

Changes to undergraduate orthodontic teaching during the COVID-19 pandemic

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My own contributions, fully and explicitly indicated in the thesis, have been to: Writing the protocol, develop a bespoke questionnaire, carry out pre-testing of the draft questionnaire and modification, gaining ethical approval, recruiting participants, data collection and analysis and thesis write up.

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Abstract

Introduction: Coronavirus disease 2019 (COVID-19) significantly impacted teaching worldwide and posed major challenges to the delivery of teaching. Currently, limited research exists on undergraduate orthodontic teaching practices in the UK prior to the COVID-19 pandemic, while no data exists on teaching during and after the COVID-19 pandemic.

Design and Setting: National cross-sectional survey of dental schools in the UK, using a mixed methods approach.

Aim: To describe undergraduate orthodontic teaching delivery and assessment in the UK in the pre-COVID-19, peri-COVID-19 and post-COVID-19 periods.

Method: A bespoke, 20-item online questionnaire was developed and pre-tested locally with people involved in delivering undergraduate teaching at the University of Leeds. The questionnaire was disseminated to fifteen undergraduate orthodontic leads in the UK. Questions related to the timing (years in which teaching takes place), delivery methods, hours of teaching allocated, assessment methods and staffing at all three periods. Feedback was gained from the participants as well as inquiring what student feedback they had received on COVID-related changes to teaching.

Results: Responses were received from eleven dental schools in England and Scotland (representing 69% of all UK dental schools). Variation was identified in teaching practices, assessment and staffing for undergraduate orthodontic teaching prior to COVID-19. During the peak of the pandemic, clinical and face-to-face teaching were replaced with online teaching methods. A blended approach remained in the post-COVID-19 period. Respondents had mixed perceptions regarding the impact of COVID-19, with some feeling that it had a negative effect on clinical teaching while others felt it was an opportunity to improve their delivery of teaching. Student feedback was reported to be mainly positive.

Conclusions: Variation existed in the delivery of undergraduate orthodontic teaching, and this persisted during and after the COVID-19 pandemic. The pandemic itself, as well as staff shortages and reduced clinical chair capacity, have influenced the delivery of undergraduate teaching and stimulated the use of more online resources. The development of new online resources during the COVID-19 lockdown and the retention of a blended approach to teaching in the post-pandemic period requires further evaluation of their effectiveness due to the mixed feedback provided by respondents and students.

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Glossary

BOS	British Orthodontic Society
COVID-19	Coronavirus disease 2019
E-learning	Electronic learning
GDC	General Dental Council
GDPs	General Dental Practitioners
HoS	Heads of Dental Schools
IOTN	Index of Orthodontic Treatment Need
NHS	National Health Service
UK	United Kingdom
VIVA	Viva voce examination

Chapter 1: Introduction

Orthodontics is the specialty of dentistry which focusses on the management of the developing and developed dentition and focusses on the assessment, diagnosis and treatment of malocclusions (General Dental Council, 2015a). Malocclusion describes misalignment of teeth or irregularity of teeth when the upper and lower jaws are closed (Davies, 2007). It may be treated with various orthodontic appliances to reduce the potential harmful consequences it may pose (Leck et al., 2022).

The General Dental Council (GDC) have set learning objectives for completion of UK undergraduate orthodontic education with the purpose of preparing dentists for future practice. The knowledge and skill from their undergraduate education should allow dentists to fulfil their role as gatekeepers where they would be the initial clinicians to undertake orthodontic assessments, diagnose and refer patients with dento-facial abnormalities and treat simple orthodontic emergencies (General Dental Council, 2015a). Research has identified that dental students and graduates lack confidence and have low competence in the field of orthodontics (Fleming and Dowling, 2005; Patel et al., 2006; Gilmour et al., 2016) including inappropriate referrals being sent to secondary care which may result in wasted National Health Service (NHS) staff and patient time and resources (Reddy et al., 2016). It has been hypothesised that these problems could stem from insufficient undergraduate orthodontic teaching (Gilmour et al., 2016). Previous research described undergraduate orthodontic teaching and assessment in the United Kingdom (UK) and found that it was delivered through a variety of methods (Derringer, 2005; Derringer, 2006). However, the GDC learning outcomes document have subsequently been modified (General Dental Council, 2008; General Dental Council, 2015a) with no further research exploring the impact of these modifications.

Coronavirus disease 2019 (COVID-19) had a significant impact on teaching worldwide due to university closures and lockdown measures, which presented challenges to the delivery of teaching (Longhurst et al., 2020; Open Government Licence, 2020). The pressure from COVID-19 lockdowns, self-isolation and social distancing measures meant that rapid, unprecedented changes were required to deliver both theoretical and clinical aspects of dental education (Al-Attar et al., 2021; Farrokhi et al., 2021; Trivandrum Anandapadmanabhan et al., 2022). This included changes in undergraduate orthodontic teaching. However, to date no data has been published about how orthodontic teaching was adapted and the perception of these changes by those who organised and delivered the teaching as well as the dental students who experienced the teaching.

The aim of this research was to describe undergraduate orthodontic teaching in terms of the methods of delivery, hours allocated, timing of teaching within the undergraduate programme (the years in which teaching took place), assessments and staff numbers in the UK, to better understand current practice and changes arising from COVID-19. This may facilitate discussion and shared learning amongst undergraduate orthodontic leads, which could potentially identify ways to improve teaching in the future, particularly if rapid changes are required again.

The use of a bespoke, pre-tested online questionnaire was chosen for this study to collect data from the sixteen UK undergraduate orthodontic leads who were involved in organising the undergraduate teaching in the pre-COVID-19, peri-COVID-19 and post-COVID-19 periods. A survey was chosen for data collection following a review of the literature, which identified that the majority of previous studies of this type used surveys to collect similar data with high response rates (Lynch et al., 2010; Al Raisi et al., 2019; Grindrod et al., 2020). Interviews were considered but these require greater training to ensure robust data collection and analysis, and this was not feasible within the current study.

A draft questionnaire was developed based on a literature review and consultation with experts to develop the initial content. A pre-testing stage with representatives from the target population was used to test content validity and modifications were made as required. Ethical approval was gained from the University of Leeds Dental Research Ethics Committee and permission requested from UK Head of Dental Schools to undertake the research at their institute. Recruitment of undergraduate orthodontic leads was via email. Data was automatically collected and collated into Microsoft Excel through the OnlineSurveys programme (Online Surveys, 2022) then analysed descriptively.

Chapter 2: Literature Review

2.1 UK undergraduate dental teaching

2.1.1 The genesis of UK undergraduate dental teaching

Undergraduate dental education began when infrequent lectures were given at Guy's Hospital towards the end of the 18th century (British Dental Association, 2021). The Royal College of Surgeons of England established the first official British dental qualification, the Licentiates in Dental Surgery (LDS) in 1858, when the first dental hospital and dental schools were founded, known as the Dental Hospital of London and the Metropolitan School of Dental Science (Gelbier, 2005). Following the opening of these schools, the Dentist Act of 1878 required all dentists to undertake the LDS qualification and be registered to ensure the practice of dentistry was being regulated (British Dental Association, 2021). Further dental schools established themselves throughout the UK and the first degree in dentistry was awarded in 1904 at the University of Birmingham, with other universities following shortly after (Gelbier, 2005). UK dental education is now regulated by the General Dental Council (GDC) (General Dental Council, 2019).

2.1.2 Traditional, competency and outcomes-based undergraduate dental education

A review article by Khanna and Mehrotra, (2019) described the evolving delivery of undergraduate dental education and the evidence of the successful implementation of the competency and outcomes-based education. Although the article was based on dental education in India, it related to the changing practices in countries worldwide, including the UK. The article revealed that traditionally, teaching in dentistry was discipline-based, teacher-orientated and didactic, which usually took place in the form of a more lecture-based approach and was driven by examinations. The focus on delivery of knowledge and retaining information was found to be unstimulating for students and not representative of problem solving in 'real-life' situations. As a result, the competency and then an outcomes-based approach was adopted (Chambers, 1993; Khanna and Mehrotra, 2019).

Competency within dental education is defined as '...a complex behaviour or ability essential for the general dentist to begin independent, unsupervised dental practice' by the American Dental Education Association (ADEA) (American Dental Education Association, 2008). This has been adopted in dentistry as a way to shift the ownership of learning to the student by setting out expectations and learning outcomes (American Dental Education Association, 2008). This form of andragogy encompasses all skills required in developing dentists which will prepare them for future practice including knowledge,

professionalism, communication, critical and high-order thinking, reflective practice, self-directed learning, ethical values, technical and procedural skills (American Dental Education Association, 2008; Khanna and Mehrotra, 2019). Furthermore, assessments are more focussed on continuous learning so formative assessments have been incorporated to ensure learning is being evaluated and competencies are being attained throughout the dental curriculum (Khanna and Mehrotra, 2019).

The outcomes-based approach is similar to the competency-based approach and these terms may be used interchangeably (Morcke et al., 2012). However, while the competency-based approach focusses mainly on completing certain activities, acquiring or demonstrating skills or competencies which are clearly defined within the curricula, the outcomes-based approach focusses on the end-product whereby students are expected to have completed certain learning outcomes by the end of the course (Malan, 2000). The outcomes-based approach therefore represents a broader concept of andragogy, providing a framework which is holistic in its outcomes by incorporating different educational practices (Malan, 2000). This approach is based on the socio-constructivist approach of learning, which is discussed in section 2.1.5.1. In the UK, dental education is now based upon this well-defined, outcomes-based system outlined by the GDC, a requirement to establish competence (General Dental Council, 2015a).

2.1.3 The evolving UK dental undergraduate learning outcomes

The GDC has released five versions of the document, 'Preparing for Practice', most recently revised in 2015 (General Dental Council, 2015a). The documents set out the learning outcomes required for complete registration as a dental professional following successful completion of an approved dental programme (Mossey, 2003). The GDC outlined the foundations and conditions needed for dentists to complete safe and successful clinical dental practice. These are based upon the European guidelines set by the Association of Dental Education of Europe (ADEE), known as the Bologna Declaration on undergraduate dental education (Cowpe et al., 2010). This aimed to improve the quality of the dental curricula in over 200 different dental schools in Europe (Cowpe et al., 2010).

The initial documents based on 'The First 5 years' (Clark et al., 2003) reflected the initial implementation of the detailed specification of the competency-based approach of medicine and dental education, which required the old UK dental curricula to be adapted significantly to match these competencies. The following versions have been based more upon the 3-circle model of Harden (Harden et al., 1999) based upon learning outcomes for medicine. Clark et al., (2003) modified this model for dentistry and reported this to be more beneficial as it outlined and summarised learning

outcomes specific to undergraduate dental education (Clark et al., 2004). The model was described as a simple and effective method to ensure different aspects of the curriculum such as expected learning outcomes, learning needs, content and design, educational strategies, teaching methods, assessments, the educational environment and communication amongst staff and students were being reviewed and addressed by the educational providers (Clark et al., 2004). The second edition 'The First 5 years 2002', was the first of the documents to have a clear list of learning outcomes and the first to be based around Harden's model (Clark et al., 2003).

Changes have taken place throughout the years to these GDC documents to incorporate topics such as Information Technology (IT) skills, law, ethics, professionalism, health and safety, education in an outreach environment, continuous development, and pain and anxiety control into UK dental curricula (Clark et al., 2003).

The most recent version of this document states learning outcomes are based upon four main domains: clinical practice, communication, professionalism, and management and leadership. All of these are underpinned by scientific knowledge and overlap to support each other (General Dental Council, 2015a). Over time, more emphasis has been given to patient-centred care, evidence-based practice, team-working and professionalism which are consistent with the principles of the GDC document 'Standards for the Dental Team' (General Dental Council, 2013; General Dental Council, 2015a). UK dental schools have also evolved their dental curricula to reflect these changes (General Dental Council, 2015a).

The GDC learning outcomes are based upon sound principles to develop dentists who will 'attain the highest standards in terms of knowledge, skills, including clinical and technical skills, and professional attributes...'. However, they are still broad in their nature. The GDC is aware of the different variables in the delivery of teaching based upon service structures, learning and teaching styles, and they encourage innovation and development of new methods of teaching, learning and assessment by educational providers (General Dental Council, 2015a). Ultimately, educational providers must ensure the learning outcomes are delivered by their dental curriculum, but this can be tailored to how they feel best meets the needs of their students.

2.1.4 Purpose of dental teaching, alignment of competencies and learning outcomes

The purpose of undergraduate dental teaching is to prepare undergraduate students for future practice (McGleenon and Morison, 2021) and the ultimate responsibility of this lies with the UK dental

schools (General Dental Council, 2015b). The standards and requirements for providers must be met to be accepted for registration (General Dental Council, 2015b). All elements need to align in terms of purpose for teaching, best practice in teaching methods, competencies and outcomes set, with the incorporation of the different andragogical approaches to ensure that the correct skill-sets have been gained. Numerous assessments have been used to ensure learning outcomes are met. As there is no best practice guidance for UK undergraduate dental teaching practices, it is difficult to establish which methods are best aligned to meet these learning outcomes.

2.1.5 Structure of UK dental teaching

2.1.5.1 UK dental school providers, courses available and the GDC

There are sixteen UK dental schools, fifteen of which provide a standard five year undergraduate dental programme (Dental Schools Council, 2023c) all of which teach thirteen specialties within dentistry (British Dental Association, 2023). Three dental schools provide a graduate entry course enabling graduates with honours degrees in science subjects to apply for a shorter dental degree (usually three or four years). Two universities provide a six year dental degree for those who did not complete the required subjects at A-Level or equivalent. Finally, two provide 'gateway to dentistry' courses to allow those who are of high ability but experienced socio-economic/educational barriers during their earlier education to apply for dentistry in the UK (Dental Schools Council, 2023c).

The GDC are the regulatory governing body for dentists and dental care professionals (General Dental Council, 2019). They work with the UK dental school providers, outline learning objectives for the dental curricula and quality assure education for undergraduate dental students to determine dental competency which is needed for registration (General Dental Council, 2015a). Once the undergraduate dental programme has been completed and appropriate qualification gained, all dental professionals must register with the GDC in order to practice within their dental field. The main purpose of the GDC is to ensure patient safety and set the standards for dentists to ensure professionalism and safe standards of practice within all dental roles.

2.1.5.2 Delivery methods and underpinning learning theory

The current undergraduate dental teaching in UK dental schools involve a multitude of different methods which are tailored to each institution as described by the scoping review by McGleenon and Morison, (2021). This review discussed the purpose of these different methods used in benefitting student learning, these have been described later in this section. In dentistry, learning theories are

important to guide educational providers to enhance student learning and underpin the delivery methods used (Badyal and Singh, 2017). The review article by Badyal and Singh, (2017) thoroughly described the different andragogical theories and some of the educational methods aligning with these. Although the paper is based on the processes used in medicine, it can be directly related to dentistry as similar teaching methods are used.

Badyal and Singh, (2017) described the following theories:

1. **Behaviourism theory:** Conditioning and changing of behaviour to a stimulus which involves encouragement for positive behaviour, repetition, feedback and reinforcement. It is useful in the outcomes-based curricula upon which the current dental curricula is based and is also useful in demonstrating psychomotor skills (Torre et al., 2006).
2. **Cognitivism theory:** Being focused upon the mental processes in learning including insight, information processing and memory.
3. **Constructivism Theory:** Development of new understanding from current knowledge. It involves construction of meaningful information from experiences through critical reflection.
4. **Sociocultural Theory:** Learning occurs from observations and interactions with others in multiple clinical and academic settings.
5. **Humanism Theory:** Learning is of the understanding that it is a personal act to achieve the learner's full growth and potential.

McHarg and Kay, (2009) expanded on these theories in their review paper, which discussed the rationale for designing a dental curriculum in the twenty-first century. They described learning falls into the three categories of psychomotor i.e. learning technical skills (hands), affective i.e. learning the skill of empathy (heart) and cognitive domains i.e. using clinical reasoning and critical skills to make decisions (head).

The scoping review by McGleenon and Morison, (2021) was based upon the work of research teams working in eleven UK dental schools. It should be noted that the teaching practices in five UK dental schools were not identified from the 57 articles reviewed. Due to this, the methods of teaching delivery cannot be generalised to all UK dentals schools, even if it would be expected that similar methods were used. The authors recognised some other limitations which included: omitting the last step, consultation, an optional requirement to increase the rigour of the research when conducting a scoping review, the majority of the research was carried out by one researcher which may have caused the potential for bias throughout the results and finally that international and grey literature were

excluded which meant any new forms of teaching delivery may not have been identified. Though most weaknesses were discussed, the article was useful to give an overview of data on undergraduate dental teaching practices in the UK. They reported didactic teaching such as lectures, tutorials and seminars are frequently used to deliver dental education in these schools. These relate to cognitive, constructive and sociocultural theory as information is delivered in a structured way to facilitate learning and retention, is self-directed, reflective skills are developed and current knowledge is built upon from previous knowledge and experiences. Furthermore, group discussion in seminars and tutorials can further encourage critical thinking, problem-solving, learning from peers and deeper understanding of concepts. A smaller number of dental schools taught via problem-based learning (PBL) (McGleenon and Morison, 2021). This method relates to both cognitive and constructive theory and promotes high-order thinking to encourage students to apply their knowledge to clinical real-life scenarios. Some dental schools enhanced their teaching with digital and audio-visual teaching methods, with the majority using online portals which facilitated access to their university learning resources. These teaching methods are used to deliver foundational dental theoretical principles to increase knowledge.

Clinical teaching is described as 'teaching and learning focused on, and usually directly involving, patients and their problems' and lies at the heart of medical education (Spencer, 2003). Clinical teaching was provided by many dental schools with multi-disciplinary clinics as well as clinics in outreach centres which gave students a diverse patient base, provided a sufficient number of patients and ultimately enabled students to gain experience in providing a range of dental procedures (McGleenon and Morison, 2021). This form of teaching is a vital aspect of dental education adopted by dental schools to ensure students gain the essential skills required as described by the GDC (General Dental Council, 2015a; McGleenon and Morison, 2021). Communication skills are applied during clinical teaching or in a simulated, workshop-based environment with actors posing as patients to represent real-life patient scenarios (McGleenon and Morison, 2021). This encourages effective history taking, diagnosis and patient management.

Operative skills were learnt in a simulated environment on phantom heads in laboratories in all reporting dental schools, with cadavers used in some (McGleenon and Morison, 2021). This enabled students to perform dental extractions and practice restorative procedures in order to enhance practical skills and become familiar with instruments and procedures prior to patient contact (McGleenon and Morison, 2021). More advanced teaching methods have been used in few dental schools involving virtual reality and computer-based haptic stations as an alternative to laboratory

teaching. Three-dimensional (3D) virtual reality can be created to simulate oral cavity and dental objects, usually used as an adjunct to teaching rather than complete replacement (McGleenon and Morison, 2021).

Clinical teaching involving patients and other practical skills involving laboratory work and practical simulation build psychomotor skills (McHarg and Kay, 2009). Learning also occurs through behavioural and sociocultural theory as dental procedures are practiced through repetition, feedback, reinforcement and role modelling (Badyal and Singh, 2017). Behavioural and sociocultural theories are also related to understanding patients and the role of empathy and motivating patients i.e. building the affective domain (McHarg and Kay, 2009).

Dental teaching is also provided in the form of electronic learning (e-learning) which can be defined as 'a learning process created by interaction with digitally delivered content, network-based services and tutoring support...and is any technologically mediated learning using computers whether from a distance or in a face to face classroom setting (computer assisted learning)' (Jethro et al., 2012). Virtual Learning Environments (VLE) are an online platform where online resources such as webinars, recorded lectures and tutorials are available, providing an adjunct to in-person teaching. Many dental schools used a blended approach where both this online VLE platform and face-to-face teaching were used in combination to teach dentistry (McGleenon and Morison, 2021). Benefits of a more online approach have been described by McGleenon and Morison, (2021) as being more flexible and encourage independent practice where the student can set the location, time and speed at which they work.

Teaching of self-development involved peer assessment, self-direction and group learning and reflective portfolios (McGleenon and Morison, 2021). These teaching methods encouraged students to develop their critical and reflective skills, facilitated discussion and enhanced teamwork. Self-direction was key to allow students to develop as independent practitioners with portfolios giving students a record of their achievements from the start. This encouraged development of reflective skills, deepening of their learning and self-assessment (McGleenon and Morison, 2021), particularly when revisiting these in later stages of the dental programme. Both learning through online technology and self-directed learning is underpinned by humanist theory which develops autonomy, self-discipline, time management and organisational skills (Torre et al., 2006; Badyal and Singh, 2017).

Another method of teaching which is used in UK undergraduate dental schools is the flipped classroom approach (Isherwood et al., 2020). Nair et al., (2022) described flipped classroom as the concept of providing homework or tasks prior to the classroom teaching i.e. flipping the components. As this method encourages engagement and discussion during classroom sessions and thus promotes deeper thinking, it is underpinned by the cognitivism, constructivism and humanism theory. Flipped classroom is further discussed in section 6.1.1.

2.1.5.3 Timing of teaching

Teaching may be longitudinal or short-term, both of which have benefits and limitations (Marinović et al., 2009; Norris et al., 2009). Longitudinal involves embedding the learning of topics throughout a course over a longer period with the ethos of progressive learning for students. Teaching is continued throughout the undergraduate degree, promoting patient and learner-centredness as there are more opportunities to practice, apply knowledge and develop skills (Norris et al., 2009). In addition, integrating different overlapping topics on numerous disciplines, over longer periods encourages deeper learning (Norris et al., 2009). The spiral curriculum follows similar principles but while one describes teaching over a longer period i.e. longitudinal, spiral describes the process of returning to basic concepts to build on them with more complex ones once the initial foundations have been built (McHarg and Kay, 2009). Challenges to these include the logistical complexities of regular training, faculty development and increased costs. However, research has reported that the positive feedback from students and benefits of learning in this way outweigh the challenges and medical schools have absorbed the costs (Norris et al., 2009). Teaching through discrete modules i.e. over a shorter duration, has the benefits of providing focussed learning on specific topics, can be taught with different delivery methods suited to that topic and can offer increased flexibility in relation to a changing or developing curriculum. Although research on timing of teaching is limited in dentistry, medicine-based research has reported teacher and student preference for longitudinal courses over short-term concise and intensive courses (Marinović et al., 2009; Mojtahedzadeh and Mohammadi, 2016).

