. & HASSELL, A. B. 2016a. Evidence regarding the utility of multiple mini-interview (MMI) for selection to undergraduate health programs: A BEME systematic review: BEME Guide No. 37. *Med Teach,* 38**,** 443-55.

REES, E. L., HAWARDEN, A. W., DENT, G., HAYS, R., BATES, J. & HASSELL, A. B. 2016b. Evidence regarding the utility of multiple mini-interview (MMI) for selection to undergraduate health programs: A BEME systematic review: BEME Guide No. 37. *Medical Teacher,* 38**,** 443-455.

ROBINSON, P., MILLAR, B. & TAYLOR, J. ASSESSMENT OF UCAS FORMS AS A PREDICTOR OF DENTAL STUDENT PERFORMANCE. JOURNAL OF DENTAL RESEARCH, 1995. AMER ASSOC DENTAL RESEARCH 1619 DUKE ST, ALEXANDRIA, VA 22314, 874-874.

SALVATORI, P. 2001a. Reliability and validity of admissions tools used to select students for the health professions. *Adv Health Sci Educ Theory Pract,* 6**,** 159-75.

SALVATORI, P. 2001b. Reliability and validity of admissions tools used to select students for the health professions. *Advances in Health Sciences Education,* 6**,** 159-175.

SCHWARTZ, S. 2004. Fair admissions to higher education: recommendations for good practice. *Department for Education and Skills*.

SEBOK, S. S., LUU, K. & KLINGER, D. A. 2014. Psychometric properties of the multiple mini-interview used for medical admissions: findings from generalizability and Rasch analyses. *Adv Health Sci Educ Theory Pract,* 19**,** 71-84.

SMITH, B. PREDICTING PERFORMANCE IN UK DENTAL STUDENTS USING MULTIPLE-REGRESSION ANALYSIS. JOURNAL OF DENTAL RESEARCH, 1975. AMER ASSOC DENTAL RESEARCH 1619 DUKE ST, ALEXANDRIA, VA 22314, L138-L138.

SMITH, B. 1976a. The value of tests of spatial and psycho-motor ability in selecting dental students. *British Dental Journal,* 141**,** 150-154.

SMITH, B. 1989. A longitudinal study of the value of a spatial relations test in selecting dental students. *British Dental Journal,* 167**,** 305-308.

SMITH, M. 1976b. A comparison of the value of trainability assessments and other tests for predicting the practical performance of dental students. *International Review of Applied Psychology*.

SRIVASTAVA, S., JOHN, O. P., GOSLING, S. D. & POTTER, J. 2003. Development of personality in early and middle adulthood: Set like plaster or persistent change? *Journal of personality and social psychology,* 84**,** 1041.

STEGERS-JAGER, K. M. 2018. Lessons learned from 15 years of non-grades-based selection for medical school. *Medical Education,* 52**,** 86-95.

STRINGER, N., CHAN, M., BIMPEH, Y. & CHAN, P. 2017. Preadmission schooling context helps to predict examination performance throughout medical school. *Advances in Health Sciences Education,* 22**,** 505-519.

TIFFIN, P. A., DOWELL, J. S. & MCLACHLAN, J. C. 2012. Widening access to UK medical education for under-represented socioeconomic groups: modelling the impact of the UKCAT in the 2009 cohort. *Bmj,* 344.

UIJTDEHAAGE, S., DOYLE, L. & PARKER, N. 2011. Enhancing the reliability of the multiple mini-interview for selecting prospective health care leaders. *Acad Med,* 86**,** 1032-9.

URBANKOVA, A. & ENGEBRETSON, S. P. 2011. The use of haptics to predict preclinic operative dentistry performance and perceptual ability. *Journal of dental education,* 75**,** 1548-1557.

WENGHOFER, E., KLASS, D., ABRAHAMOWICZ, M., DAUPHINEE, D., JACQUES, A., SMEE, S., BLACKMORE, D., WINSLADE, N., REIDEL, K. & BARTMAN, I. 2009. Doctor scores on national qualifying examinations predict quality of care in future practice. *Medical education,* 43**,** 1166-1173.

WHITEHEAD, F. 1974. The relationship of advanced level qualifications to subsequent academic performance of dental students. *British Dental Journal,* 137**,** 173-176.

WHITLA, D. K., ORFIELD, G., SILEN, W., TEPEROW, C., HOWARD, C. & REEDE, J. 2003. Educational benefits of diversity in medical school: a survey of students. *Acad Med,* 78**,** 460-6.

WILKINSON, T. J., WELLS, J. E. & BUSHNELL, J. A. 2004. Are differences between graduates and undergraduates in a medical course due to age or prior degree? *Medical education,* 38**,** 1141-1146.

WILSON, S. G., WALDMAN, K. B. & MACDONALD, G. 1991. An analysis of abilities underlying early periodontal skill development of dental students. *Evaluation & the Health Professions,* 14**,** 41-60.