2.1.5.4 Hours of teaching

Overall hours of teaching provided by UK undergraduate dental schools can vary as long as the learning outcomes and standards for education are met (General Dental Council, 2015a; General Dental Council, 2015b). Some universities use a higher education credit system (Quality Assurance Agency for Higher Education, 2021). A credit is the total hours taken of teaching and learning activities to obtain a learning outcome or be allocated when block teaching has been achieved and includes both

face-to-face and non-face-to-face activities (Akram et al., 2021; Quality Assurance Agency for Higher Education, 2021). Credits can be given different values in relation to their hours and universities can use this method to ensure dental educational providers work with the governing teams to reach minimum requirements (Quality Assurance Agency for Higher Education, 2021). They are also used to ensure quality assurance to teaching, learning and assessment with appropriate credits/hours being tailored to different topics (Quality Assurance Agency for Higher Education, 2021). As no literature exists on the UK undergraduate dental credit system or for how many hours of teaching are provided per university, it is difficult to establish or comprehend this information.

2.1.5.5 Assessments in dentistry

High quality assessments have been described by Epstein, (2007) in the literature as being reliable (the degree to which the measurement is consistent and reproducible), valid (whether the assessment measures what it claims to measure), impacts on future learning and practice, acceptable to learners and faculty, and cost effective. This review article by Epstein, (2007) discussed commonly used assessment types in medicine (described below), different domains being assessed, and their limitations and strengths. Although it was based at The University of Rochester in the USA, as concepts are mirrored in UK-based medicine and dentistry, the paper can be related to assessments in the UK. Assessments in dentistry ensure the intended learning outcomes set by the GDC (General Dental Council, 2015a) have been achieved in a valid and reliable way and align with what is being taught (General Dental Council, 2015b; Ghaicha, 2016).

In dentistry, many forms of assessment exist. Written forms include: Multiple-choice questions (MCQs), short-answer questions (SAQs), extended-matching questions (EMQs), single-best-answers (SBAs) and essays. Work-based assessments (WBAs) include: Mini-clinical evaluation exercise (mini-CEX), direct observation procedures (DOPs), multi-source feedback (MSF), case-based discussions (CBDs) and portfolios (Epstein, 2007; Williams et al., 2015). Oral assessments include: Viva voce (VIVA), spotter tests and practical assessments such as objective structured clinical examination (OSCE) and simulations in a clinical setting or in a laboratory (Williams et al., 2015). Some dental schools use a newer practical assessment similar to the OSCE, the integrated structured clinical examination (ISCE) (Ganesanathan et al., 2021). Both assessments involve multiple stations but the ISCE integrates assessment of specific skills including diagnostic and management skills within a clinical case. By doing this, the ISCE can provide an overall assessment of the student's clinical aptitude (Ganesanathan et al., 2021).

Summative assessments have been described as final assessments which make an overall decision about competence and/or progression through a course while formative assessments are frequent assessments to guide future learning through continued feedback to students, provide reassurance and promote reflection (Epstein, 2007). Both summative and formative tests have advantages and disadvantages (Connors, 2021). Summative assessments are beneficial to measure overall learning at the end of a course, ensure learning outcomes are met and can measure the effectiveness of a programme. They do not, however, provide instant feedback which may be a barrier to understanding student strengths and weaknesses. Students may be driven more by performance rather than learning and those who do not test well may be misrepresented (Connors, 2021). Moreover, they are known to evoke stress and anxiety amongst students due to their high-stake decisions and teachers may teach to assessment rather than ensuring deeper understanding is being achieved. Connors, (2021) further described formative assessments as providing a good indication to both students and teachers of the level at which students are in their learning, encourage a more active learning role by students where students may be more motivated to reach achievable goals, and teachers have multiple areas to form individual plans for improving understanding of topics. Disadvantages of formative assessments include: being more time-consuming for teachers to formulate and carry out, with reliability and validity testing of more frequent formative assessments being more difficult and as a consequent, results could be biased and inaccurate (Connors, 2021). UK undergraduate dentistry encompass a mix of summative and formative assessments (Williams et al., 2015).

2.1.5.6 Teachers in UK-based dentistry

In UK undergraduate dentistry, teachers include personnel with a range of educational backgrounds and experience in different fields: Academics, junior/senior lecturers, specialty doctors/associate specialists, clinical assistants and supervisors, consultants, professors, educational supervisors, junior and senior registrars in specific specialties and senior dental officers (Derringer, 2005; Buchanan and Parry, 2019). Having multiple teachers highlights the importance of having experts to teach different topics so student knowledge is vast over numerous areas (Buchanan and Parry, 2019). More common in medicine than dentistry, some teaching may also be provided by patients. This has been reported to be beneficial to learners by enabling access to personal knowledge, experience and putting learning into context, which deepens student understanding and confidence (Wykurz and Kelly, 2002).

It is important to understand what constitutes being a good teacher in dentistry. Noor Affendy et al., (2021) used seven domains to explain this:

- **Modelling:** Teacher acts as a role model.
- **Coaching:** Observation and providing constructive feedback.
- **Scaffolding:** Allowing the student to work independently but being supportive where needed.
- **Articulation:** Asking questions to increase knowledge and understanding.
- **Reflection:** Stimulation of dental students to think about strengths and weaknesses.
- **Exploration:** Stimulating dental students to form individual goals.
- **General learning environment:** Teacher showing interest, giving enough supervision time and ensuring their availability.

2.1.5.7 Evaluation of teaching

Student and teacher feedback is a requirement by the GDC as documented in 'Standards for Education' (General Dental Council, 2015b). The second standard of three in this document is 'Quality evaluation and review of the programme' which requires rigorous internal and external quality assurance and evaluation. This is achieved by gaining feedback from students, educational providers and patients to ensure the development of the dental programme. Feedback from students, teachers and patients is highly valuable: Student feedback characterises good practice, encourages continuous improvement in teaching, provide information on if the learning objectives are being met and encourage the engagement of students (Freeman et al., 2020). Teacher feedback identifies areas to improve faculty teaching and helps to understand how students perceive their teaching so learning needs can be met (Leung et al., 2021). Patient feedback informs programme development (General Dental Council, 2015b). In addition, relevant policies, procedures, external bodies such as Quality Assurance Assessment (QAA), The Office of Qualifications and Examinations Regulation (Ofqual) and other external examiners also review the teaching regularly to ensure high quality of teaching is being delivered in the UK (General Dental Council, 2015b).

2.1.5.8 General learning styles

As well as having different teaching methods to teach different dental concepts; different learning styles and preferences also exist. Learning styles refers to the concept that people have different modes of study which is most effective to them (Pashler et al., 2008). It is thought that optimal learning occurs once we have diagnosed the individual's learning style and then tailor the learning to this. There are multiple learning style models which have been described in the literature from multiple intelligences learning (Denig, 2004) to the experiential learning cycle by David Kolb (Kolb, 2007) and numerous others. The key is to incorporate many styles within the undergraduate dental and

orthodontic teaching practices to enable students to learn new material in the most effective way to them.

2.2 Orthodontics

Orthodontics is the specialty of dentistry which focusses on the management of the developing and developed dentition specifically in relation to facial growth, physical, mental and dental health. It focusses on the assessment, diagnosis and treatment of malocclusions in both children and adults, which may be treated with a number of different appliances (General Dental Council, 2015a). It is also involved in the prevention of developing malocclusions or reducing the complexity of future malocclusion i.e. orthodontic interceptive treatment (General Dental Council, 2015a).

Malocclusion describes misalignment of teeth when the upper and lower jaws are closed (Davies, 2007) and is defined by Houston et al., (1992) 'as an appreciable deviation from ideal occlusion'. Malocclusion can cause potential harm in patients, which have been described by Benson et al., (2015) to presumably affect long term dental health, psychological well-being and social well-being. Some of the common benefits supported by more evidence for the use of orthodontics are reduced damage to roots of teeth or pathological cystic changes caused by anomalies such as impacted teeth, traumatic dental injury (TDI) from an increased overjet and poor oral health-related quality of life (OHRQoL) (Leck et al., 2022). Other associated risks identified from malocclusion are susceptibility to dental caries and periodontal disease, reduced dental function, restorative difficulties, functional shifts, Temporomandibular Joint Dysfunction (TMJD), masticatory and speech limitation, and sleep apnoea. However, literature supporting the idea of using orthodontics to correct or reduce these specific risks is controversial (Benson et al., 2015; Leck et al., 2022). Seehra et al., (2011) conducted a cross-sectional survey using a validated questionnaire on 336 children between 11-14 years at three different hospitals. This was to measure the relationship between self-reported frequency and severity of bullying, self-esteem and OHRQoL and those who were being referred for orthodontic treatment. The study found that certain malocclusion traits were associated with experiencing increased bullying, reduced social and athletic competence, reduced physical appearance-related self-esteem and general self-esteem. Of those who were bullied relating to their malocclusion, correcting this with orthodontics was found to have a positive effect and also improved their OHRQoL (Seehra et al., 2013). Biases however may have affected the results in that factors other than malocclusion may have increased the chance of bullying for a child, there may have been different interpretations of bullying/teasing by participants, participant population were those who were referred for hospital

treatment and had high Index of Orthodontic Treatment Need (IOTN) scores which may not have been generalisable to the primary care patients, these were all acknowledged by the authors (Seehra et al., 2013). The British Orthodontic Society (BOS) have described other benefits of orthodontic treatment as aligning the teeth and removing crowding or closing spaces for improved aesthetics, enhancing facial aesthetics, treating unerupted or displaced teeth, moving teeth to accommodate restorative treatment and treating tooth drifting (British Orthodontic Society, 2023). The lists provided above of potential risks from malocclusion and benefit from orthodontics are not exhaustive.

2.2.1 The delivery of orthodontic treatment in the UK

In the UK, most orthodontic treatment is provided in primary care to children and adolescents. This may be funded by the National Health Service (NHS) or self-funded as part of private treatment (General Dental Council, 2023a). To qualify for treatment on the NHS, patients are objectively assessed to have a treatment need using the IOTN screening tool, which assess the severity of the malocclusion (Jawad et al., 2016). Patients with more severe cases are deemed to benefit from correction of their malocclusion to prevent or reduce the risk of harm (Leck et al., 2022). Some people may choose to seek private treatment for correction of mild malocclusions where the risks of orthodontic treatment versus benefit is relatively lower (Van Beek, 2009) or may be adult patients who no longer qualify for NHS treatment but have more significant malocclusions (General Dental Council, 2023a).

Most orthodontic treatment is provided by specialists who have completed a recognised, approved three-year training programme in orthodontics. Structured objectives are set out for the completion of the course (The Specialist Advisory Committee in Orthodontics, 2010). Furthermore, appropriate development and experience of each applicant in dentistry is required to pursue a career in orthodontics and as such, a fully registered dentist needs to complete a year of dental foundation training as well as a minimum of two years of dental core training (The Specialist Advisory Committee in Orthodontics, 2010). This extensive journey and comprehensive training are intended to provide the necessary knowledge, skill and competence in the orthodontic management of patients in a primary care setting. Once the programme requirements have been completed including completion of the Membership of Orthodontics examination provided by the Royal College of Surgeons (MOrth RCS), recognition as an orthodontic specialist can be obtained with the clinician entering the GDC specialist register (The Specialist Advisory Committee in Orthodontics, 2010; General Dental Council, 2023a). Orthodontist specialists can complete two further years of training to allow them to fulfil the role of an NHS Consultant which allows clinicians to provide orthodontics to more complex patients requiring multi-disciplinary team care. This service is provided in a secondary or tertiary care setting

such as district general or teaching dental hospitals. During this additional training period, further skills are required in areas such as complex multi-disciplinary care often requiring surgery, restorative and paediatric input, alongside further leadership and management training (NHS England, 2015; General Dental Council, 2023a).

Orthodontic treatment can also be delivered by other appropriately trained clinicians who are registered with the GDC including registered general dental practitioners (GDPs), orthodontic therapists and orthodontic technicians (General Dental Council, 2015a). GDPs can provide orthodontic treatment following the teaching and training provided at undergraduate level if they have the appropriate competencies (General Dental Council, 2015a) or they can complete additional courses to increase their knowledge and competency (Christensen, 2002). These additional courses may be shorter to gain some limited experience to provide simpler orthodontic treatment or longer to establish more comprehensive orthodontic concepts and treatment (Christensen, 2002).

The purpose of orthodontic teaching at undergraduate level is to equip graduates with orthodontic knowledge and skills to identify, recognise and understand the importance of abnormal facial growth and dental irregularities and ultimately prepare them for future practice (General Dental Council, 2015a). At the time of graduation, students should be able to undertake an orthodontic assessment, identify occlusal abnormalities, explain principles of interceptive treatment, refer where necessary for specialist orthodontic opinion and/or treatment and to carry out limited orthodontic emergency procedures (General Dental Council, 2015a). The principal role of a GDP is to identify patients with an orthodontic need in a timely manner, refer for assessment and treatment, and provide simple orthodontic emergency dental care where needed (General Dental Council, 2013; General Dental Council, 2015a). There is no expectation for general dentists to provide comprehensive orthodontic treatments to patients (The Specialist Advisory Committee in Orthodontics, 2010; General Dental Council, 2015a). Once assessed and referred by the GDP, the referral pathway is based upon the complexity of the case as described by the commissioning guidelines, where the patient can be seen by a dental practitioner with a specialist interest in orthodontics under the supervision of an orthodontist in primary care, specialist orthodontist in primary care or by consultants in secondary care (NHS England, 2015).

The role of the GDP compared to a specialist orthodontist is highlighted by two separate GDC documents (The Specialist Advisory Committee in Orthodontics, 2010; General Dental Council, 2015a). Both provide explicit objectives for expectations of undergraduate and postgraduate training.

2.2.2 Undergraduate orthodontic teaching in the UK

The undergraduate orthodontic teaching has evolved as the GDC document 'Preparing for practice' (General Dental Council, 2015a) has evolved. Historically, the first version of this document, 'The first five years' (Clark et al., 2003) published in 1997, expected newly qualified dentists to provide full, orthodontic comprehensive treatment plans and treatment. However, due to limited experience in undergraduate teaching this was deemed unrealistic, which led to reduced expectations from the GDC (Rock et al., 2002). Following this, the versions released in 2002, 2008 and 2015 were a turning point for the undergraduate curricula which created a framework for dental education, allowing standardisation over UK dental programmes rather than merely describing content. They progressively provided succinct learning objectives to clarify the expectations of dental students and undergraduate orthodontics was more focussed on a simpler, diagnostic approach to patients with an orthodontic treatment need (Mossey, 2003; General Dental Council, 2008; General Dental Council, 2015a). The most recent version focusses on recognition and assessment and understanding the management of patients in terms of onwards referral and providing simple emergency orthodontics.

The various teaching practices used in dentistry highlighted in section 2.1.5 by McGleenon and Morison, (2021) are also used in undergraduate orthodontic teaching. The last published research reported on undergraduate orthodontic teaching structure, content and assessment in the UK was based on data collected in 2004 (Derringer, 2005; Derringer, 2006). The author reported that teaching was delivered through lectures, seminars (some as part of problem-based learning and case-scenario based), diagnostic clinics, treatment clinics, laboratory teaching, over a period of 18 months to three years. Total teaching hours ranged from 76-240 hours with a variation of 1-6 patients being treated per student. The content of teaching included: Development and aetiology of the dentition, biology of tooth movement, growth, aim of orthodontics, classification of malocclusion with crowding and spacing, interceptive orthodontics, appliances, anchorage, treatment in Class I, Class II (division 1), Class II (division 2) and Class III cases, retention and cases which need referral. Treatment clinics involved teaching on removable, fixed and functional appliances. Assessment formats were written papers and clinical, some of which included short answer papers, case presentations, OSCEs and VIVAs. There was significant variation in the delivery, hours of teaching, in-course assessments, and format of examination amongst the curricula of the twelve participating dental schools in this study (Derringer, 2005; Derringer, 2006).

Other published studies have further explored what was being taught at undergraduate level with regards to orthodontics in the UK (Rock et al., 2002; Hobson et al., 2004). Hobson et al., (2004) reported teaching at Newcastle Dental School and described similar delivery methods of teaching to Derringer, (2005). Additional content included: Dental anatomy, embryology, cephalometry, dental materials and case-based discussions. Other assessments included competency assessments and completion of clinical portfolios. Rock et al., (2002) revealed that the delivery of teaching in 1998 was through: Lectures, seminars, Computer Aided Learning, laboratory course and clinical work. The number of patients treated was 2-12 patients with a total teaching time of 109-286 hours. The findings agreed with the findings of Derringer, (2005) in that there was significant variation in different UK undergraduate orthodontic programmes.

It is important to note that the papers describing the undergraduate orthodontic teaching structure, content and assessment were published in 1998 and 2004. Since then, there have been multiple changes to the document 'Preparing for Practice' (General Dental Council, 2015a) and potentially further more radical changes to the undergraduate orthodontic teaching due to the recent COVID-19 pandemic. Therefore, what is currently taught in the UK undergraduate orthodontic curriculum and how it is taught, is unknown.

Consideration should also be given to online teaching which has been incorporated into UK undergraduate orthodontic programmes since the early 1980s (Al-Jewair et al., 2009). In orthodontics, it is usually used as an adjunct to support learning in diagnosis and treatment planning (Al-Jewair et al., 2009). The current literature on the use of online methods in orthodontics have been given mixed reviews. Many are in support of online teaching and suggest an increase in knowledge, improved exam results and positive attitudes from students over traditional methods (Luffingham, 1984; Rosenberg et al., 2005; Al-Jewair et al., 2009). In contrast, some research has found delivery of teaching via traditional methods achieves better results than the sole use of e-learning (Hobson et al., 2011). More recent research has reported positive results of using a blended method of learning which combines traditional methods of teaching with online teaching (Jeganathan and Fleming, 2020) and has reported positive feedback from students.

2.2.3 Confidence and competence in orthodontics

As discussed in section 2.2.1, the purpose of undergraduate orthodontic teaching is to prepare dental students and newly qualified dentists for future orthodontic practice in primary care (General Dental Council, 2015a). However, current literature does not support this idea. Gilmour et al., (2016)

surveyed final year dental students at Cardiff University on their confidence levels in performing procedures from a mix of different specialties. Results reported that some of the lowest scores of confidence were for '...the design/fit/adjustments of orthodontic appliances.' However, as this paper was based in Cardiff only, it may not be generalisable to the greater population of the UK. Furthermore, the author documented that the paper was based upon an indicative personal view of self-confidence of dental students therefore although students may not have had the self-belief to undertake these procedures, they may have been competent in doing so.

Another study by Patel et al., (2006) suggested that low confidence in managing orthodontic patients may continue through to dental practice. In this study, a piloted questionnaire was posted to newly qualified dentists and trainers to identify how undergraduate orthodontic training had prepared them for practice. Results stated that 60% of newly qualified dentists lacked confidence in orthodontic case assessment. Trainers considered only 50% of newly graduating students as being well prepared for orthodontic assessments and as such felt the undergraduate orthodontic training was insufficient. This paper was based upon opinions and perceived confidence by both trainers and new dentists thus the risk of response bias and social desirability was high which may have skewed the results. This coupled with not describing the validation methods of the questionnaire means the validity of these results may be compromised. Furthermore, the responses were from England only and may not be generalisable nationally.

Fleming and Dowling, (2005) surveyed more experienced GDPs to evaluate their undergraduate orthodontic training, the variety of orthodontics being carried out in practice and the levels of perceived competence in performing certain orthodontic procedures. The study concluded that only 60% of GDPs were confident in dealing with orthodontic emergencies although there was satisfaction with undergraduate orthodontic training. This survey was based in the Greater Dublin area only however and as such may not be generalisable to the greater population of the UK.

There has been concerns that GDPs are sending poor quality orthodontic referrals to specialist orthodontic practice or secondary care (Reddy et al., 2016). Reddy et al., (2016) completed a two cycle audit of 228 patients sent in via primary care referral pathways at King's College Hospital. Results identified that only 37.2% GDPs met the standards for correct referrals in the first cycle and this dropped to 33.3% in the second cycle. Of note, the action plan introduced after the first cycle results to give information on correct referral guidelines and pathways to the referring practitioner, as well as sending detailed information for why their referral was inappropriate, did not help to improve

referrals being sent. This may have been as the more difficult concepts of timing of referral and reasons for referral may still have been poorly understood by the GDPs. As the GDP is the main gatekeeper for identifying and referring patients for orthodontic management, it is imperative that sufficient training is given in these areas particularly at an undergraduate level to tackle this problem at the root cause, ultimately to ensure patient care is not compromised or delayed (Jawad et al., 2015).

Another important competency required by dentists is the ability to use the IOTN screening tool which aids in identifying patients who have a high orthodontic treatment need and it has been considered a useful tool for the provision of orthodontics (Jawad et al., 2016). However, a recent cross-sectional survey conducted by undergraduate fourth and fifth dental students based in the UK, identified dental student's ability and confidence in correctly assessing patients, applying the dental health component of the IOTN and judgement on appropriate onward referrals as inadequate (Bouskandar et al., 2023). Recommendations were unable to be made due to the low response rate which was noted by the author (Bouskandar et al., 2023). Another study conducted by Jawad et al., (2016), described an experimental study to compare the use of IOTN by groups with different dental education backgrounds. They reported the inaccurate use of IOTN by newly qualified dentists and general dentists where the level of agreement for the use of the dental health component of IOTN was not acceptable compared to expert scores. Biases were noted in these results as there was a tendency of participants to underscore both in the dental health and aesthetic component of the IOTN. This may have been if traits were not correctly identified or due to omission error. The validity of results when a borderline IOTN score was given was unable to be accounted for. These papers identify gaps in knowledge and the need for further education and training in IOTN so appropriate and timely referrals can be made from primary care.

The research reporting lack of confidence and competence is suggestive of undergraduate orthodontic teaching not being sufficient and effective in fulfilling its role to prepare newly qualified dentists for practice and education practices may need to change to improve this.

2.3 The COVID-19 pandemic

The Coronavirus Act 2020 has described Coronavirus Disease 2019 (COVID-19), as an infection caused by a type of beta coronavirus, Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) (Open Government Licence, 2020). It is a pathogenic and transmissible viral infection (Shereen et al., 2020) and those infected with COVID-19 may present with symptoms ranging from persistent dry cough,

shortness of breath, new loss of taste or smell, any symptoms related to viral pneumonia and many others (Centers for Disease Control and Prevention, 2022). As symptoms affect people with different severities, government policies were formed in attempt to reduce the spread of the virus (Longhurst et al., 2020).

2.3.1 Timeline of COVID-19

Figure 1 shows the timeline of key events of the pandemic, described by the World Health Organisation (WHO), which started in December 2019 (World Health Organization, 2019; Longhurst et al., 2020; Mahase, 2020; Public Health England, 2020; World Health Organization, 2020). As more information was released over time, the government enforced progressive measures to continue to attempt to contain the virus (Longhurst et al., 2020).

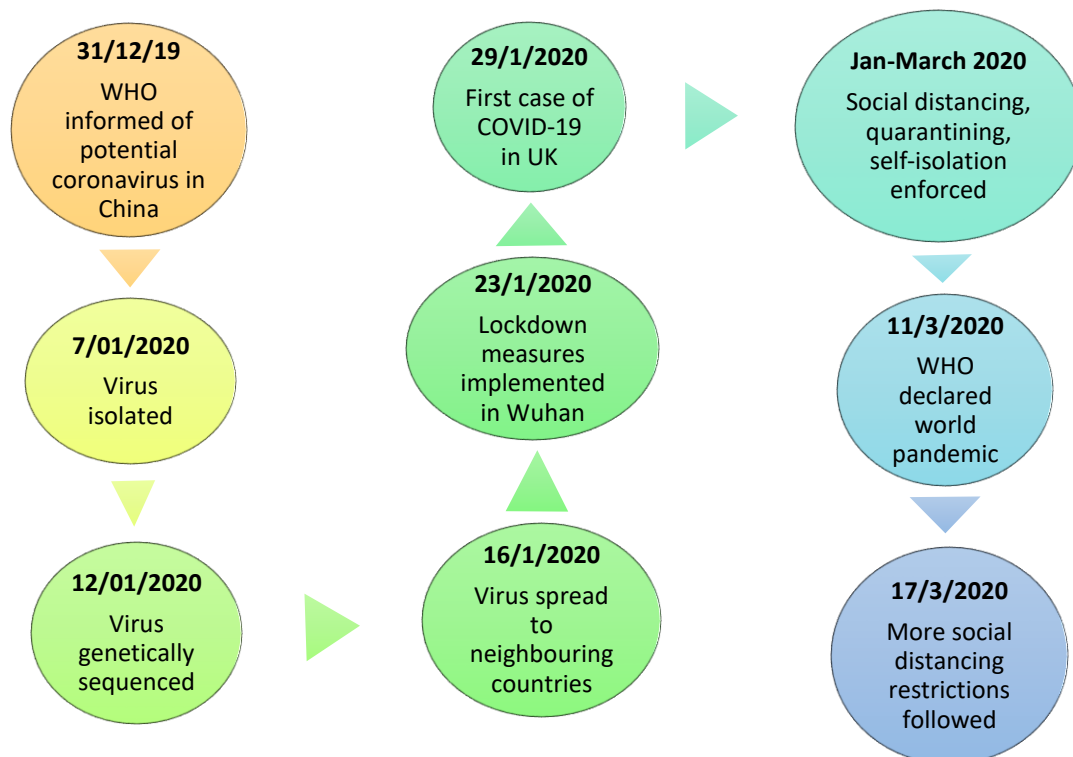


Figure 1: Timeline of events of COVID-19

2.3.2 General impact of COVID-19 on undergraduate education

It has been reported that COVID-19 had negative effects on undergraduate education worldwide (United Nations Educational Scientific Cultural Organization, 2020). According to United Nations Educational Scientific and Cultural Organisation (UNESCO) statistics, more than 100 countries closed education facilities worldwide which disrupted the education of over 1.5 billion students with millions

more affected due to localised school closures in an attempt to contain the virus (Longhurst et al., 2020; United Nations Educational Scientific Cultural Organization, 2020; United Nations Educational Scientific Cultural Organization, 2021).

In the UK, on the basis of public health guidance for educational institutions, university authorities decided upon temporary closures and completely suspended face-to-face teaching from 16th March 2020 to meet social distancing criteria (Longhurst et al., 2020; Open Government Licence, 2020). Students returned to universities and some medical clinical placements were resumed by September 2020 (Cairney-Hill et al., 2021). These measures have affected and disrupted the long standing higher educational practices that have been applied for many years (Gill et al., 2020). Following the university closures, higher education providers were forced to adapt their methods of delivery and substituted face-to-face teaching with online methods (Longhurst et al., 2020). Some of these unconventional approaches were provided within only a few days of the lockdown and university closures (Longhurst et al., 2020). Furthermore, assessment methods were also modified by the Minister of Higher Education during this time with many being temporarily suspended or adjusted to be delivered online. All of these outcome measures have been outlined in the guidance from the government in 'Briefing on COVID-19 responses in the Education and Training Sector' (Ireland Department of Education and Skills, 2020).

2.3.3 Impact on clinical teaching

2.3.3.1 Clinical teaching in medicine

During the first wave of the COVID-19 pandemic, the majority of clinical placements for medical students were suspended to focus mainly on patients who suffered from COVID-19 (Gill et al., 2020; Kelly et al., 2020). The temporary discontinuation of clinical teaching resulted in cohorts of undergraduate students missing four months of clinical experience, which would usually be fundamental in their educational learning, training and progression (Gill et al., 2020).

Medical examinations were also cancelled, postponed or became online-based as face-to-face teaching was suspended from mid-March 2020. These, as well as other forms of pre-pandemic teaching re-started from September 2020 onwards (Longhurst et al., 2020).

Medical students resorted to training remotely through online resources or textbooks. Recent articles have identified challenges experienced by students learning this way and stated online teaching

cannot solely replace clinical education due to the need for direct patient contact for key learning requirements (Gill et al., 2020; Kelly et al., 2020; Cairney-Hill et al., 2021). In contrast, other researchers took the pandemic to be an opportunity to make technological advances in their teaching and developed new online resources (Gill et al., 2020; Kelly et al., 2020; Longhurst et al., 2020; Cairney-Hill et al., 2021).

2.3.3.2 Clinical teaching in dentistry

Dental education has also been affected worldwide with similar positive and negative perceptions of experiences. A review article by Trivandrum Anandapadmanabhan et al., (2022) described how COVID-19 compelled dental institutions and universities to place their clinical training on hold and switch to online programs for distance learning in different countries. Furthermore, these changes to teaching caused psychological distress and exacerbated poor mental health amongst some dental students worldwide. A further recent study in the United States of America conducted as a cross-sectional survey, identified that anxiety, depression and burnout were experienced by many dental students and many students reported the intention to leave their training programmes during the COVID-19 pandemic (Chi et al., 2021). The author for this paper however acknowledged that there were three potential sources of bias which included: A relatively low response rate, they focused on a single dental school in the USA and that the paper only explored intention to leave the program which did not necessarily translate to attrition. The scoping review by Farrokhi et al., (2021) and review by Trivandrum Anandapadmanabhan et al., (2022) further discussed other difficulties experienced by students: Lack of preparation and motivation for online education, poor internet connection, and reduced student/teacher interaction.

In contrast, positives have been discussed: The pandemic was seen as an opportunity for modernisation of UK undergraduate dental education (Machado et al., 2020; Trivandrum Anandapadmanabhan et al., 2022). The development and use of simulation, haptics and virtual reality aided in clinical teaching (Deery, 2020). For theory on clinical teaching, online platforms such as Google educational tools and Skype were used as alternatives to face-to-face teaching. Simulation, online case-based discussions and access to online textbooks were ways to develop distance teaching (Machado et al., 2020; Farrokhi et al., 2021; Trivandrum Anandapadmanabhan et al., 2022).

The response in undertaking undergraduate dental examinations was institution dependent worldwide. Practical examinations for dental undergraduates were cancelled, postponed or adapted to online formats while some continued unchanged (Trivandrum Anandapadmanabhan et al., 2022).

Others converted to graded online coursework and projects, clinical case presentations, small group discussions, case-based discussions and team based learning, timed online assessments on clinical work completed via webinars or teleconferences in the presence of supervisors (Trivandrum Anandapadmanabhan et al., 2022).

2.3.4 Impact on students from COVID-19

A cross-sectional study involving undergraduate dental students across UK universities by Al-Attar et al., (2021) reported that 85% of students felt the COVID-19 lockdowns and university closures negatively impacted their overall learning and 6% reported the closures had a positive impact. Furthermore, paired samples t-tests were used to compare students' perceptions of teaching quality, communication, satisfaction with the support received, and overall course satisfaction before and after the lockdown period. Statistical significance was set at a p-value of <0.05. Interestingly, there was an overall reduction of these areas explored, suggesting negative feelings from students (Al-Attar et al., 2021). All these results were statistically significant with p-values of <0.001. Students also felt less confident in treating patients at the start of 2020-2021 when compared to 2019-2020. However, 61% of respondents did state some positive factors on their learning which included the more flexible nature of remote learning, the ability to structure their days more productively, being less intimidated to ask questions on an online platform, the ability to replay online resources and less pressure in sitting face-to-face exams.

The systematic review conducted by Patano et al., (2021) supported the positive feedback reported by Al-Attar et al., (2021) and identified that e-learning was an effective method of teaching and learning amongst both teachers and students from 2005-2021 (thus including the period in which COVID-19 occurred), in the fields of Orthodontics and Paediatric dentistry. It complimented the traditional teaching methods and there was a high level of acceptability, knowledge level, positive attitude and perception of e-learning techniques amongst both teachers and students.

2.3.5 Quality assurance of changes to clinical teaching during COVID-19

Quality assurance takes place to ensure dental graduates have met the GDC learning outcomes and ultimately ensure patient safety (General Dental Council, 2015b). Conventionally, changes to curricula usually occur after strategic planning and collaboration with other academics based upon evidence-based andragogical approaches and take a substantial amount of time to materialise (Longhurst et al., 2020). During the pandemic, quality assurance of teaching was adapted by the GDC to form a bespoke, risk-based quality assurance process which focussed on targeted evidence requests and analysis from

all UK undergraduate dental education providers (Das, 2021). To do this, the GDC worked closely with dental schools to form a feedback mechanism to better support and develop new graduates; this ensured the quality of education and training, while measures were taken to control the spread of the virus (Das, 2021). Ultimately, the GDC's role was to ensure that new graduates fulfilled the requirements and completed the learning objectives set to become safe beginners and worked competently (Das, 2021). Though it is expected this role was fulfilled, there is no current research evidence on this.

2.3.6 Impact of COVID-19 at the University of Leeds

For the purpose of the current research, a virtual interview was carried out with Dr Jane Wardman, Director of Dental Education at The University of Leeds to discuss the delivery of undergraduate teaching during the pandemic. The interview revealed that there was complete suspension of face-to-face student clinics as well as any other face-to-face teaching provided from March 2020 to September 2020. Module modifications were made rapidly to allow teaching including lectures, seminars and tutorials to become online, which allowed for the continuation of dental education. Most practical examinations were also suspended during this period (only some OSCEs were continued) and converted to online written examinations. All module changes were reviewed at faculty level, quality assured and approved swiftly.

All clinics for undergraduate dental students resumed in September 2020. The NHS Leeds Teaching Hospitals Trust guidance was adhered to and patient capacity was reduced. Furthermore, a hybrid form of teaching was adopted with small group, face-to-face teaching and online methods via asynchronous (pre-recorded lectures) and synchronous delivery. Gateway clinical skills assessments were introduced in September 2020 to assess safety and confidence of student skills in performing dental procedures prior to treating patients. The use of simulation also accelerated and involved the development of novel videos and 3D technology which continued in the post-pandemic period. Furthermore, new non-air coolant high-speed contra-angle handpiece (HSCAH) instruments were purchased after positive research was conducted at Leeds Dental Institute (Vernon et al., 2021). This research compared an air-turbine handpiece to the non-air-coolant, HSCAH and concluded that settled bioaerosols was reduced by 99.72%, 100% and 100% for no mitigation, aspiration and rubber dam, respectively in favour of the HSCAH. The author was aware that due to potential operator-induced errors, a single operator performed the crown preparation, root canal access and bacteriophage dispersal detection to keep the results consistent between variables and reduce bias from this. They also acknowledged the results may not have been directly translatable to 'real-life

clinic/surgery' as the airflow may be varied however the results were still useful for indicating the efficiency of aerosol reduction between the two instruments.

2.3.7 COVID-19 changes relating to undergraduate orthodontic teaching

It is clear the COVID-19 pandemic had significant effects on undergraduate academic and clinical teaching worldwide in medicine and dentistry, with current evidence suggesting that face-to-face teaching was reduced and replaced with teaching remotely (Longhurst et al., 2020; Trivandrum Anandapadmanabhan et al., 2022). Currently, there is no literature to describe the changes which occurred, if any, relating to the undergraduate orthodontic teaching practices peri-pandemic and post-pandemic, in UK dental schools. It is important to identify positive changes planned to be retained which may ultimately help to improve the delivery of undergraduate orthodontic education on a national level.

2.4 Literature review for the choice of methodology

The purpose of the current research was to identify the current undergraduate orthodontic teaching practices nationally at three time-frames. Pre-COVID-19 (prior to March 2020) to provide baseline information, peri-COVID-19 (March 2020-September 2020) i.e. during the first lockdown and post-COVID-19 (September 2020 onwards) to provide information on whether changes were retained. Undergraduate orthodontic leads organised the undergraduate orthodontic teaching and were involved with module changes, including any changes made during the pandemic so these were the target audience for the research. Data about teaching could be obtained from the research participants using a questionnaire, individual interviews or focus group interviews. Each of these methods was considered.

2.4.1 Identification of articles from the literature review

A thorough literature review identified relevant published articles on undergraduate teaching in different areas of healthcare. The searches were carried out on the database Ovid Medline, Embase and PubMed. A general search was also completed on the database Google Scholar to ensure no relevant papers were missed. All the search terms used were based on undergraduate teaching and related to six key areas; UK and non-UK-based orthodontic teaching, general teaching methods in dentistry, teaching in different dental specialties, clinical teaching during the COVID-19 pandemic in different healthcare fields (medicine, dentistry) and impact on dental students during COVID-19 to inform the questionnaire of the current study.

From the large numbers of studies identified on these areas, relevant studies were selected by reading abstracts and entire papers to ensure the information was relevant to the objectives of the current study (Table 1). Not all studies were related directly to undergraduate orthodontic teaching. However, those selected all held important information to guide the development of the current project. As there were no studies related to undergraduate orthodontic teaching in the peri- and post-COVID-19 periods, studies were identified in different healthcare settings such as in medicine and dentistry. By exploring and understanding the patterns and changes which occurred to clinical teaching in these settings during the pandemic, ideas were formed on general topics and the types of questions which should be asked.

Topic	Setting	Relevant papers identified
Undergraduate Orthodontic teaching (pre-COVID-19)	UK-based	(Derringer, 2005) (Derringer, 2006) (Rock et al., 2002) (Hobson et al., 2004)
	Non-UK	(Burton et al., 1994) (Adamidis et al., 2000)
General modes of teaching delivery and assessment methods in dentistry	UK-based	(McGleenon and Morison, 2021)
Undergraduate teaching in different dental specialties	UK-based	(Grindrod et al., 2020) (Macluskey and Durham, 2009) (Al Raisi et al., 2019) (Lynch et al., 2010) (Heasman et al., 2015)
General changes to undergraduate clinical teaching in different areas of healthcare during the COVID-19 pandemic	Medicine	(Walls et al., 2021) (Cairney-Hill et al., 2021) (Kelly et al., 2020) (Longhurst et al., 2020) (Gill et al., 2020)
	Dentistry	(Trivandrum Anandapadmanabhan et al., 2022) (Farrokhi et al., 2021) (Machado et al., 2020) (Deery, 2020)
Impact on dental students during COVID-19	Dentistry	(Patano et al., 2021) (Al-Attar et al., 2021)

Table 1 The areas that were explored to develop the general topics for the questionnaire

2.4.2 Review of previous studies evaluating undergraduate teaching

2.4.2.1 Methods used in orthodontics to evaluate undergraduate teaching

A literature search did not identify any research about undergraduate orthodontic teaching practices in UK in the peri- and post-COVID-19 period. There were three UK-based studies which looked into

details of the undergraduate orthodontic teaching in relation to the methods, timing and hours of teaching, assessment methods and staffing prior to the COVID-19 pandemic (Rock et al., 2002; Derringer, 2005; Derringer, 2006). Derringer, (2005) and Derringer, (2006) undertook a cross-sectional descriptive survey to investigate teaching and assessment in UK dental schools. A questionnaire was emailed to orthodontic course leaders in UK dental schools, data summarised, re-sent for verification and course manuals were requested. Rock et al., (2002) used a cross-sectional questionnaire at two time points (1994 and 1998), disseminated to UK Heads of Orthodontics. Response rate was 77% and 100% at the two time points but it was unclear whether the questionnaire dissemination was postal or web-based. In these studies there was no explanation of: Questionnaire development, identification of participants and recruitment methods, validity and reliability considerations, non-response, incomplete questionnaire response and recall biases, ethical approval and piloting. Furthermore, though there is no established limit for what constitutes a 'high response rate' in current literature, an 80% rate has been described as excellent (Booker et al., 2021). Low response can cause non-response bias, inaccuracies in generalisability, validity and reliability of the results therefore attempting to achieve high number of responses is key to reduce biases within survey research (Booker et al., 2021). The 77% and 100% response rates in Rock et al., (2002) would therefore be regarded as high.

Burton et al., (1994) compared differences in undergraduate orthodontic teaching in Toronto, Canada and Liverpool, UK. Information was collected directly from the curricula, a questionnaire, and personal interviews. The response rate was 70%. The methods described were vague in relation to how, what and where curricula information was derived from and more information was needed on questionnaire development, piloting, dissemination method and recruitment.

Adamidis et al., (2000) explored the undergraduate orthodontic teaching in 23 different European countries in 1997, using a postal questionnaire. The questionnaire used quantitative, closed questions. Questionnaire development involved reviewing the published literature on undergraduate orthodontic teaching in Europe, piloting with the Professional Development Group followed up by a face-to-face meeting or correspondence for clarification. The development of a single-page questionnaire and participants being members of the EUR-QUAL BIOMED II project led to a response rate of 100%. The brevity of the questionnaire meant important details to aid better understanding of European undergraduate teaching practices were not captured. The author acknowledged the possibility of response bias in the results; if responses were based on individual dental schools, this would not be representative of the full country.

2.4.2.2 Methods used in other dental specialties to evaluate undergraduate teaching

In the UK, other specialties in dentistry have also used cross-sectional questionnaires to explore undergraduate teaching (Macluskey and Durham, 2009; Lynch et al., 2010; Heasman et al., 2015; Al Raisi et al., 2019; Grindrod et al., 2020).

Grindrod et al., (2020) disseminated an online questionnaire using OnlineSurveys. The survey was piloted at three different dental institutes and an overall high response rate was achieved of 75%. The 27-item questionnaire included a mixture of mainly closed questions on topics taught, delivery methods and assessment. Some open-ended questions were used which supported answers to closed questions. Lynch et al., (2010) also used OnlineSurveys for dissemination of their questionnaire and achieved a high response rate of 80% from senior clinical academics in the UK. Both open and closed questions were used in their constructed questionnaire on pre/clinical teaching, techniques used, perceived challenges and collected anonymously. Macluskey and Durham, (2009) disseminated a questionnaire via email attachment to oral surgery teaching staff within UK and Ireland dental schools. Two face-to-face meetings were held for clarification. Response rate was high at 87%. Al Raisi et al., (2019) used an online version of a previous paper-based questionnaire to evaluate the undergraduate endodontic teaching in UK dental schools. The questionnaire covered methods of teaching, topics covered, teaching resources, timing and hours of teaching and staff involvement and the questionnaire was piloted locally. A mix of 24 closed questions and open-ended questions were used. The study had a high response rate of 94% and described well in terms of identification of study participants and recruitment methods. However, more detail was needed on the process of piloting.

In all the studies described above, none fully described questionnaire development stages. Generally, poor explanations were given for any potential biases involving: Non-response, response from incomplete responses and recall, identification of participants and recruitment methods, validation and reliability considerations and the data analysis process and ultimately are of poor quality.

2.4.2.3 Methods used to evaluate undergraduate teaching in medicine during COVID-19

A recent paper by Walls et al., (2021) studied the provision of undergraduate radiation oncology (RO) teaching within medical schools in the UK and Republic of Ireland (RoI) in the pre, peri and post-COVID-19 periods. A cross-sectional survey design was used with the development of a questionnaire. A thorough literature review was carried out with the formation of a bespoke survey instrument based upon another European survey using the online software SurveyMonkey. Thirty questions, mainly

closed with some free-text questions were categorised into five domains: 1. Teaching structure, 2. Teaching format and faculty, 3. Teaching content, 4. Short-term impact of COVID-19, 5. Longer-term impact of COVID-19. The questionnaire was piloted by three appropriate participants and disseminated to RO leads. The method was appropriate to the aim of the study, although further validation and reliability considerations during questionnaire development and the analysis methods of incomplete questionnaire responses would have improved the study to improve accuracy of the results. The author acknowledged potential response bias, even though a high response rate was achieved (79%).

2.4.3 Consideration of other methods

Consideration was given to collecting the data through interviews for this study. Structured, semi-structured and unstructured interviews can give more detailed responses from participants to provide greater in-depth insight to the research and response rates may be higher (Christensen et al., 2014). Interviews are more time-consuming to arrange and conduct however, with less flexibility once these have been scheduled (Doody and Noonan, 2013). Appropriate training and support is required to complete and transcribe interviews skilfully, then perform a qualitative analysis (Doody and Noonan, 2013).

2.4.4 Principles of questionnaire design

2.4.4.1 Stages involved in questionnaire development

The principle objective in the development of a well-designed questionnaire is to collect data which is reliable, valid, unbiased from a representative sample within a timely manner (McColl et al., 2001). Oppenheim, (1992) described the stages in questionnaire design and survey conduct (Figure 2).

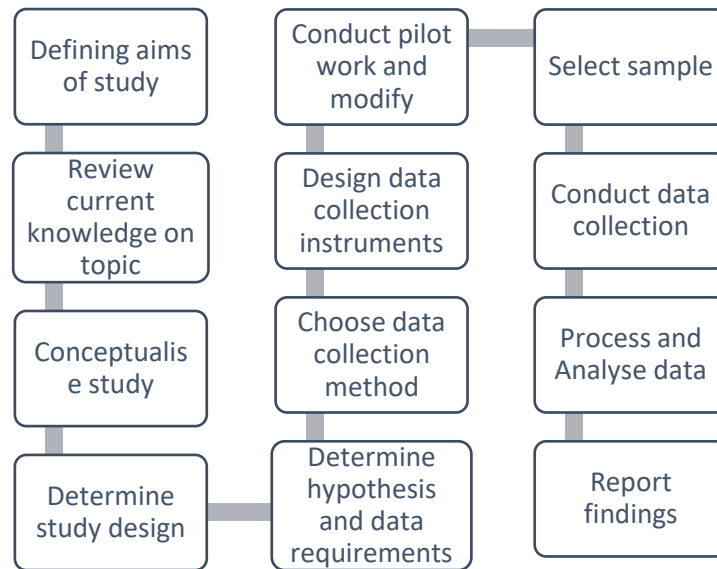


Figure 2: Oppenheim's stages of questionnaire design

2.4.4.2 Wording and format

When considering the process of question development, the wording of questions, choice of response formats, question sequencing, questionnaire layout and presentation are important considerations (McColl et al., 2001). Language of the questions must be within the participant vocabulary and avoid unnecessary jargon and complex terms (Krosnick, 2018).

Furthermore, items in the questionnaire should not be ambiguous, too long, double barrelled, leading, contain more than one concept which may be misinterpreted by different responders and result in error or bias in the results (Acharya, 2010; Krosnick, 2018). The question order should exhibit a funnel sequence i.e. begin with simple questions and then progress to more specific ones which will aim to keep the participants engaged (Acharya, 2010; Krosnick, 2018).

2.4.4.3 Question types

The value of open compared to closed questions has been discussed extensively in the literature (Oppenheim, 1992; McColl et al., 2001; Siniscalco and Auriat, 2005; Acharya, 2010). Acharya, (2010) described closed-ended questions as structured, more difficult to construct but easier to respond to by participants and analysis may be simpler. On the other hand, open-ended questions are often unstructured, more difficult and time-consuming to answer for participants which could risk non-response and may induce inferential bias when analysing the data-set (Acharya, 2010). Data however may be richer (Oppenheim, 1992) resulting in better understanding of the research topic. Semi-closed questions provide a closed question but with an additional option to give more details or 'to specify'

if a particular category has been chosen or if the correct response option is not available (Acharya, 2010). These have the benefit of providing a more structured answer that may be easier for a participant to answer, and potentially provide an in-depth answer if more information is given however in this case analysis may be more difficult (Acharya, 2010).

2.4.4.4 Data collection method

Questionnaires can be disseminated via postal surveys or through digital methods (email attachment or survey software) (Durrant and Dorius, 2007; Sammut et al., 2021). Web surveys are advantageous as they may be easily created and disseminated (eliminating travel time), reducing the administration, cost and completion time for participants (Sammut et al., 2021). Paper surveys are generally advantageous for smaller scale research projects (Durrant and Dorius, 2007). Although historically web-based surveys have had poorer response rates (Pedersen and Nielsen, 2014), a recent paper by McMaster et al., (2017) suggested a web-based survey produced a higher response rate than solely a paper-based survey. Furthermore, web surveys involving survey software allow data to be collated and exported (Online Surveys, 2022), which may simplify analysis.

2.4.5 Quality in survey research

2.4.5.1 Potential biases in survey research

Biases can affect the quality of research and consequently affect the accuracy of the results. The main potential sources of bias in survey-based research are self-selection bias (participants choose whether they would like to volunteer), incomplete data responses, recall bias and bias from ambiguity of questions (Oppenheim, 1992; McColl et al., 2001). Attempts need to be made to reduce these biases (see section 4.2.1.1).

2.4.5.2 Questionnaire validity

Validity refers to how accurately an instrument measures what it was designed to measure (Carmines and Zeller, 1979). Table 2 describes the four main types of validity and whether they would be useful for the current study.

Type of validity	Definition	How it can be measured	Use in this research
Content validity	The extent to which a measure represents all facets of a given social concept (Roopa and Rani, 2012).	Expert judgement (two or more subject matter experts) (Roopa and Rani, 2012).	Yes - Completed as part of pre-testing stage.
Face validity	An estimation of whether the items of a questionnaire are appropriate at face value (Roopa and Rani, 2012).	Piloting with randomly selected 5-10% of population sample of laypeople.	No - Face validity observations only relevant for layperson.
		Bilingual method: Translators employed to assess face validity in both languages	No - Questionnaire required only in English.
Criterion validity	How well a questionnaire can predict the outcomes of what it measures. The responses are measured against a gold standard/external criteria (Roopa and Rani, 2012).	Statistical analysis: Dependent on type of data: odds ratios, correlation coefficient, standardised mean differences (Borneman, 2010).	No - No other validated tools available to be used as 'gold standard' or external criteria to measure against.
Construct validity	Whether a new questionnaire is consistent with existing ideas concerning the concepts/constructs being explored (Roopa and Rani, 2012).	Statistical analysis: Factor analysis – investigates internal structure of item responses (Markus and Lin, 2010).	No - No existing ideas exist relating to concepts being explored.

Table 2: Types of questionnaire validity, methods for measuring and usefulness for this study

2.4.5.3 Reliability of questionnaire research

Reliability quantifies the extent of consistency of questionnaire responses (Roopa and Rani, 2012).

Table 3 describes the three types of reliability testing, how they can be measured and whether any of these reliability types are useful for the current research.

Type of reliability	Definition	How it can be measured	Useful for this research
Test-retest	Measure of consistency of responses over time (Roopa and Rani, 2012) (Variance over time)	Correlation between each test taken. Statistic: Kappa statistics Reliability Coefficient (Pearson and Spearman). Cronbach's Alpha.	No - Factual data collected at two different intervals unlikely to be different and will be burdensome for respondents.
Internal consistency reliability	Estimation of consistency of the results of different items measuring the same construct (Roopa and Rani, 2012). (Variance of items)	Reliability Coefficient such as Cronbach's alpha coefficient and Split-half reliability correlation coefficient.	No - Collecting the same factual information from respondents in two different ways is likely to frustrate respondents and may unnecessarily elongate the questionnaire.
Inter-observer reliability	The degree to which different observers make consistent estimates of the same phenomenon (Roopa and Rani, 2012).	Interrater agreement measures: Percentage of agreement. Statistic: Kappa statistics Reliability Coefficient (Pearson and Spearman).	No – it is not feasible to ask two respondents from the same institute to complete the questionnaire and people from different institutes would be

		Cronbach's Alpha.	expected to provide different answers.
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Table 3: Types of questionnaire reliability, methods for measuring and usefulness for this study

2.4.5.4 Critical appraisal tools for online survey research

To aid the assessment of quality of research, many critical appraisal tools exist (Critical Appraisal Skills Programme, 2023). For online survey research, reporting guidelines such as the 'Checklist for Reporting Results of Internet E-Surveys (CHERRIES)' have been published for assessing quality (Eysenbach, 2004). Others such as the critical appraisal tool to assess quality of cross-sectional studies published by Downes et al., (2016) may also be used. Both these tools exist as guidance on different aspects of survey research and can be adapted to suit individual surveys to ensure good quality research is completed.

2.4.6 Methods for pre-testing and piloting a questionnaire

Both pre-testing and piloting are processes by which researchers are able to revise and reflect on their research prior to the main study being carried out (Erin et al., 2015). Both have a similar goal to improve the main research study, but they are different concepts.

Pre-testing is preliminary testing completed to measure the research instrument being used. It is completed as part of questionnaire development stage which requires construction, trying out, revision and refinement to ensure it yields the data intended, a staged process described well by Oppenheim, (1992). Pilot testing is a trial run of the main study with a smaller sample representative of the research population, in a real-world setting, to ensure all processes run smoothly. This sample is usually separate from the main study participants (Oppenheim, 1992; Erin et al., 2015).

Pre-testing can be completed in many different forms (Erin et al., 2015):

1. **Behaviour coding:** Respondents complete the questionnaire in the presence of the researcher and behaviours such as hesitation, confusion and frustration are observed relating to questions.
2. **Cognitive interviewing methods:** This is term to cover many different tools for understanding the thought processes and decision-making of participants when answering questions. The two main forms involve the 'think-aloud method' where participants are asked to verbalise their thoughts simultaneously to answering questions and 'verbal probing' where the interviewer asks open questions (Collins, 2015).

3. **Individual debriefing:** Researchers gain feedback and reactions after questionnaire completion.
4. **Group Debriefing:** Researchers bring test participants together after completing the survey for focus group discussion.

Modifications can be made once feedback has been obtained from any of the above methods. There is no strict rule on pre-testing sample size and although a guide has been suggested of 5-10 participants (Beatty and Willis, 2007), the sample size depends on the complexity of the research being carried out and differences in participant population.

2.5 Summary of literature review

The current study aims to describe pre-COVID-19, peri-COVID-19 and post-COVID-19 teaching practices, assessment and staffing without determining causal relationships or making wider inferences.

Published literature has described undergraduate orthodontic teaching practices in the pre-COVID-19 period in the UK and worldwide (see section 2.4.1) (Burton et al., 1994; Adamidis et al., 2000; Rock et al., 2002; Derringer, 2005; Derringer, 2006). Other published papers have discussed undergraduate teaching in other dental specialties (Macluskey and Durham, 2009; Lynch et al., 2010; Heasman et al., 2015; Al Raisi et al., 2019; Grindrod et al., 2020). Overall, these have reported a variation in teaching practices. Only one relevant paper by Walls et al., (2021) explored the specific undergraduate teaching practices of a specialty in medicine during the pandemic. The review of the studies identified a need for further explanation on the methodologies used, in particular: questionnaire development, ethical approval, piloting, data analysis and any biases which could affect results.

All the studies reviewed used a cross-sectional descriptive survey as their research design using questionnaires as their main form of data collection. Questionnaires may be favoured due to their many advantages some of which include; rapid dissemination, participant completion time and thus collation of responses, being inexpensive, inclusive of a larger target population and use of visual aids (Jones et al., 2013). Furthermore, the increased flexibility for completion, being void of interviewer influence, ability to maintain anonymity and a well-designed questionnaire being able to provide in-depth data have also been seen as favourable (Oppenheim, 1992; Jones et al., 2013).

The literature review identified outdated information on the pre-COVID-19, UK undergraduate orthodontic teaching practices and did not identify any research in relation to undergraduate orthodontic methods, timing and hours of teaching, assessment methods and staffing in the UK, in the peri- and post-COVID-19 period.

A cross-sectional survey using a well-designed questionnaire on current UK undergraduate orthodontic teaching practices would therefore be a useful addition to the existing research knowledge base.

Chapter 3: Aims and Objectives

3.1 Aim

To describe how undergraduate orthodontics is taught across the UK and how this was affected by the COVID-19 pandemic.

3.2 Objectives

- To describe undergraduate orthodontic teaching practices in terms of timing of teaching, methods of teaching delivery, hours of teaching allocated, assessment and staffing in the UK prior to the pre-COVID-19 pandemic (March 2020).
- To identify any changes to undergraduate orthodontic teaching practices in terms of timing of teaching, methods of teaching delivery, hours of teaching allocated, assessment and staffing in the UK during the peak of the COVID-19 pandemic (March 2020-September 2020).
- To identify if any of these changes have or will be retained and how this might affect future teaching practices, assessment and staffing.

Chapter 4: Methods and Materials

4.1 Study design and participants

This was a cross-sectional survey of dental schools in the United Kingdom (UK) providing undergraduate dental teaching. A mixed methods approach was used with a predominantly quantitative data component. A smaller qualitative element was also used to support the quantitative data. The target respondents were undergraduate orthodontic leads i.e. people responsible for the organisation and delivery of undergraduate orthodontic teaching, who were asked to provide information on behalf of their institute.

4.2 Study methods

Prior to commencing the research, ethical approval was granted by the University of Leeds Dental Research Ethics Committee (071122/MH/359 granted 16/01/2023).

4.2.1 Participant recruitment and enrolment

Prior to recruitment, permission was requested from all sixteen UK Heads of Dental Schools (HoS) to carry out this project at their individual institute. An email was sent to the HoS with the details of the current project to request permission for the lead researcher (MH) to contact the undergraduate orthodontic lead representing the specific dental school between 16th January 2023 - 9th March 2023. University email addresses for the sixteen HoS were identified through individual dental school and university websites. A follow up email was sent to the HoS if no reply had been received two weeks after the initial email. Where there was no response, attempts were made to contact the HoS through the undergraduate orthodontic lead. Fifteen HoS responded overall and gave permission for the current study to be carried out at their dental school.

To identify the undergraduate orthodontic leads, two methods were used. Firstly, the British Orthodontic Society University Teachers Group (UTG) Chair was contacted by the lead researcher to request they contact members to ask if they could share their names and email addresses with the lead researcher. Where there was no response to the UTG Chair, the lead researcher identified the names and email addresses of undergraduate orthodontic leads through individual dental school websites.

Once all undergraduate orthodontic leads had been identified and permission gained from the HoS, a personalised invitation was sent with a summary of the current project, the participant information sheet, the research participant privacy notice and the link to the online questionnaire. The questionnaire was disseminated to fifteen out of sixteen undergraduate orthodontic leads as permission was not gained from one HoS to carry out the project at their dental school. The recruitment period was from 19th January 2023 – 15th March 2023.

Undergraduate orthodontic leads were informed that participation was voluntary. A mandatory and explicit tick box consent statement for participation in the research was included at the start of the questionnaire (*see Appendix 1 Final questionnaire PDF V3 150123*). First, second and third reminder emails were sent at two-weekly intervals to those who had not completed the questionnaire. The project was planned to collect data over a six-week period initially but an extension of two weeks was given to attempt to increase response rate from potential participants. Participants were informed that they could withdraw from the study at any point prior to data analysis.

4.2.1.1 Methods to reduce bias in the study

Self-selection bias was mitigated by explaining the relevance and importance of the research being carried out to participants in the participant information sheet, personalising emails, formalising the project by involving the British Orthodontic Society (BOS) Chair to enquire about participation- this also had the effect of sending pre-notification, frequent reminders were sent, access to the survey link was easy i.e. provided directly in the recruitment email, anonymity was assured, extending the duration to complete the survey (a two-week extension was given), an anonymised summary of the results was provided to participants which acted as a reward for taking part and finally the questionnaire was kept as concise as possible to reduce participant burden (McColl et al., 2001).

Incomplete responses to the questionnaire was addressed by mandating relevant questions. If necessary, emails were sent for clarification. Recall bias was reduced by distributing the questionnaire as soon as possible to make it close to the pandemic, as knowledge of the changes to teaching were recent. Furthermore, avoiding ambiguity in questions was achieved by pre-testing the questionnaire. Prompts, such as definitions and examples, were provided to ensure respondent understanding of the questions was as intended (Oppenheim, 1992; McColl et al., 2001; Krosnick, 2018).

4.2.2 Data collection and management

Participants completed the online questionnaire via OnlineSurveys (<https://www.onlinesurveys.ac.uk/>), which is an online survey tool used for academic research and education (Online Surveys, 2022). Questionnaire responses were collected and stored by OnlineSurveys then exported in a Microsoft Excel spreadsheet. OnlineSurveys is fully compliant with UK General Data Protection Regulation (GDPR) laws (Online Surveys, 2022). Both personal data and research data were kept in accordance with the University of Leeds Code of Practice on Data Protection and the University's Information Protection Policy (GDPR) (Favager, 2019).

The lead researcher was able to identify those who did and did not respond to the initial recruitment email to allow enrolment to be monitored. Participants were informed that responses were not anonymous to the lead researcher but that research data would be separated from personal information for storage and analysis and all published data would be reported anonymously to reduce risk of identification.

Participants were informed that during analysis of the data they may be contacted via email to clarify any details to ensure all responses were interpreted correctly.

4.2.3 Data analysis

All responses were pseudo-anonymised by assigning a code to each respondent to allow anonymised analysis. Incomplete questionnaires were included in the analysis.

Quantitative data was analysed using descriptive summary statistics to address the study objectives. These were to describe undergraduate orthodontic teaching practices in terms of timing of teaching (years), methods of delivery, hours allocated, assessment and staffing in:

1. The pre-COVID-19 period
2. During the peak of the COVID-19 pandemic
3. In the period following the pandemic.

As the target population was small, it was expected that the data would not be normally distributed so non-parametric summary statistics were used. Categorical data was analysed using counts and frequencies then displayed using a stacked bar chart (for example demographics, years taught, type of teaching, hours allocated, assessments and staffing pre-COVID-19). Semi-closed and some open questions were used to allow flexibility to provide data. Data from these were interpreted, coded and

turned into categorical data and displayed in tables and graphs (for example changes to hours and type of teaching and assessments peri-COVID-19 and retention post-COVID-19). Although no rigid analysis framework was used to analyse qualitative data from free-text boxes, (for example data on the feedback from participants and perceived student feedback), a simple qualitative analysis method was used where responses were examined for common trends or topics. This entailed interpretation of the individual comments and grouping those of similar concepts. Common and divergent views were then integrated into the research results to provide context and depth to the quantitative data with supportive illustrative quotes. Inferential bias was reduced when analysing these results by discussing this data with research supervisors who also aided in interpreting and coding the comments made by participants.

4.3 Questionnaire development

A bespoke questionnaire was developed for the purpose of completing this project because no appropriate tool existed. Best practice guidance for questionnaire development was used to inform the process for this project in order to form a well-designed and concise questionnaire that balanced participant burden with collection of high quality data (Oppenheim, 1992; Williams, 2003; General Medical Council, 2011; NHS England, 2018). This process involved five main stages (Figure 3).

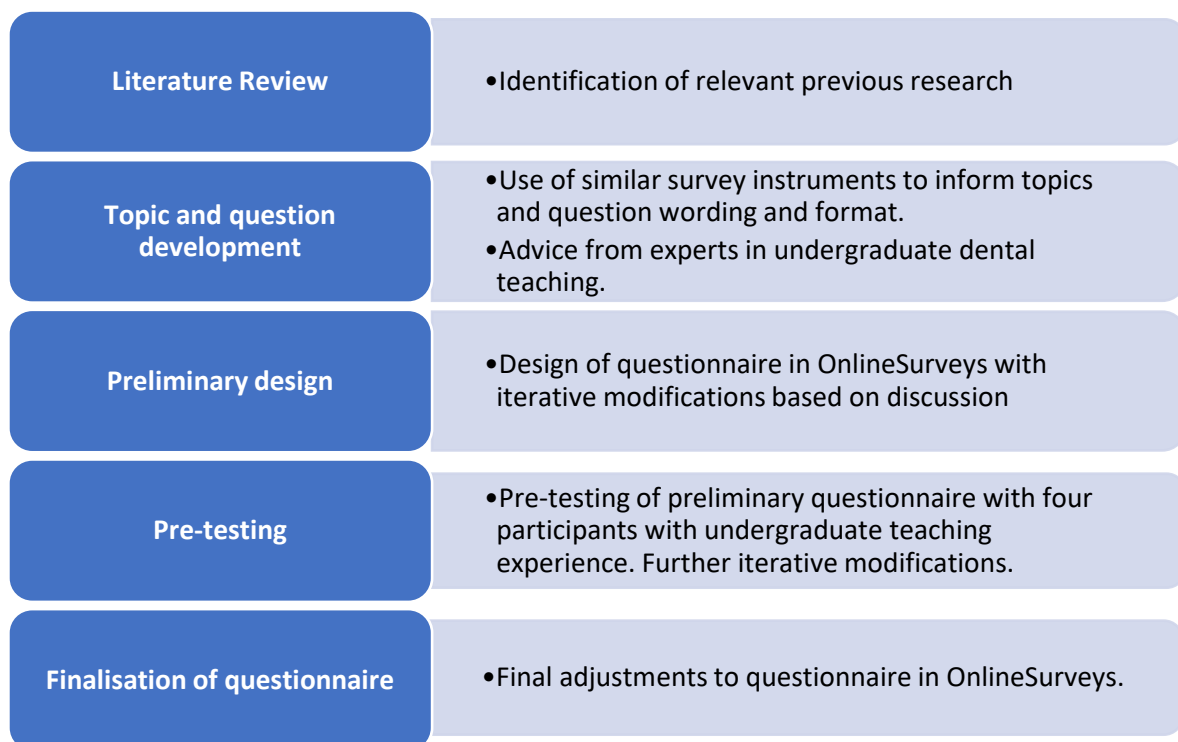


Figure 3: Stages of questionnaire development

4.3.1 Literature review

Please see section 2.4.1 and section 2.4.2 for methods of identification of articles, to understand what published data was available on undergraduate teaching practices and the review of these papers. The articles identified aided in developing general topics and types of questions to include in the current study particularly relating to developing a bespoke questionnaire.

4.3.2 Topic and question development

McColl et al., (2001) and Krosnick, (2018) previously described the importance of question wording, layout and language (see section 2.4.3.2). For the current study, these principles and survey instruments from relevant studies were examined to inform the wording, format and response options. The language used was appropriate for the participants due to their experience in organising undergraduate teaching. For example, specific terms such as 'synchronous, asynchronous, flipped classroom, simulation' etc which relate to specific delivery methods were used as these terms were used within their normal field of work. A page of definitions was also provided to avoid different interpretations of specific terms.

A mix of open, closed and semi-closed questions were used in the current study as the value of having a mix has been discussed extensively in the literature (see section 2.4.3.3) (Oppenheim, 1992; McColl et al., 2001; Siniscalco and Auriat, 2005; Acharya, 2010). These questions gained information on the structure of undergraduate orthodontic teaching for the current study which involved the timing (years) of teaching, delivery methods used, hours of teaching, assessment and staffing and thus aided in answering the research aims and objectives. The questions were reviewed from papers which explored undergraduate teaching in orthodontics, paediatrics and endodontics in the pre-COVID-19 period (Adamidis et al., 2000; Derringer, 2005; Derringer, 2006; Al Raisi et al., 2019; Grindrod et al., 2020). Questions relating to changes to undergraduate teaching peri-COVID-19 and post-COVID-19 were reviewed from the following medical paper (Walls et al., 2021). Other papers also informed the questions about how the events of COVID-19 related to teaching.

4.3.3 Consultation with an expert

A meeting with Dr Jane Wardman, Director for Dental Education at The University of Leeds, was undertaken to explore the challenges experienced in adapting the undergraduate dental teaching delivery during the peak of the COVID-19 pandemic. This was undertaken at the beginning of the research to provide an overall understanding of the impact of the pandemic and it informed questions relating to changes of undergraduate teaching practices and assessments during and after COVID-19.

In addition, discussions between the lead researcher and supervisors to discuss format, relevant content and question type frequently took place allowing for regular modifications of the questionnaire.

4.3.4 Preliminary design and layout

The preliminary questionnaire was programmed into OnlineSurveys for the pre-testing stage. The design and layout were continuously discussed and modified to optimise usability and relevance. The outline of the preliminary questionnaire is shown in Table 4.

Table 4: Overview of the preliminary questionnaire structure and content

Section	Item	Format
Introduction	Study information	Text
	Confirmation of consent to participate	Mandatory tick box
Participant details	Name	Free Text – single line
	Representing dental school	Tick box
	Role in undergraduate orthodontic teaching	Free Text - single line
Structure and delivery of teaching	Definitions of methods of teaching	Text
	Undergraduate orthodontic teaching structure pre-COVID-19	Free Text – multiple line
	Structure and delivery of teaching changes peri-COVID-19	Free Text- multiple line
	The changes to be retained	Free Text – multiple line
Staffing	Number of staff members pre-COVID-19	Free Text – Grid
	Changes to staff members peri-COVID-19	Free Text – multiple line
Orthodontic Examinations	Orthodontic assessments pre-COVID-19 (formative and summative)	Free Text- multiple line
	Changes to orthodontic assessments peri-COVID-19	Free Text- multiple line
	The changes to be retained	Free Text- multiple line
Impact of COVID-19	Impact of COVID-19 – Respondent evaluation	Free Text- multiple line
	University evaluated changes with feedback	Tick box and if ticked yes, Free Text- multiple line
	Undergraduate student feedback	Tick box and if ticked yes, Free Text- multiple line
Additional Information	Any additional information from respondents	Free Text- multiple line
	Feedback of the questionnaire	Free Text- multiple line
	Permission to allow discussion between other colleagues	Tick box
Permission for further contact	Statement for permission	Tick box
Closing statement	Thank you statement	Text

	Explanation of anonymous summary data to be sent to each participant.	
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4.3.5 Pre-testing of the preliminary questionnaire

In the current study pre-testing was completed to ensure content validity which aimed to improve question wording, clarity, ensure interpretation of questions was as intended, relevance of the questionnaire and questionnaire length to measure duration. Piloting was not completed for the current study due to the small pool of target participants and as the pilot sample would usually be separate from the main study (see section 2.4.5).

Pre-testing for the preliminary questionnaire involved four staff members from The University of Leeds (Table 5). All participants had extensive experience in the organisation and delivery of undergraduate dental teaching (three had experience in undergraduate orthodontic teaching) to represent the target population.

Table 5: Credentials of the participants involved in pre-testing the questionnaire

Participant 1	Associate Professor in Paediatric Dentistry Associate Postgraduate Dental Dean for Yorkshire and the Humber Lead for Postgraduate Paediatric Dentistry programme at University of Leeds
Participant 2	Honorary Clinical Associate Professor in Orthodontics Involved in teaching postgraduate orthodontic students and supervising undergraduate and postgraduate research. Research interests include dental education.
Participant 3	Honorary Senior Clinical Lecturer at University of Leeds
Participant 4	Honorary Senior Clinical Lecturer Undergraduate Orthodontic Lead at University of Leeds

Testing involved virtual or face-to-face interviews where each participant accessed the questionnaire through OnlineSurveys with the lead researcher observing. Questions were completed in real-time and the lead researcher took notes using a pre-designed, data collection template. Feedback was gained from a mixture of behaviour coding, think-aloud method, verbal probing and individual debriefing (see section 2.4.5 for further explanation on these).

Feedback was requested about question wording, response options, design and layout, usability and content of the questionnaire. Three of the pre-testing sessions were recorded on Microsoft Teams to ensure all details were accurately recorded including the duration of questionnaire completion. The final pre-testing session was not recorded as the participant for this was also a research supervisor for the current study and involved with questionnaire development. As there was familiarity with the majority of the questionnaire content, it was not deemed necessary to record this final pre-testing. It was however considered useful to pre-test the questionnaire with this supervisor and for one final time as previous pre-testing modifications were assessed and feedback given from someone who represented the target population. It also provided good indication of questionnaire completion duration. Recordings were kept securely until the research project was completed. Approximately 25 minutes was taken to complete the questionnaire by all four participants.

4.3.6 Finalisation of questionnaire

Modifications were made to the final questionnaire using feedback from all four participants to finalise the questionnaire. Only minor modifications were made relating to question wording and response options. However, significant formatting changes were made to Question 6 (Table 6). The final full questionnaire is included in the appendix (*See Appendix 1 Final Questionnaire PDF V3 150123*).

Table 6: Recommendations from pre-testing and the subsequent modifications that were made

Participant	Section	Item	Change recommended	Change made	Reason provided
1	Structure and Delivery of teaching	Undergraduate orthodontic teaching structure pre-COVID-19	Adapt more closed-ended question format.	Yes. Open-ended questions adapted to grid display, split into two columns: Activity per year and Hours per activity.	Question too subjective and as open-ended, hours can be missed per activity. More focussed responses required for easier analysis.
	Staffing	Number of staff members pre-COVID-19	1. Add date 2. Add part-time (PT) or full-time (FT) staff 3. Add clearer staff titles as overlap between some.	1.Yes. Added pre-pandemic and date. 2. Made inclusive of PT & FT. 3. Added/ Changed titles.	Enabled clarity in areas.
	Orthodontic Examinations	Orthodontic assessments pre-COVID-19	Add VIVA to options.	Yes. Added VIVA to options	Be more inclusive of all options.
2	Structure and Delivery of teaching	Definitions of methods of teaching	Better access to definitions.	Yes. Added a link to open in new window.	Respondents may not recall definitions later in questionnaire.
		Undergraduate orthodontic teaching	1. Remove pre-dental row in grid. 2. Consider further closed questions and add clinical teaching.	1.Yes. Removal of pre-dental. 2.Yes. Categorized teaching activities more with larger grid	1. Pre-dental not a clinical year.

		structure pre-COVID-19	3. Consider teaching per year rather than per activity. 4. Request any university documents to aid understanding of their teaching.	with multiple boxes & included clinical section. 3.Yes. Changed to teaching hours per year. 4. Not requested more documents.	2. Difficult analysis if not more defined. Clinical added to specify hours. 3. Understanding overall teaching practices more important than specifics. 4. Respondents unlikely to provide confidential university audit trails and handbooks.
	Staffing	Number of staff members pre-COVID-19	1.Further define options of staff roles.	Yes. Adapted to define further. Change University employed staff to University professor/Senior Lecturer.	Some categories still overlapping. Added further roles to ensure clarity.
	Impact of COVID-19	Undergraduate student feedback	Consider removal of question as may induce ethical issue.	No	Feedback on changes specific to COVID-19 teaching practices only, not on overall preparedness.
3	Participant details	Role in undergraduate orthodontic teaching	Consider Tick box for less typing.	No	Too many possible options.
	Structure and delivery of teaching	Changes to be retained	Add 'please describe the changes made'.	Yes	Question initially only requested for Yes or No response. Allows more explanation of changes.

	Staffing	Changes to staff members peri-COVID-19	Add examples	Yes. Provided examples.	Prompts provided for question responses.
	Orthodontic Examinations	Changes to orthodontic assessments peri-COVID-19	Add examples	Yes. Provided examples.	Prompts provided for question responses.
4	Structure and delivery of teaching	Undergraduate orthodontic teaching structure pre-COVID-19	Remove mandating sections for completion	Yes. Removed mandating sections.	Will allow respondents to complete sections relevant to them and reduce duration of completion.
	Impact of COVID-19	University evaluated changes with feedback and Undergraduate student feedback	Questions too similar and consider removal of one.	No.	Question querying different types of feedback i.e. student feedback and university metrics.

Chapter 5: Results

Overall, 11 out of 16 dental schools responded (69%) including nine from England and two from Scotland. No dental schools responded from Wales or Northern Ireland.

5.1 Undergraduate orthodontic teaching prior to the COVID-19 pandemic

5.1.1 Timing of teaching

Figure 4 summarises the timing of undergraduate orthodontic teaching at the eleven dental schools. The majority of dental schools (≥ 7 universities) taught undergraduate orthodontics in the later years (between years 3-5) with eight schools teaching over a minimum of three years. Only two universities taught orthodontics across all five years, while one university taught orthodontics in one year only i.e. in Year 4.

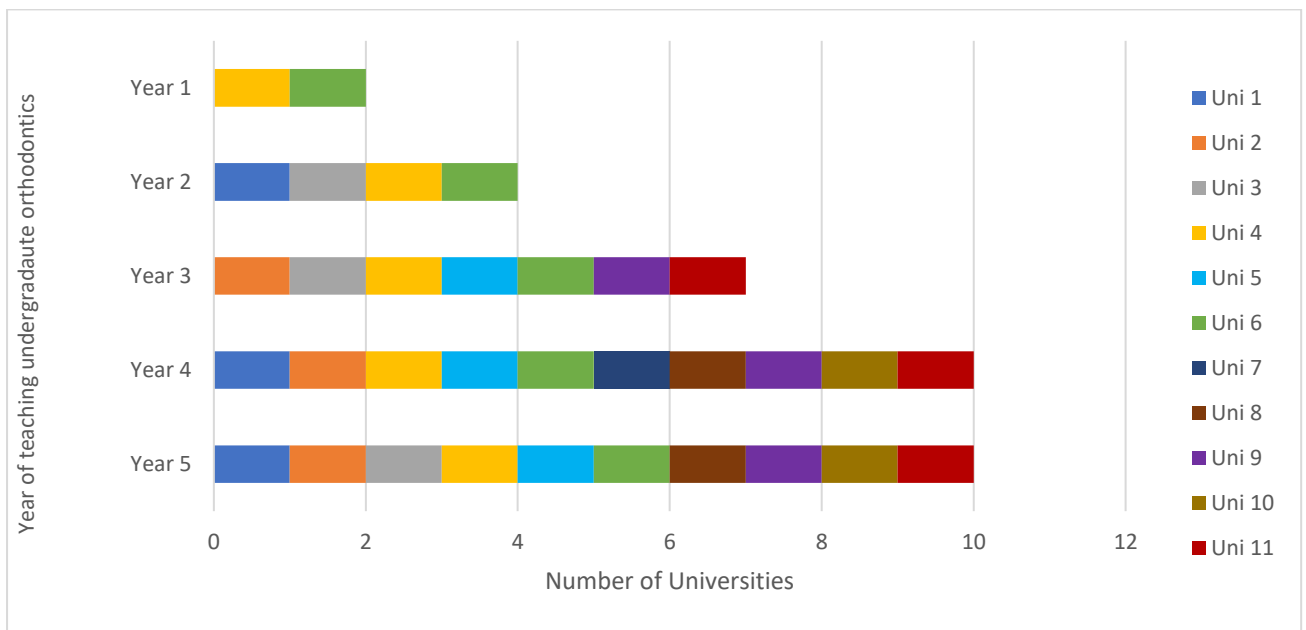


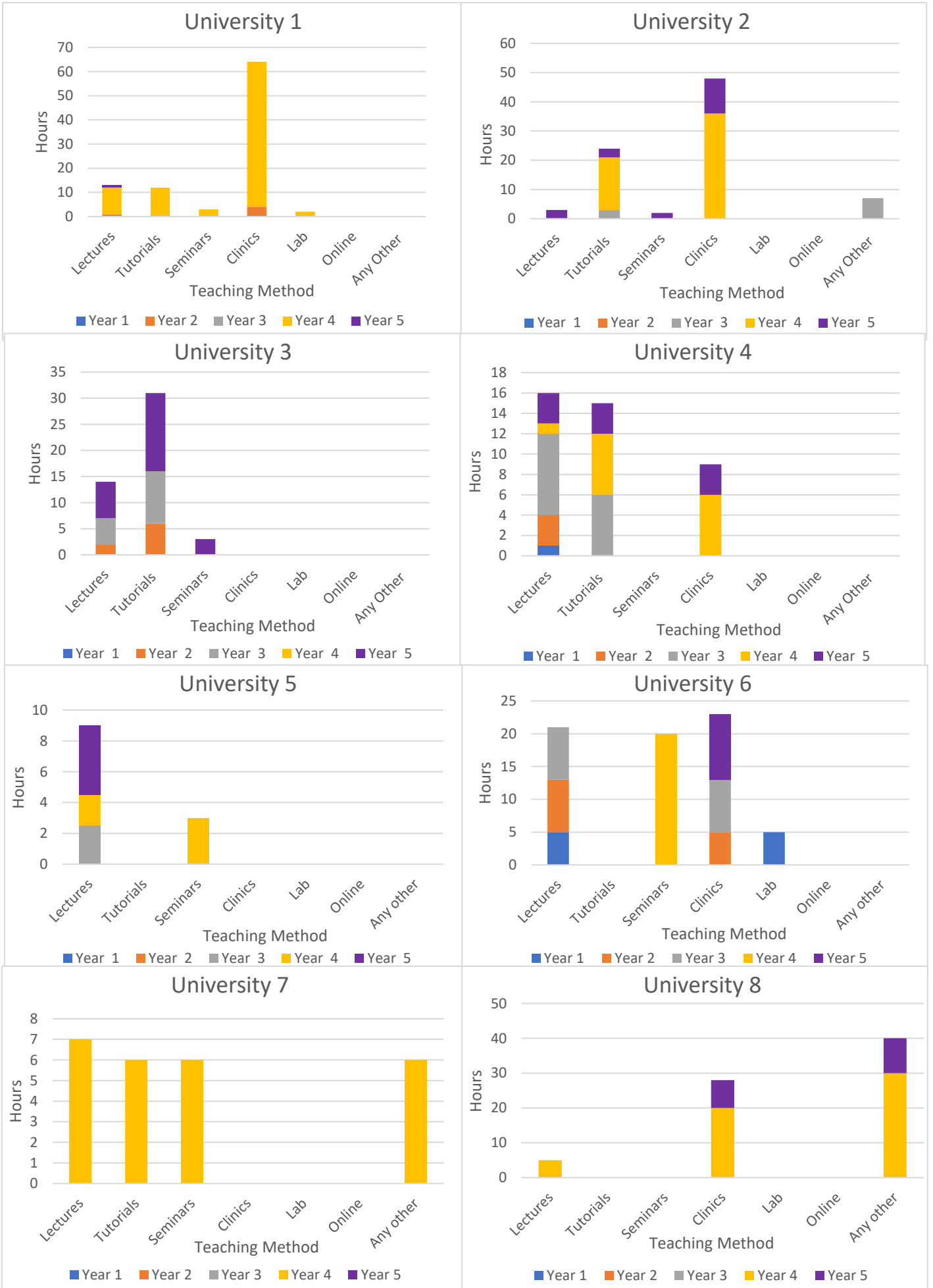
Figure 4: Timing of undergraduate orthodontic teaching at each of the participating dental schools

5.1.2 Delivery method

Three universities did not complete the question eliciting information about pre-COVID-19 teaching methods and hours and there was no response to follow up emails requesting this information. The results therefore relate to only eight universities.

A variety of delivery methods were reportedly used at different times in the eight universities including lectures, tutorials, seminars, clinical teaching, laboratory teaching (Figure 5), with lectures being the most common delivery method. Eight universities provided clinical orthodontic teaching. The 'Other' category included practical teaching on impression taking, IOTN and orthodontic emergencies and use of the flipped classroom approach. None of the universities reported using online teaching prior to the COVID-19 pandemic.

Figure 5: The total hours of undergraduate orthodontic teaching provided by eight universities, reported by delivery method and year of delivery



5.1.3 Hours of teaching

The total hours of teaching at each of the different universities ranged from 12 to 94 hours (Figure 6). The median number of hours of teaching per student was 58.5 hours (IQR 39.5).

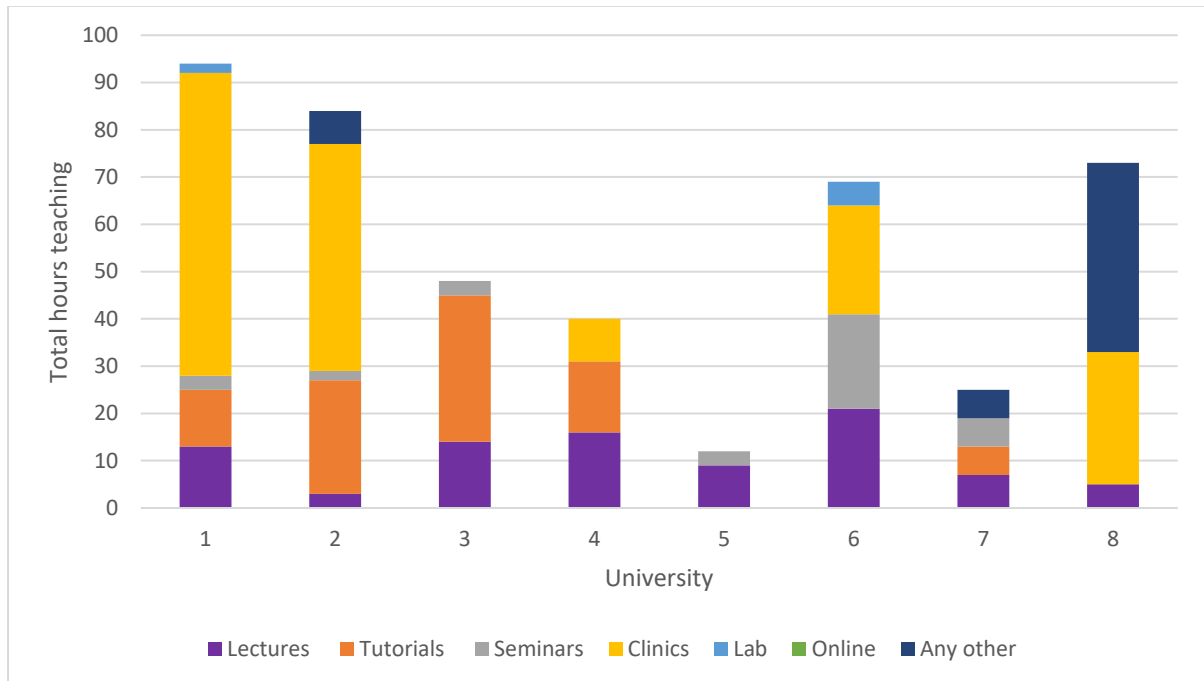


Figure 6: Summary of total hours of undergraduate orthodontic teaching provided per university pre-COVID-19

5.1.4 Undergraduate orthodontic assessments

Table 7 summarises the number and type of assessments at each university in the pre-COVID-19 period. The number of assessments ranged from two to ten with a median of five (IQR 1.5). The majority of dental schools (n=9) used summative assessments, with two dental schools using a combination of both formative and summative. There was variation in the types of assessments between different dental schools. All but one university used at least two types of assessment.

University	Pre-COVID number of assessments	Examples of all assessment types (pre-COVID-19)
1	3 (summative only)	<ul style="list-style-type: none"> • Objective Clinical Structured Exam (OSCE) • Written • Structured Clinical Reasoning (SCR) • Single Best Answer (SBA) • VIVA • Multiple Short Answers (MSA) • Work Based Assessment (WBA) • Modified objective structured long examination review (MOSLER) • Short Answer Questions (SAQs) • Multiple Choice Questions (MCQs) • Student participation
2	5 (summative only)	
3	5 (summative only)	
4	8 (formative and summative)	
5	6 (summative only)	
6	5 (summative only)	
7	2 (summative only)	
8	2 (summative only)	
9	10 (summative only)	
10	5 (formative and summative)	
11	5 (summative only)	

Table 7: Type and number of assessments used pre-COVID-19

5.1.5 Teaching staff

The number of staff involved with orthodontic teaching prior to the pandemic ranged from one to seventeen staff members, with a median of six staff members (IQR 7) (Table 8). These involved personnel from a range of dental education backgrounds including different orthodontic education and experiences.

University	1	2	3	4	5	6	7	8	9	10	11
Staff No	4	13	17	3	3	6	1	5	9*	7	12

Table 8: Number of total staff per dental school pre-COVID-19

(*best estimated guess based on information given in the rest of the questionnaire)

5.2 Undergraduate orthodontic teaching in the peri-COVID-19 period

5.2.1 Timing of teaching

Two universities made changes to when orthodontic teaching was delivered, with one reducing from teaching in three years to two, while another increased teaching from three years to four. The

respondents clarified that structural changes relating to timing, hours taught and teaching type were planned prior to the pandemic but the pandemic allowed them to be expedited and the changes were beneficial and maintained post-COVID-19.

“The school moved to a new curriculum in 2018. Changes to structure and delivery towards this new curriculum was planned pre-covid.”

“Covid came as we were evaluating the Undergraduate Orthodontic programme, it brought forward the changes we were proposing and integrated the programme into the wider undergraduate course... so it acted a catalyst...”

5.2.2 Delivery method

During the peak of the pandemic, all eleven dental schools changed their teaching (Table 9). Eight dental schools reduced face-to-face teaching, six reduced clinical teaching, three reduced tutorials and one reduced their seminars. Many of the responding participants expressed concerns that reduced face-to-face and clinical teaching may have negatively impacted on the undergraduate orthodontic teaching.

“COVID-19 limited the interaction with staff which will have inevitably reduced some learning opportunities”

For all the dental schools, peri-COVID-19 alternative teaching methods involved some form of online teaching, either as partial or complete replacement of face-to-face methods. One university increased their laboratory teaching to replace clinical teaching. There was variation in the online teaching methods used including both synchronous and asynchronous teaching and different platforms. All universities managed to continue orthodontic teaching despite certain methods, such as face-to-face and clinical teaching, being completely suspended in certain universities due to restrictions. Three respondents reported reintroducing face-to-face methods in a staged process due to the social distancing rules and staff shortages. There was no data from the other eight undergraduate orthodontic leads on if they reintroduced their face-to-face teaching in this staged method.

University	Reduction in teaching method	Alternative teaching method	Examples of online methods used
1	Clinical Tutorials Face-to-face	Online	1. Asynchronous <ul style="list-style-type: none"> • Pre-recorded lectures • Pre-recorded tutorials 2. Synchronous Online <ul style="list-style-type: none"> • Live lectures • Live seminars • Via Teams • Via Collaborate 3. Case-based discussions 4. Orthodontic emergencies YouTube videos 5. New patient virtual clinics 6. Online interactive teaching modules 7. Flipped Classroom
2	Clinical Tutorials Face-to-face	Online	
3	Seminars	Online	
4	Clinical~ Lectures~ Tutorials~	Online	
5	Face-to-face	Online	
6	Face-to-face	Online	
7	Face-to-face	Online	
8	Face-to-face	Online	
9	Clinical Face-to-Face	Online	
10	Clinical Face-to-face	Online	
11	Clinical	Online and laboratory teaching	

Table 9: Changes to teaching method during the peri-COVID-19 period)

(~best estimated guess based on information given in the questionnaire).

5.2.2.1 Experience of online teaching

Respondents perceived that students indicated a preference for face-to-face teaching rather than online teaching due to the interactive nature of this.

“...students prefer face to face as opposed to online as more interactive”

Respondents reported some difficulties engaging students on an online platform and reported challenges from poor internet connection causing disruptions in teaching.

“Less student engagement with online teaching”

“Without face-to-face teaching, I have found it difficult to engage with individual students. Often cameras are turned off and it is difficult to communicate and therefore be inclusive if the internet connection is disrupted/ suboptimal.”

On the contrary, others found online teaching to be beneficial to teaching undergraduate orthodontics, particularly in relation to developing better online resources and effective delivery of teaching. Some participants indicated that the reduction of clinical teaching was potentially disadvantageous to dental students; however, there were gains from the alternative teaching provided.

“more focused, better online prep material, more efficient delivery in final year”

“In orthodontics - reduced access to live patients but records was a good substitute”

“There were challenges regarding the amount of clinical experience gained by the undergraduates. There were also opportunities in terms of the development of pre-recorded lectures and synchronous online teaching.”

5.2.3 Hours of teaching

The hours of delivery reduced in six universities during the peri-COVID-19 period (Figure 7). However, it was difficult to quantify the change from the information provided. The undergraduate orthodontic leads from three universities were unaware of any changes to pre-COVID-19 teaching hours and two universities reported the hours were not affected. It was recognised that some universities may have delivered the majority of their teaching in the first two terms so restrictions between March-September 2020 may not have impacted on their teaching hours.

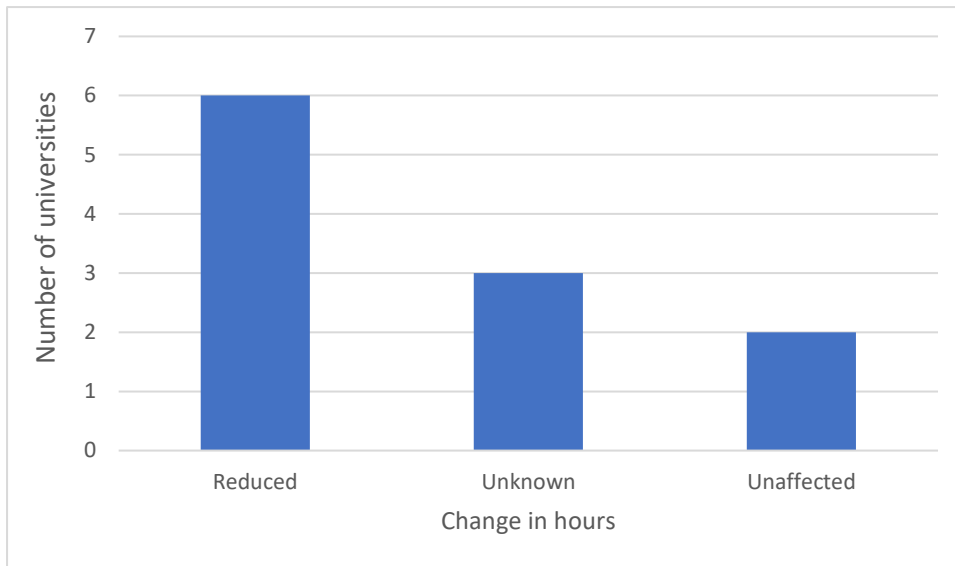


Figure 7: Changes to hours of undergraduate orthodontic teaching peri-COVID-19 compared to pre-COVID-19.

5.2.4 Undergraduate orthodontic assessments

During the COVID-19 pandemic four universities reduced the number of assessments while three universities maintained the same number of assessments but converted these into an online format (Figure 8). Three universities did not change the number or structure of assessments and the undergraduate orthodontic lead for one university (University 9) was unsure whether there were changes. The number of total assessments ranged from zero to eight with a median of 3.5 (IQR 3). The respondent which reported no assessments took place at their university (University 5) clarified that assessments were suspended for the May period and the year was to be repeated by the dental students.

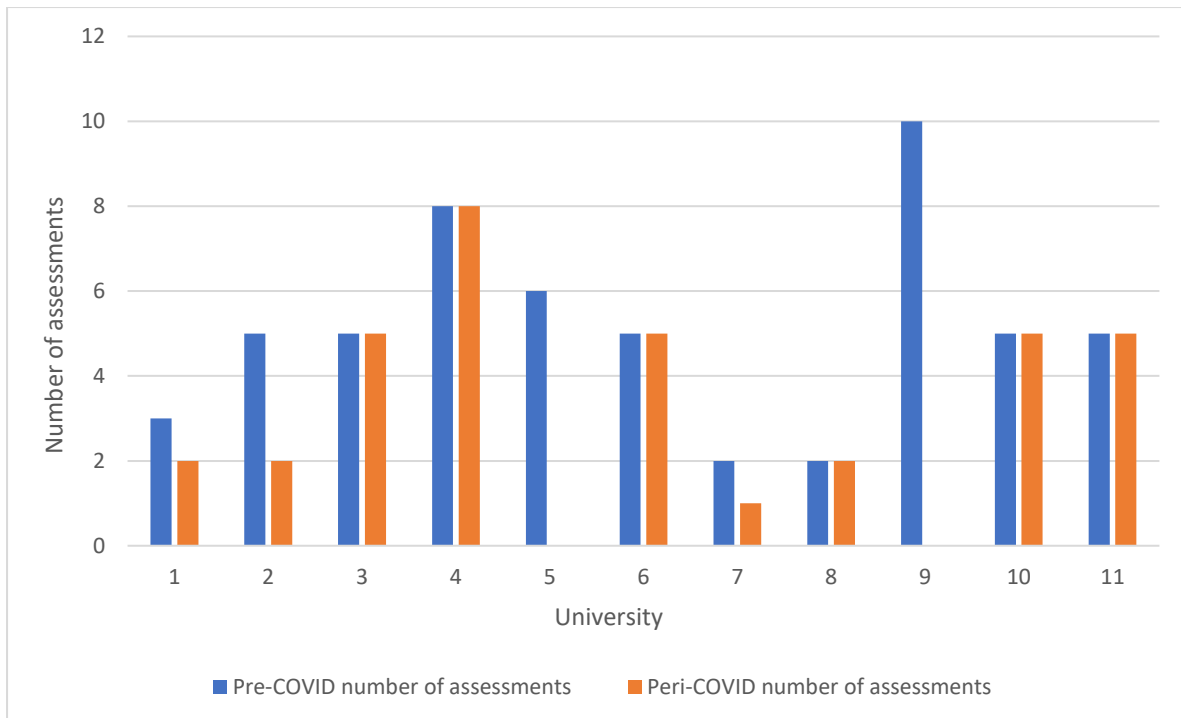


Figure 8: Comparison of assessments during the peri-COVID-19 period and pre-COVID-19 period

Changes to the number, structure or method of assessments was reported by seven respondents due to either a reduction in number of assessments, change to online form or temporary suspension of assessments. Largely changes were based upon the original assessment format and adapting these rather than introducing a new type. However, one university converted their practical OSCE to an ISCE but this was due to curriculum changes rather than the pandemic.

5.2.5 Teaching staff

Only three universities reported a change in their overall staff number (Figure 9). However, changes to staff roles took place in eight universities during the pandemic. Some of these staff role changes involved senior orthodontic registrars being more involved in undergraduate orthodontic clinic teaching, specialty training completion for registrars and new staff employment. Only one respondent stated explicitly that the changes in staff roles was a direct result of the increased pressures during the COVID-19 pandemic. They reported NHS consultants were unable to supervise undergraduate dental students on new patient clinics due to reduced clinic capacity, so attendance of the dental students on these clinics was suspended.

“The increased pressure on the NHS consultants reduced the capacity on the clinics for undergraduates to attend... NHS consultants requested post-CCSTs* to supervise on

treatment clinics and then declined to have undergraduates on their new patient clinics.

Only 2 consultants now covering the new patient clinics”

* post-CCSTs: Senior registrars completing their consultancy training.

Though changes to staff roles took place in many universities, it was not clear from the data provided if these changes were a direct consequence of the pandemic or due to other university-related or personal changes.

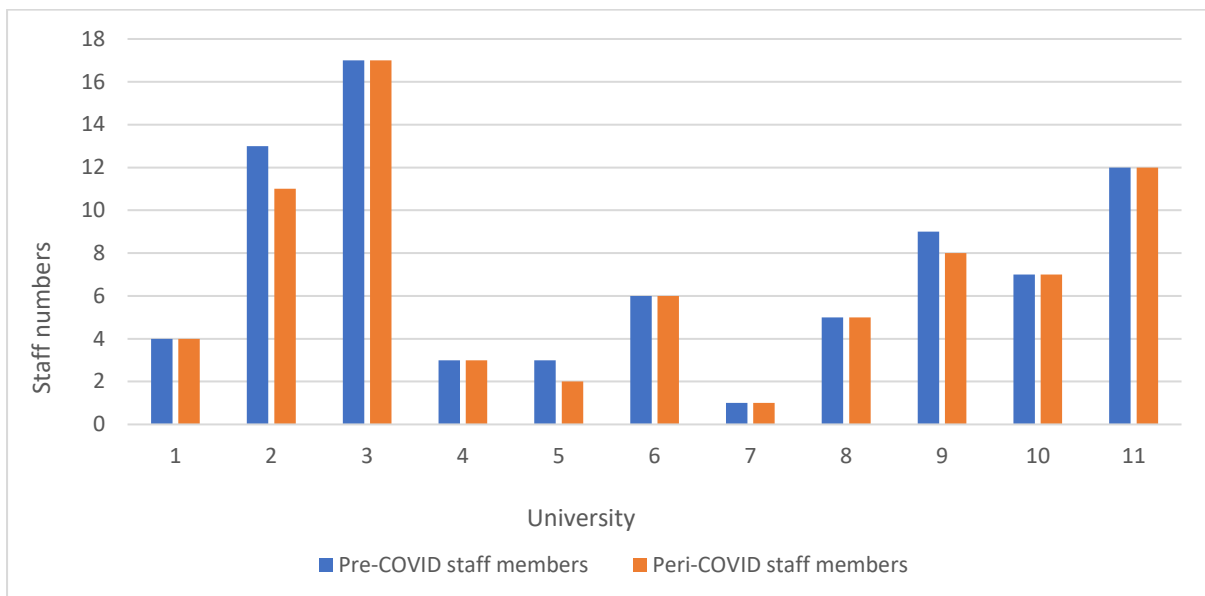


Figure 9: Comparison of number of staff members during the pre and peri-COVID-19 periods

5.3 Undergraduate orthodontic teaching in the post-COVID-19 period

5.3.1 Timing of teaching

The timing of teaching remained the same as peri-COVID-19 for all the participating dental schools. Any changes to which years the undergraduate orthodontic teaching was taught had already been planned prior to the pandemic and these therefore continued in the post-COVID-19 period.

5.3.2 Delivery method

Post-pandemic teaching methods were significantly influenced by the peri-COVID-19 changes in the majority of dental schools (8/11, 73%) with teaching consisting of a mixture of pre-pandemic face-to-face teaching methods, the use of new online resources and live online teaching (Table 10). Some of

the alterations to teaching methods, such as the use of flipped classroom, asynchronous and synchronous lectures, seminars and tutorials, case-based discussions, phantom head teaching and other online resources were fully or partially retained in the post-COVID-19 era.

University	Methods of teaching delivery	Reason for structure change from pre-COVID-19 to post-COVID-19
1	Face-to-face and online	<ul style="list-style-type: none"> • New curriculum design • COVID-19 caused reduced group sizes
2	Face-to-face and online	<ul style="list-style-type: none"> • New curriculum design. • Online methods caused by COVID-19.
3	Face-to-face and online	<ul style="list-style-type: none"> • Caused by COVID-19
4	Face-to-face (including new resource)	<ul style="list-style-type: none"> • Caused by COVID-19
5	Face-to-face and online	<ul style="list-style-type: none"> • Caused by COVID-19. • Online resources available still due to staff shortages and lack of time.
6	Face-to-face	<ul style="list-style-type: none"> • Back to Pre-COVID-19 teaching
7	Face-to-face and online	<ul style="list-style-type: none"> • Caused by COVID-19
8	Face-to-face	<ul style="list-style-type: none"> • Back to Pre-COVID-19 teaching
9	Face-to-face	<ul style="list-style-type: none"> • Back to Pre-COVID-19 teaching
10	Face-to-face and online	<ul style="list-style-type: none"> • Caused by COVID-19
11	Face-to-face and online	<ul style="list-style-type: none"> • Caused by COVID-19 • Retained due to staff shortages and chairs

Table 10 Methods of teaching delivery in the post-COVID-19 period and reasons for changes pre-COVID-19 to post-COVID-19

The COVID-19 pandemic had an indirect effect through the impact on staff and clinical capacity. In contrast, another respondent commented on the ease of returning to routine clinical orthodontics due to the non-aerosol generating procedure (non-AGP) nature of many orthodontic procedures.

“The undergraduate orthodontic programme has been affected not only due to covid but due to lack of staff and time available for NHS Consultants making timetabling teaching activities challenging.”

“keep [changes] due to a shortage of staff and chairs”

“When clinics resumed in March 2021, students were able to get back to routine work in Orthodontics (albeit smaller group size of students) due to the non AGP nature of the work.”

Student feedback was successfully obtained by six universities who all shared the feedback relating to the peri- and post-pandemic changes to the undergraduate orthodontic teaching. The majority of these comments were positive and many related to inclusion of the live online teaching, new online resources and practical laboratory teaching. However, there was recognition that some students missed the face-to-face teaching.

“+ve feedback. Enjoyed the course. Rated best module in BDS.”

“They give very positive feedback on the course.”

“Positive feedback regarding the use of pre-recorded lectures and online tutorials.”

“Students have loved their new phantom head sessions and the new CBDs on a weekly basis have really benefited their knowledge of treatment”

“Really liked the final year seminar structure” (this related to a change providing more online delivery in larger groups to final year students)

“Liked the orthodontic case based discussions but prefer face to face”

However, one respondent explained that attempts were made to gain student feedback but they were unable to retrieve this data.

“I have been unable to obtain the data from the questionnaire that I devised and disseminated.”

5.3.3 Hours of teaching

Six universities returned to pre-COVID-19 hours in the post-pandemic period, while five universities retained their new hours of undergraduate orthodontic teaching. The main reasons given for not returning to pre-COVID-19 hours were due to shortage of staff (one university), clinical capacity related to COVID-19 (two universities) and curricula changes (two universities).

It was unclear how many hours were currently being provided for the majority of the dental schools because insufficient data was provided to quantify this. This may be because some of the participants were not aware of the extent of the changes made during the pandemic.

“It is difficult to fully evaluate the true extent of the changes made during and as a result of the pandemic.”

“The staff delivering undergraduate orthodontic teaching changed significantly from Oct 2021, so it is difficult to comment with specific details on the quality/methods of teaching utilized prior to this date.”

5.3.4 Undergraduate orthodontic assessments

The majority of universities did not keep the changes to assessments (Figure 10). Two universities kept their changes due to a preference for non-face-to-face assessments.

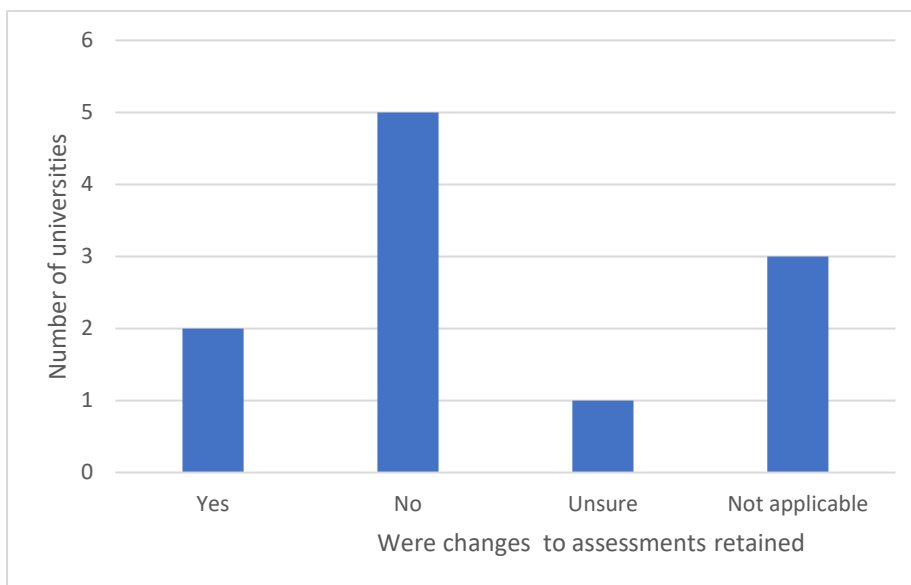


Figure 10: Number of universities who retained their changes to assessments in the post-COVID-19 period

NB: ‘Not applicable’ in the above graph, related to three universities who did not change the number or structure of assessments during the lockdown period.

Chapter 6: Discussion

6.1 Key findings

The important findings from this study were:

- There was considerable variation in the undergraduate orthodontic teaching prior to the COVID-19 pandemic.
- During the peak of the pandemic there was a reduction in face-to-face and clinical teaching and the partial or full replacement with online methods.
- Since the peak of the pandemic, a blended approach to learning has been maintained with greater use of online resources. This is in part due to continued impact on clinical teaching capacity.

6.1.1 Variation in undergraduate orthodontic teaching prior to COVID-19

The first important finding was that there was considerable variation in the undergraduate orthodontic teaching prior to the COVID-19 pandemic amongst the eleven dental schools who responded. Variation was seen in timing, delivery methods, hours allocated, assessment methods and staffing. The timing of undergraduate orthodontic teaching prior to COVID-19 varied across the dental schools with most providing their teaching in later years. These findings are similar to those identified in a previous study of undergraduate orthodontic teaching from 2005 (Derringer, 2005). This study found seven of the twelve participating dental schools taught orthodontics in years 3-5 over a minimum of three years.

Orthodontics may be taught in the later years because dental curricula are now designed to encompass an integrated, spiral curriculum (McHarg and Kay, 2009). McHarg and Kay, (2009) described this spiralling curriculum as delivery of basic dental theory, then revisiting concepts with the aim of building and deepening these foundations by adding complexities year on year. The balance of integrating andragogical theories with this spiral method of learning when developing knowledge, skill and attitudes in a structured manner is also explained by McHarg and Kay, (2009). This relates to the psychomotor, affective and cognitive domains; skills which are best learnt in a gradual and continuous process as the undergraduate dental programme progresses. As undergraduate orthodontics possibly brings in some of the more complex biomechanical concepts in dentistry (Gilmour et al., 2016), these may be most appropriately taught later in the course once basic dental foundations have been acquired and can be built upon.

In contrast, previous literature has suggested that the academic performance of dental students can be affected by numerous factors (Ali et al., 2017; Aleidi et al., 2020; Imediegwu et al., 2023). One of the factors discussed by Ali et al., (2017) was the importance of the accumulative years of dental education and early exposure to concepts i.e. students who completed dental progress tests in the latter years performed better than those who completed these earlier and thus suggesting more knowledge, skill and experience gained throughout their cumulative years of their undergraduate dental teaching had the beneficial effect of better academic performance. Furthermore, in the present study, two universities taught undergraduate orthodontics in every year, employing the concept of longitudinal teaching (Norris et al., 2009); teaching over longer periods, which can encourage progressive learning for students, returning to concepts and deeper understanding. Cumulative years and longitudinal teaching hypothesise that teaching undergraduate orthodontics in more years may benefit the learning process and ultimately enhance the academic performance.

For the current study, only one participating university taught undergraduate orthodontics in one year which is a variation to the findings in the paper by Derringer, (2005) as all their participating universities taught in at least more than one dental year. The findings from Ali et al., (2017) support the idea that teaching in cumulative years could improve academic performance, however the delivery of teaching for this university was through a range of teaching modalities, a factor which previous research has deemed important for improving the student learning experience (Kharb et al., 2013). Undergraduate orthodontics was taught via lectures, seminars, tutorials and practical teaching and therefore it could be argued that the quality of teaching for this university was not compromised.

Different teaching methods were used but lectures were the most common, followed by clinical teaching. This is consistent with previous literature which has also reported similar teaching methods used in orthodontics in the UK (Rock et al., 2002; Hobson et al., 2004; Derringer, 2005). The methods used in dental education can significantly impact the experience and effectiveness of student learning with regards to academic performance (Imediegwu et al., 2023) and preparedness for practice (McGleenon and Morison, 2021). Awareness of different learning theories and preferences for different learning styles (Gatt and Attard, 2023) has led to educational providers incorporating a mixture of teaching methods into their curricula (Kharb et al., 2013; McGleenon and Morison, 2021) as seen from our results.

Literature has reported that lectures delivering dental theory prepare dental students poorly for practice-based dentistry (Khanna and Mehrotra, 2019) but they are still used frequently to provide an

easy, logical and effective way to transmit large amounts of information to bigger groups of students (Nair et al., 2022). Furthermore, the incorporation of different types of lectures, such as interactive lectures, live lectures delivered on an online platform, pre-recorded lectures and lectures delivered via flipped classroom method may increase the engagement of students, as student attention begins to drop at 15-20 minutes (Nair et al., 2022; Gatt and Attard, 2023).

Two dental schools reported flipped classroom was their main format for delivering dental theory prior to the pandemic. Nair et al., (2022) described flipped classroom as provision of homework or tasks prior to the classroom teaching. Once the students have completed the initial tasks, the lecture-based teaching is delivered. The in-person classroom time includes more activities and interaction from students and is thought to encourage critical thinking skills and construction of meaning (Isherwood et al., 2020).

Published research on flipped classroom reported mostly positive responses from students due to: Increased convenience and flexibility, better in-class teaching efficiency (Othman et al., 2022), encouragement of effective learning through improved engagement, being more aware of learning needs, and catering for a combination of learning styles (Isherwood et al., 2020). However, disadvantages included: The need for more practical teaching in the in-person lectures (Othman et al., 2022), students may not always have watched/accessed the videos provided and technical difficulties. Other problems have been discussed: Non-relevance of certain material or needing to supplement the material with other methods, the inability to replace clinical teaching with this method and that conventional lectures could yield similar academic results to flipped classroom (Isherwood et al., 2020; Othman et al., 2022).

Both the papers described above predominantly gained qualitative data from focus groups to explore students' perception on the implementation of flipped classroom and used well-described, full thematic analysis with the interviewers having sufficient training in qualitative research. However both papers also had limitations. Isherwood et al., (2020) completed a randomised controlled trial to complement the qualitative research. Though the results reported improved student satisfaction, the quantitative data revealed a non-statistical difference between academic performance of the conventional lecture group and flipped classroom group. This contradiction in results was recognised by the author by the limitation of the quantitative examination with regards to limited questions and lack of revision to showcase knowledge in students when they may have found flipped classroom superior to conventional lectures. Furthermore, recruitment details of students involved with the

focus groups were not provided which could have induced bias in the feedback given. In Othman et al., (2022) the interviewers for the focus groups were known to the interviewees, which may have induced response bias from students with regards to openness and honesty. Finally, both the studies described were of a single context i.e. conducted on dental students in a single year in one dental school in the UK (Isherwood et al., 2020) and Malaysia (Othman et al., 2022) which meant the data could not be fully generalisable to other contexts.

Clinical teaching was also a common format for teaching undergraduate orthodontics, which reflected the importance of learning through clinical experience due to the practical nature of dentistry (McGleenon and Morison, 2021). Clinical exposure to patients in different environments such as: Outreach clinics, dental hospital diagnostic and treatment clinics, NHS community settings and multi-disciplinary clinics exposed dental students to a diverse range of patients with different malocclusions and dental health needs to gain a 'real-life' and authentic experience as to what they might see and manage in their independent working lives (McGleenon and Morison, 2021). Three of the dental schools did not provide clinical teaching. However, as clinical-based training demands both intellectual and technical skills, being sensitive to patient needs' and considerations of risks and benefits, this could develop dentists who are ultimately disadvantaged in clinical competence and lack confidence, which may lead to poor quality treatment provision and outcomes (Li et al., 2022). It has been suggested that the reformation of dental education could compensate for this clinical teaching through three-dimensional modelling and simulated teaching through virtual reality. However, lack of training in these methods currently exist due to their modern nature, thus in current circumstances, lack of clinical training would remain disadvantageous.

Prior to COVID-19 there was considerable variation in the hours of orthodontic teaching, ranging from 12 hours to 94 hours per student. Previous research has discussed hours of teaching and its relationship with academic achievement (Rivkin and Schiman, 2015). This paper supported the idea that increasing instructional hours could increase the output of academic achievement. It reported adequate hours allocated to teaching was essential to cover subjects in more depth, build-in more group work with project-based tasks, encourage the engagement of practical/hands-on elements and build critical thinking skills. The paper however, supported other literature, by further explaining that increasing the hours of teaching alone did not increase the learning output and that other influencing factors existed such as: The quality of teaching instruction, classroom environment and the rate at which students consolidate this knowledge (Rivkin and Schiman, 2015). These, as well as the independent university dental curriculum, student learning preferences, university resources and

staffing and personal factors relating to students were other potential influencing factors (Rivkin and Schiman, 2015; Aleidi et al., 2020; Gatt and Attard, 2023; Imediogwu et al., 2023). Therefore, although the current study revealed variation in hours amongst dental schools, it was difficult to comment on whether this difference would have had an impact on the learning experiences and preparedness of the dental students.

Many different types of assessment methods were reportedly being used prior to the pandemic, usually incorporating more than one assessment type, with two universities reporting undertaking both summative and formative assessments. These findings were similar to the paper by Derringer, (2006). In the 'Preparing for practice' document, the GDC stated that assessments were essential in the outcomes-based curriculum and completion would be 'a gateway for students to become qualified to practise independently' (General Dental Council, 2015a). However, each education and training provider had the freedom to design their dental curriculum and assessments (General Dental Council, 2015a). If dental schools were covering the required learning outcomes, then variation in assessment types was not a problem. Furthermore, assessments should have been underpinned by theory of education which needed to align with the learning outcomes (Ghaicha, 2016). This process meant that different assessment methods were needed to test competence in different skills: Communication, knowledge, technical skills, clinical reasoning, emotions and values, and reflection (Ghaicha, 2016) which was in line with the findings of the current study.

Assessments from this research were categorised into three main types as reported in medicine: Written, which tested a range of basic factual knowledge to in-depth clinical knowledge and this was provided by all participating dental schools (MCQs, SAQs, SBA, MSA); assessments by supervising clinicians (VIVAs, WBAs, Case Reflections, Student Participation and Structured Clinical Reasoning) provided by six dental schools and; clinical simulation (OSCE, ISCE and MOSLER) (Epstein, 2007) provided by six dental schools. These encompassed performance and practical skills and ensured the testing of deeper understanding of principles (Epstein, 2007). The two universities providing both summative as well as formative assessments highlighted the importance of providing ongoing feedback to ensure students were learning continually throughout the course, as well as ensuring they had gained overall competence at the end of the undergraduate dental programme.

Interestingly, three respondents reported no changes to the structure or number of their assessments during the lockdown period. As it was expected for assessments taking place to have been modified during the peak of the pandemic, these responses would require further verification or clarification.

Pre-pandemic, the number and education backgrounds of staff involved in undergraduate orthodontic teaching at each university varied considerably. Imediogwu et al., (2023) reported that one of the most important factors influencing successful performance in assessments by final year dental students was the impact of certain course lecturers. The authors highlighted that due to the more practical nature of dentistry, motivated and engaging tutors could have a bigger impact, particularly in clinical teaching where attentive teaching from the tutor with a smaller number of students, could have more influence on the learning of particular skills. It should be noted however, that the results described factors which final year dental students perceived to influence their academic performance; this in itself would be susceptible to biases such as response bias and social desirability. Furthermore, the authors used a cross-sectional survey design with the use of an online, semi-structured questionnaire which underwent content and internal validity. The authors reported measures were taken to limit response and non-response bias and systematic errors. However, further clarification was needed on these methods, the questionnaire development stages and limitations of the study.

Supervision for clinical teaching was a key aspect of the learning process and in the training of dental students to enable the psychomotor and cognitive skills to be developed (Torre et al., 2006; Badyal and Singh, 2017). Understanding the different aspects of a good teacher and thus quality of the teaching instruction should be given more importance than numbers of staff. Therefore, in the current study, if the quality of teaching for all the participating universities remained excellent, it could be speculated that numbers of staff would have less influence (whether the teaching involved one staff member or 17), and this would allow the dental students to flourish in their preparedness in becoming skilful, independent practitioners.

6.1.2 Adaptations to teaching during the peak of the pandemic

The second important finding was that during the peak of the pandemic there was a reduction in face-to-face and clinical teaching and the partial or full replacement with online methods. The pandemic was a catalyst for changes planned prior to COVID-19 to dental curricula in two dental schools and therefore COVID-19 was perceived by these respondents as positive for undergraduate orthodontic teaching. These positives were consistent with other literature who reported that the crisis of COVID-19 'may prove a catalyst for overdue modernisation, allowing us to better align clinical education with current practice and prepare students for the new ways of working that have emerged over this period.' (Cairney-Hill et al., 2021).

Online delivery was widely used to continue medical and dental teaching during the lockdown period through many different formats (Kelly et al., 2020; Longhurst et al., 2020; Cairney-Hill et al., 2021). Simulated cases, case-based discussions, access to PDF textbooks, Instagram, Telegram, LinkedIn, Pinterest, Jitsi, Webex were used for teaching theory (Machado et al., 2020; Farrokhi et al., 2021; Trivandrum Anandapadmanabhan et al., 2022). It was recognised that online teaching was not able to transfer practical skills as well as face-to-face teaching (Farrokhi et al., 2021). To aid practical teaching in dentistry, technology such as manikin simulation, haptics, and 3D-virtual reality systems have been used (Deery, 2020); however, these were not currently being used in orthodontic teaching.

Online teaching allowed the continuation of undergraduate orthodontic teaching, other benefits included: Maintaining social distancing, accelerating the use and development of new online learning resources (Cairney-Hill et al., 2021) and increasing flexibility for students to study at their own pace and in their own environments (Kelly et al., 2020). Other advantages included: Providing the opportunity to return to and re-watch videos to consolidate knowledge and understanding, improving student interaction for those who felt more confident on an online platform, potentially improving the work hours of educators and relieving university pressure with regards to capacity and resources (Kelly et al., 2020; Trivandrum Anandapadmanabhan et al., 2022). It was recognised that although hours of working may have improved once online teaching was developed, unprepared university instructors had to make necessary changes and adjustments to teaching during the initial lockdown period very swiftly, which may have initially increased pressure and workload (Iglesias-Pradas et al., 2021). Other potential barriers have also been identified from pandemic-related research (Farrokhi et al., 2021) including: Poor internet connection, issues with device compatibility, student and educator skills for utilising online resources, and students' skills for self-directed learning (Kelly et al., 2020). Lack of socialisation and human interaction in this teaching modality amongst students and teachers may have also affected the mental health of students (Chi et al., 2021). Reduced motivation and engagement of students have also been reported (Farrokhi et al., 2021). Consideration was also needed for the use of online teaching in how equality, diversity and inclusion (EDI) was maintained (General Dental Council, 2023b). Those from low-income households (Gill et al., 2020) and students with neurodiversity or disabilities may have been disproportionately affected and required additional support (He et al., 2022; Le Cunff et al., 2022).

Literature has described that reduction in clinical and face-to-face teaching during the COVID-19 pandemic was detrimental to cohorts of medical and dental students, which resulted in loss of essential training and lack of progression in patient-focused care and practical work (Gill et al., 2020;

Longhurst et al., 2020; Cairney-Hill et al., 2021; Farrokhi et al., 2021; Trivandrum Anandapadmanabhan et al., 2022). It would therefore be expected that the undergraduate orthodontic teaching may also have been negatively affected. However, research comparing academic performance of dental students during the peak of the pandemic and pre-pandemic suggested dental students achieved better or equal academic grades than in the summer of 2019 (Zheng et al., 2021; Binrayes et al., 2022; Gatt and Attard, 2023). On the contrary, research by Arponen et al., (2023) reported that their 'falling grades' percentage was comparable to the 'rising grades' percentage during COVID-19 and the authors concluded that their online teaching did not systematically improve or worsen the examination performance of undergraduate dental students.

The respondents in the current study reported mixed experiences with the changes to teaching delivery during the pandemic. Some felt that online teaching reduced the learning opportunities for students due to the limited interaction with staff while others saw it as an opportunity to develop their dental programme. Generally there was concerns that reduction in clinical teaching would impact negatively on the students but replacement with online methods was a reasonable substitute. These mixed sentiments reflect those reported in the literature (Gill et al., 2020; Kelly et al., 2020; Trivandrum Anandapadmanabhan et al., 2022). The student feedback gained for the current study was reported as mainly positive for the online methods, with some preference for face-to-face teaching due being more interactive. These findings were similar to the systematic review by Patano et al., (2021) which found that e-learning was an effective method of teaching, complementing the traditional teaching methods, and that the dental students had a positive attitude, acceptability and knowledge for these online methods for teaching orthodontics and paediatric dentistry. Though not directly relating to undergraduate orthodontics, other research has reported negative experiences for learning through online methods (Abbasi et al., 2020; Al-Attar et al., 2021) thus again mixed feelings have been reported directly from students.

The pandemic resulted in a reduction in the hours of undergraduate orthodontic teaching in over half the participating dental schools. Scottish dental schools were advised to extend their 2020-2021 by a year (BBC News, 2021) because COVID-19 had impacted significantly on the hours of clinical teaching gained in aerosol generating procedures, leaving students with less experience in a vital part of their training. The Scottish Health Secretary, Jeane Freeman, acknowledged that extending the year for those who were planning to graduate in year 2020-2021 may have been disappointing, however it was deemed as appropriate for the dental students to 'enter the profession as confident, fully-qualified clinicians' (BBC News, 2021). A mixed methods study exploring student perspectives of their training

in oral surgery after this one year was completed, found most students agreed that the additional year of training was beneficial and necessary in providing them with the sufficient experience and confidence in oral surgery to use in the next stage of their career paths (Macluskey et al., 2022). No research existed on the impact on orthodontics for these Scottish dental students compared to those in England who did not extend their training time.

During the pandemic there was a reduction in the number of assessments, changes to online assessment or temporary suspension of assessments. The new online assessments were adapted from the original face-to-face rather than introducing new assessments. Most assessments were reported to be summative so it was unlikely that reduction or suspension would have had significant long-term effect, as these were returned back to the pre-pandemic structure and number in the following year. Moving assessments online may have had an impact on performance during the pandemic, due to unfamiliarity and technical challenges. A previous study evaluating online assessments found it could improve student commitment, allow quicker feedback from assessors, enhance flexibility around place and time of the assessment and reduce the burden on lecturers for marking. The study also stated that technological mishaps, trustworthiness of students during assessment and being more familiar with written assessments could be challenges (Baleni, 2015).

During the pandemic there was a reduction in staff number in three universities only and a change in staff roles in eight universities. Reasons for staff changes included staff resignation, retirement, specialty completion and new staff employment. In some cases orthodontic specialty trainees had to become more involved in the undergraduate teaching because consultants were unable to provide this. As staff changes occur regularly throughout universities, it was difficult to determine whether these changes were a direct influence from the pandemic. The one university that stated staff changes were due to university pressures from the pandemic perceived that students preferred less variation in staff because this 'lead to a clearer message'. This may have related to the suggestion that certain teachers had a positive impact on students (Imediegwu et al. 2023) or it may be easier to build rapport with a smaller number of teachers.

6.1.3 COVID-19 legacy on orthodontic teaching

In the period following the peak of the pandemic (September 2020 onwards), different approaches to teaching were maintained, with the majority of dental schools using blended teaching (Jeganathan and Fleming, 2020). Of the three universities which returned to their pre-pandemic teaching structure, one mainly used the flipped classroom approach for teaching theory. Clinical teaching was resumed

in all the participating dental schools once self-isolation and social distancing restrictions ended (Longhurst et al., 2020). One reason for retaining online methods was continued staff and chair shortages which affected the usual activities so online resources were compensating for this. Another reason for the retention of online methods was the potential benefits to the students' learning experience reported in the positive feedback from both tutors and students. Research suggested students generally preferred a blended teaching approach to solely traditional face-to-face teaching or solely e-learning methods (Bains et al., 2011; Kumar, 2017; Jeganathan and Fleming, 2020). More recent research conducted during the pandemic has revealed that although initiated by pandemic pressure, the incorporation of online teaching methods were favoured by students and the majority would have liked continuation of online teaching (Zheng et al., 2021; Gatt and Attard, 2023). This suggested that although the undergraduate dental teaching practices were initially driven by the pandemic, continuation may have been driven by increased student demand.

Respondents did raise concerns about reduced engagement and interaction from students when using an online platform. This related to the sole use of online teaching during the COVID-19 lockdown period rather than a blended approach post-pandemic, so this feedback may have been influenced by the respondents and students wider experience of the pandemic. However, it was important to consider and evaluate this when incorporating online methods into the future programme. These comments reflected research conducted by Abbasi et al., (2020) who reported that 84% of their medical and dental students experienced reduced interaction amongst the students and teachers during the pandemic. The integration of interaction and engagement of the student and teacher were related to the andragogical learning processes of cognitive and socio-cultural theory, which considered the social element of the learning experience to be as important as learning the theory (Badyal and Singh, 2017; Hodges et al., 2020).

Another factor when considering the development or incorporation of more online teaching methods was the effect this may have on staff. Gill et al., (2020) described that many clinical teachers were required to learn additional skills to support e-learning or to incorporate virtual classrooms into their teaching. This could further burden busy consultants who had other work commitments related to treating patients or other academic staff members who's workload were increased. Furthermore, forming or incorporating new online methods of delivery required educational institutions to commit more time, resources and finances to develop these with the addition of technological assistance (Trivandrum Anandapadmanabhan et al., 2022). Despite this, teachers identified virtual learning as an alternative approach to traditional teaching during the pandemic and this positive view may have

allowed for online teaching to be further developed into something more substantial (Farrokhi et al., 2021).

Five universities retained their reduced peri-pandemic teaching hours due to either existing pre-pandemic plans for curricula changes or due to COVID-19-related reduction in capacity for teaching and due to staff shortages. The majority of dental schools did not quantify the hours of teaching they were providing to their undergraduates for orthodontics in either the peri-pandemic or post-pandemic period. A couple of the undergraduate orthodontic leads commented that it was difficult to fully evaluate the true extent of changes to hours and delivery as a result of the pandemic. This may have been because the UK dental schools had to adopt the emergency remote teaching approach (Hodges et al., 2020). This was where rapid changes were made to teaching in a crisis situation to provide temporary access to instructional delivery. These changes were not usually permanent as they occurred without the usual robust planning.

The majority of dental schools returned to their pre-COVID-19 assessments although two kept non-face-to-face assessments because these were preferred. The general preference for a return to the pre-pandemic assessment format suggested that traditional assessment methods may have been seen as advantageous, possibly as a result of the familiarity (Baleni, 2015).

It is acknowledged that although variation in teaching pre-COVID-19 and further changes to this peri-COVID-19 and post-COVID-19 were identified, the current study did not assess whether this impacted on the preparedness for future practice for dental students, as such inferences could not be made between the two. Variation in teaching practices had both challenges and benefits. Challenges may have arisen in the ability to standardise teaching (Derringer, 2005). Standardisation of higher education in Europe has been carried out for many years (Fejes, 2006) as it has carried many of its own advantages. Some of these have included: Students receiving similar teaching which leads to a more consistent curricula, being a tool for students to gain meaningful outcomes and usually undergoes rigorous evaluation to ensure quality assurance which therefore meets the expectations of educational providers (Bjerede, 2013). Other advantages have also been identified: Any problems associated with delivery of teaching by inexperienced teachers can be eliminated through a scripted curriculum and finally standardisation does not incur risks related to changes of teaching practices (Bjerede, 2013). Opposing arguments however have also been reported for standardisation of the curriculum (Bjerede, 2013). These have included: Reducing flexibility in delivery of teaching and consequently affecting universities which are limited by resources and staffing, a 'one-size-fits-all'

contributes to inefficiencies in suiting different learning needs and could lead to disengagement of students and a scripted curriculum can de-skill teachers who can use their experience in teaching critical thinking. In addition, this standardised curriculum may lead to shifting teaching practices to content-coverage rather than promoting deeper understanding where alternative methods would be more appropriate (Bjerede, 2013). Furthermore, the requirement of rapid adaptation with the use of online teaching during COVID-19 in the current research suggested that curricula could hugely benefit from continuous innovation, which a rigidly standardised curriculum could prevent. Though the GDC have standardised UK undergraduate orthodontic education through learning objectives (General Dental Council, 2015a), educational providers still had the freedom to implement their undergraduate curriculum through different teaching practices as identified in the current study. This raises the argument that more transparency may be needed for the student (the consumer) applying to study dentistry in the UK, who may not have fully understood their journey in achieving these expected outcomes may have been very different to their peers who studied at different universities. It could therefore have benefitted them to undertake a thorough background search into UK dental teaching practices to align and suit their learning preferences more.

6.2 Critique of the research

6.2.1 The questionnaire

A bespoke questionnaire was designed for this study because no suitable tool currently existed for capturing the required data. The questionnaire was designed using best practice guidance (Oppenheim, 1992; McColl et al., 2001; Williams, 2003; General Medical Council, 2011; NHS England, 2018) following the principles of good questionnaire design (Oppenheim, 1992). The current questionnaire was pre-tested with the target respondent group to test content validity, question wording, response options, design and layout and usability, however, no other formal testing was performed.

Despite all the attempts to test the questionnaire, including prompts provided to aid clarity about what information was required, clarification emails were required for seven respondents due to missing data (n=3) and to resolve ambiguity (n=4). Some respondents provided some of the missing or ambiguous data but many did not respond so the data remained missing or a best estimated guess was made from other information provided by the respondent elsewhere in the questionnaire. Open-ended questions were used to give participants more freedom when providing information but this

resulted in some questions being left incomplete. Free text questions about the perceived impact of the pandemic on undergraduate teaching and student feedback provided additional and useful data that gave context and greater depth to the quantitative questions. Recall bias of the questionnaire was reduced by undertaking this research close to the pandemic.

Overall, the online questionnaire was judged to capture acceptable quality data. However, in hindsight a qualitative approach using a structured interview may have allowed greater clarification of complex information in real-time to reduce missing data and provide more detailed and accurate data. Interviews require more input from both the researcher and respondents in relation to time and training and this was not feasible within the constraints of a Masters by Research.

Although the questionnaire was developed rigorously with pre-testing and iterative revisions during the development stage, the length of the questionnaire was possibly too long at 25 minutes. This was necessary to ensure the questionnaire provided sufficient relevant data to answer the research objectives but may have deterred the completion of the questionnaire by some respondents.

Another potential risk of bias in the questionnaire was that perceived student feedback for the changes in teaching during the pandemic, was provided by respondents. This may not have been accurate or fully represented all of the student opinions. It would improve the current study to run a parallel study directly with previous students who experienced these changes personally. This data could then be compared to information provided by the undergraduate orthodontic leads to assess if their perception matched direct student feedback.

6.2.2 Response rate

Attempts were made to increase the number of responses including: Explaining the saliency of the project to participants, sending personalised emails to respondents, sending pre-notification and formalising the project (McColl et al., 2001) by making initial enquiries about participation through the University Teachers Group of the British Orthodontic Society and also by contacting all Heads of Schools for permission. Other attempts to increase responses included: Up to three reminders being sent, ensuring easy access to the survey link and questionnaire, assuring anonymity in reporting, offering an anonymous, collated summary of the results to participants, attempting to minimise burden by keeping the questionnaire as concise as possible, increasing the data collection duration by two weeks, and finally, offering solutions where any barriers were experienced in completing the questionnaire. Only one university reported a barrier relating to saving their survey responses to allow

them to complete the survey at a later date, the solution provided was to click 'Finish later' at the end of the page which gave the option of sending another link to the respondent's email to click and continue where they left the questionnaire.

The response rate for the current study was overall lower than reported in similar studies (Lynch et al., 2010; Al Raisi et al., 2019; Grindrod et al., 2020). These studies also assessed undergraduate teaching practices in dentistry and also used online questionnaires. Grindrod et al., (2020) gave 12 weeks for the survey to be completed, with one reminder email at 6 weeks but it is not clear whether a longer response period would have been beneficial in the current study. Al Raisi et al., (2019) sent a reminder email at two weeks and if there was still no response, an email was sent to the Head of Dental School to request it was forwarded on to the target respondent. In the current study, permission was gained from all Heads of Schools to collect data from their institute, however, they were not asked to assist with recruitment. Lynch et al., (2010) did not provide any information to explain how they encouraged greater response to their questionnaire.

Previously identified reasons for non-response from participants were disinterest in the research, participants were too busy or the questionnaire took too much time to complete (Massey and Tourangeau, 2013). The undergraduate academic leads are very busy, especially in the COVID-19 recovery period, so one or all of these factors may have affected their willingness to take part.

6.2.3 Generalisability of the findings

Responses were obtained from eleven out of sixteen dental schools, all of which were in England or Scotland. Therefore data was only provided by these participating universities. While it is likely other universities underwent similar changes during the pandemic, it would be unwise to generalise the results to other universities, especially in the devolved nations which were not represented and where regulations may have differed.

UK undergraduate dental education is regulated by the GDC who have produced a guidance on the required learning objectives and what is expected from training (General Dental Council, 2015a). This guidance should have theoretically resulted in few differences in the teaching provided by the different nations in the UK; however this may not have been the case. The GDC guidance does not specify the timing, structure, number of hours, content, and assessments being assigned to undergraduate orthodontic teaching (General Dental Council, 2015a). Furthermore, the GDC work in collaboration with the sixteen UK dental schools, their associated dental hospitals in the UK and

Ireland, as well as the statutory education bodies for the four devolved nations; Health Education England (HEE) (NHS Health Education England, 2012), NHS Education for Scotland (NES) (NHS Education for Scotland, 2023), Northern Ireland Medical and Dental Training Agency (NIMDTA) (Northern Ireland Medical and Dental Training Agency, 2023) and Health Education and Improvement Wales (HEIW) (Health Education and Improvement Wales, 2023), a group known as the Dental Schools' Council (Dental Schools Council, 2023a; Dental Schools Council, 2023b). Although these groups work on undergraduate dental education and discuss policy matters to ensure all the regulatory, organisational and financial aspects of dental education all work in harmony (Dental Schools Council, 2023b), there may have been differences amongst the policy providers which may ultimately have resulted in variation in the delivery of dental education in the devolved countries.

6.3 Implications for teaching

The majority of universities returned to pre-pandemic clinical teaching, however, two continued at a reduced capacity due to COVID-19 and university pressures (reduced chair capacity and staffing). These students could experience further reduced clinical teaching as the provision of teaching occurs from the consideration of NHS resources, staff capacity and the university course structure and delivery which all work in harmony to timetable students onto clinics. In addition, when students attend undergraduate new patient or treatment clinics, clinical staff are also expected to provide teaching which may reduce patient capacity for these clinics. If patient capacity has increased as an attempt to reduce hospital waiting lists from the COVID-19 backlog (General Dental Council, 2023c), it could possibly be at the expense of student teaching time.

All respondents were interested to discuss the undergraduate teaching with colleagues from other universities. By setting up undergraduate teacher peer groups, results of the current study may be discussed as well as the sharing of ideas on how teaching may be practiced going forwards. In particular, if new learning resources have been developed, these could be shared amongst colleagues to provide mutual benefit to undergraduate dental schools (General Medical Council, 2023d). This could be a short-term solution to forming teaching resources which usually undergo rigorous evaluation and are time-consuming to develop (Trivandrum Anandapadmanabhan et al., 2022).

Though variation in teaching and the adoption of more online teaching can impact students positively or negatively, imminent evaluation of these teaching practices and delivery methods using student surveys for feedback can enlighten clinical educators in understanding if these are beneficial to

student learning (Hajhamid and Somogyi-Ganss, 2021). Previously, these evaluation processes may have been overlooked or would have taken longer to carry out, with the need of additional time and resources but rapid changes adopted during the pandemic require continuous evaluation and ultimately this will aid the shaping of clinical teaching going forwards (Hajhamid and Somogyi-Ganss, 2021).

With the advancement of technology over the past decade, the imminent future of dentistry may also involve the increased use of online methods which may be further enhanced with the use of virtual reality and artificial intelligence (Tandon and Rajawat, 2020). Artificial intelligence (AI) refers to the idea of creating machines to perform tasks normally completed by humans and virtual reality refers to the use of a three-dimensional (3D) platform to gain an interactive experience. These are currently being used in dentistry in the field of oral and maxillofacial surgery, orthognathic surgery in 3D planning, implant surgery and anatomy education. Incorporating these into undergraduate orthodontics may aid with assessment, diagnosis and treatment planning.

6.4 Future research

Future research is needed using a qualitative approach such as structured or semi-structured interviews to gain a more in-depth understanding of the points raised by this research. More detail will provide the information for designing changes to teaching. Furthermore, the current research was not devised to explore the content of the teaching, the academic performance of dental students as a result of the pandemic, how variability in teaching may have affected the preparedness of the dental students for their future career or gaining feedback directly from students. Exploring the content of teaching would allow better understanding of what, as well as how it is taught. This is an important factor in determining the best approach to teaching.

Information about academic performance during and after the pandemic could help to understand how adaptations to teaching impacted on dental students' knowledge and ability to apply this knowledge. Recent research examining this in other areas of dentistry reported mixed results, suggesting this is an important area to explore in orthodontics (Zheng et al., 2021; Binrayes et al., 2022; Arponen et al., 2023; Gatt and Attard, 2023). The potential benefits and challenges of online teaching have been highlighted so more research is required to explore the design and perception of different online resources to inform how innovative solutions may be developed in the future. It should be noted however that measuring academic performance does have the caveat that

assessments may vary between dental schools as identified in the current study and as such results may not be directly comparable between UK dental schools. This may therefore need to be on an individual dental school basis.

Examining the students' perspective of the impact of the pandemic is also an important and valuable direction for future research and for the long-term evaluation of teaching. Qualitative methods could explore preferences for teaching, their experience of reduced clinical teaching, the move to online teaching and how prepared they feel for future practice. Understanding the impact on mental health is also important for educators in higher education and postgraduate training to allow support to be put in place for students who were significantly impacted by the pandemic (Chi et al., 2021) to ensure well-being is maintained.

Chapter 7: Conclusions

1. The current research revealed variation in the timing, delivery methods, hours of teaching, assessments and staffing of UK undergraduate orthodontics prior to, during and since the COVID-19 pandemic.
2. The COVID-19 pandemic had a significant impact on undergraduate orthodontic teaching. During the peak of the pandemic there was an overall reduction in clinical and face-to-face teaching due to lockdown and social distancing rules. Teaching was partially or completely replaced by online teaching which stimulated the development of new online learning resources and methods. The shift to online teaching was perceived to have both benefits and challenges by staff and students.
3. Following the peak of the pandemic, the majority of universities maintained a blended approach to teaching. The teaching has also been affected in the longer term by staff shortages and reduced chair capacity.
4. Due to mixed feedback from respondents on online resources used in the peri- and post-COVID-19 periods, further evaluation is required for their effectiveness.
5. Despite efforts to create a good-quality bespoke questionnaire, there were some challenges in collecting valid data. Future research should employ a qualitative approach such as structured or semi-structured interviews to enable collection of complex, in-depth data, reduce missing data and clarify ambiguity to capture more accurate responses.

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Appendices

Appendix 1: Final Questionnaire PDF V3 150123

ETHICS QUESTIONNAIRE V3 150123 (original)

Page 1: Introduction

The purpose of this research project is to establish how undergraduate orthodontic teaching is being delivered and assessed nationally.

The data collected will ask about the teaching practices in the pre- and peri-COVID-19 periods and current practice.

All 16 UK Dental Schools are being invited to participate in this research.

Once analysis is complete, you will receive an anonymised summary report of the research results to assess the impact of COVID-19 on undergraduate orthodontic teaching.

I hope this research will have a wider benefit to undergraduate teaching by facilitating discussion about current teaching practices. The data may also be a stepping stone for further research which may be carried out in the future in this area.

Additional information:

- The questionnaire should take 25 minutes to complete. If you wish to pause and return to the questionnaire, please ensure the question responses are saved.
- Data will be stored electronically in a secure file on the University of Leeds computers.
- You may withdraw from the study at any point up until data analysis (March 2023).
- The results of the study will be submitted for my Masters by Research (MRes). All published data will be anonymised.
- Permission has already been granted from the Dean of your dental school to carry out this survey.

Page 2: Consent statement

1. I confirm that I have read the participant information sheet (V3 150123) for the current study and I agree to take part in the study. I understand that my participation is voluntary and that I am free to withdraw up until data analysis stage (March 2023) without giving any reason. I understand that the information collected about the undergraduate orthodontic teaching at my dental school may be used to support other research in the future, and may be shared anonymously with other researchers. *Required

Yes

No

Page 3: Your details

This section will collect information about who is completing the questionnaire. This will enable me to see who has completed the survey and this data will not be shared.

2. Please enter your full name: * Required

3. Please select the dental school that you represent: * Required

- University of Aberdeen
- University of Birmingham
- University of Bristol
- University of Cardiff
- University of Central Lancashire
- University of Dundee
- University of Glasgow
- University of Leeds
- University of Liverpool
- University of Manchester
- University of Newcastle
- University of Sheffield
- King's College London
- Plymouth University
- Queen Mary University of London
- Queen's University Belfast

4. What is your role in undergraduate orthodontic teaching? * Required

Page 4: Structure and delivery of teaching

This section will ask for information about the structure of undergraduate orthodontic teaching prior to the COVID-19 pandemic and changes that were implemented during the pandemic.

Please use the following definitions: (Available to open in a separate window by clicking the link on the next page)

Synchronous teaching: *Instructors and students gathering at the same time (virtual or physical place) and interacting in "real time".*

Asynchronous Teaching: *Students accessing materials at their own pace and interacting with each other over longer periods.*

Clinical: *Teaching and learning focused on, and usually directly involving, patients and their problems.*

Seminar: *Student-led group teaching.*

Tutorial: *Tutor-led tuition group teaching.*

Flipped classroom: *Students completing direct instruction, such as viewing a lecture online, prior to the in-class discussion of the material so that they can engage in active learning.*

Simulated Teaching: *Role playing or rehearsal in which the process of teaching is carried out artificially for example Lab based/Phantom head teaching.*

Online teaching: *For the purpose of this questionnaire, online teaching will relate to ADDITIONAL resources made available on digital platforms specifically related to undergraduate orthodontic teaching. For example additional reading material, handbooks, recorded videos etc. It does not relate to pre-recorded lectures, tutorials and seminars which is asked in separate questions.*

Page 5: Description of the undergraduate orthodontic teaching structure in your dental school prior to the COVID-19 pandemic.

5. In which years was the undergraduate orthodontic teaching taught prior to COVID-19? * *Required*

- Year 1
- Year 2
- Year 3
- Year 4
- Year 5

To answer the next question, you can access the definitions from the previous page by clicking on the link below:

https://static.onlinesurveys.ac.uk/media/account/133/survey/942552/question/definitions_for_undergraduate_.pdf

6. Please describe teaching in terms of activity and number of hours of teaching for this activity for the full year (Pre-COVID-19):

	Total hours of LECTURES over full year: <i>Optional</i>	Total hours of TUTORIALS over full year: <i>Optional</i>	Total hours of SEMINARS over full year: <i>Optional</i>
Year 1			
Year 2			
Year 3			
Year 4			
Year 5			

Page 6: How has the structure and delivery of teaching changed during the COVID-19 pandemic?

Instruction:

Please give a timeline for general changes made to the undergraduate orthodontic teaching during the COVID-19 pandemic:

This specifically relates to changes which occurred during March 2020-September 2020 (peak COVID-19 lockdown) and then September 2020 onwards (post-lockdown).

Example:

- *Suspension of laboratory and clinical teaching and all other face to face teaching (March 2020-September 2020)*
- *Teaching solely replaced with non face-to-face methods (March 2020-September 2020) (Please specify the non face-to-face methods e.g. move to synchronous and non-synchronous online lectures.)*
- *September 2020-current:*
 - *Continuation of synchronous online lectures only.*
 - *Reinstated laboratory and clinical teaching at reduced capacity.*
 - *Teaching face-to-face at reduced capacity (relating to seminars and tutorials).*

7. Changes to structure and delivery of undergraduate orthodontic teaching during COVID-19 pandemic: * Required

8. Did the delivery of number of hours of undergraduate orthodontic teaching change from March 2020 onwards? * Required

- Yes
- No
- Unsure if hours delivered have been affected

8.a. Please specify how the hours of orthodontic teaching have changed? *For example: Between March 2020-September 2020: hours delivered reduced/increased by 10 hours for each of year 4 and Year 5. The hours of delivery resumed to pre-COVID-19 levels from September 2020-current for all years.*

9. Is your dental school planning to keep any of the changes to structure or delivery that were introduced during the COVID-19 pandemic? If so, please describe which ones will be retained. * Required

Page 7: Orthodontic Teaching Staff

This section asks for information about the staff involved in undergraduate orthodontic teaching prior to the COVID-19 pandemic and any changes that occurred during the pandemic.

10. In Jan 2020 (pre-COVID-19), which and how many (full or part-time) members of staff were involved with undergraduate orthodontic teaching. If zero number, please type 0.

	<i>* Required</i>
University Employed	<input type="text"/>
NHS Consultant Orthodontist	<input type="text"/>
Orthodontic Post-CCST	<input type="text"/>
Orthodontic Specialty Trainee (pre-CCST)	<input type="text"/>
Postgraduate (non-NTN)	<input type="text"/>
Non-Consultant Specialist/ Associate specialist/ Staff Grade specialist/Trust Doctor	<input type="text"/>
Non-Specialist Tutor	<input type="text"/>
Orthodontic Therapist	<input type="text"/>
Other, please specify:	<input type="text"/>

11. Please describe any changes to orthodontic teaching staff during the COVID-19 pandemic. For example: Increase in staff numbers (x1 more Orthodontic therapist)/ Reduction in staff numbers (x1 fewer NHS Orthodontic Consultant)/ No changes to staff numbers. ** Required*

Page 8: Orthodontic Examinations and Assessments

This section asks for information about the format of undergraduate orthodontic examinations prior to the COVID-19 pandemic and any changes that occurred during the pandemic.

How and when were the orthodontic assessments taken prior to COVID-19?

Instruction:

Please provide specific information on both formative and summative assessments including:

- The year that assessments are taken
 - Assessment method
-

Examples:

- *Work Based Assessments*
- *OSCE exam*
- *Written Exam*
- *MCQs/SBAs/EMQs*
- *VIVA*
- *Simulation*
- *Other*

12. Assessment method and year taken before COVID-19 pandemic:

	Assessment Method <i>(Please specify if these are Formative and/or Summative)</i> * Required
Year 1:	<input type="text"/>
Year 2:	<input type="text"/>
Year 3:	<input type="text"/>
Year 4:	<input type="text"/>
Year 5:	<input type="text"/>

13. Were changes made to the method or timing of assessment during the COVID-19 pandemic? If so, please describe the changes made. *(For example: No changes OR Yes changes made to both Summative and Formative exams: No written exams in 4th and 5th year and no practical exams, Online MCQ only etc. Continued Work Based assessments etc).* * Required

14. Is your dental school planning to keep any of the changes to orthodontic assessments that were introduced during the COVID-19 pandemic? If so, please describe which ones will be retained. * Required

Page 9: Impact of COVID-19 pandemic

This section will concentrate on how the COVID-19 pandemic affected undergraduate orthodontic teaching.

15. How do you feel the COVID-19 pandemic affected undergraduate orthodontic teaching? * *Required*

16. Have the undergraduate students given feedback to the changes made to undergraduate orthodontic teaching throughout the COVID-19 pandemic to date? * *Required*

- Yes
 No

16.a. If you are able to, please share some general feedback:

17. Are there any other ways the university have evaluated the changes made to the undergraduate orthodontic teaching throughout the COVID-19 pandemic to date? *For example: University metrics or by asking staff members.*

- Yes
 No
 Unsure if there have been further evaluation

17.a. If you are able to, please give some general feedback.

Page 10: Additional Information

18. Please feel free to add any other information you feel is relevant to this research. *Optional*

19. Do you have any additional feedback/comments about this questionnaire? *Optional*

20. Finally, would you be interested in discussing undergraduate orthodontic teaching with colleagues from other universities? * *Required*

- Yes
- No

Page 11: Permission for further contact

21. I may wish to contact you via email during the data analysis stage (March 2023) to clarify the answers provided. Please indicate whether you would be happy for me to contact you: * *Required*

Yes

No

Page 12: End of Questionnaire


Thank you for your time in completing this questionnaire.

I will send a summary report once the data has been collated and analysed. If you have any questions, please do not hesitate to contact me on **dnmha@leeds.ac.uk**.

If you have any concerns about this project, you may contact the Lead Supervisor Dr Sophy Barber: **S.K.Barber@leeds.ac.uk**


Appendix 2: Email confirmation of ethical approval


DREC ref: 071122/MH/359 📎 6 🔍 🗑️

 Julie McDermott 😊 ⏪ ⏩ ⋮

To: Mubeen Hameed Mon 16/01/2023 15:06

Cc: Karen Vinall-Collier; Sophy Barber

 DREC form V3 150123.doc
590 KB

 Research Proposal v3 15.01.2...
57 KB

☑ Show all 6 attachments (819 KB) ☁ Save all to OneDrive - University of Leeds ⬇ Download all

Dear Mubeen

DREC ref: 071122/MH/359
Study title: Delivery of undergraduate orthodontic teaching in the UK and changes during the COVID-19 Pandemic

I am pleased to inform you that your research ethics application has been reviewed by the Dental Research Ethics Committee (DREC) and can confirm that the application has been given ethical approval based on the documentation reviewed as per below and attached. Please retain this email as evidence of ethical approval in your study file.

Documents reviewed

Document	Version number/date
Research ethics application form	Dated 15/01/2023
Research proposal	Version 3 15/01/2023
Participant information sheet	Version 3 15/01/2023
Questionnaire	Version 3 15/01/2023
Live link for questionnaire	Version 3 15/01/2023
Email to Heads of Schools	Version 2 10/12/2022
Invitation email	Version 2 10/12/2022

Please notify DREC if you intend to make any amendments to the research as submitted and approved to date. This includes recruitment methodology; all changes must receive ethical approval prior to implementation. Please see <https://ris.leeds.ac.uk/research-ethics-and-integrity/applying-for-an-amendment/> or contact Julie McDermott for further information if required.

Ethical approval does not infer you have the right of access to any member of staff or student or documents and the premises of the University of Leeds. Nor does it imply any right of access to the premises of any other organisation, including clinical areas. The committee takes no responsibility for you gaining access to staff, students and/or premises prior to, during or following your research activities.

Please note: You are expected to keep a record of all your approved documentation, as well as documents such as sample consent forms, risk assessments and other documents relating to the study. This should be kept in your study file, which should be readily available for audit purposes. You will be given a two week notice period if your project is to be audited.

It is our policy to remind everyone that it is your responsibility to comply with Health and Safety, Data Protection and any other legal and/or professional guidelines there may be.

With best wishes for the success of your study.

For and on behalf of
 Dr Karen Vinall-Collier
 DREC Chair