Attitudes to remote patient monitoring among orthodontists in Ireland – a qualitative study

Submitted in partial fulfilment of the Clinical Doctorate in Dental Surgery (Orthodontics)

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Declaration

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Summary

Aims: The aim of the study was to explore the attitudes to remote patient monitoring among orthodontists in Ireland.

Methods: A descriptive, qualitative study was conducted involving a purposive sample of orthodontists working in private and public orthodontic practices across Ireland. A topic guide was developed. Six focus groups and a single interview involving 16 participants were undertaken. Semi-structured interviews were audio-recorded and transcribed verbatim with Sonix ™ software. A thematic analysis approach was carried out for data analysis using MAXQDA ™ software.

Results and Discussion: Following data analysis, seven main themes were identified. Factors influencing adoption of RPM include patient-driven factors, peer influence, settings/systems, cost-effectiveness, clinical applications, misuse and oversight, attitude for potential adoption of RPM technology. These factors were found to exert important roles as influencers, barriers or both. Orthodontists anticipate broad adoption of RPM technologies in the future allied with an increased array of applications and available technologies. An increased acceptance and penetration of RPM was acknowledged; however, not all non-user participants would be willing to embrace this. Users of RPM technology have a positive attitude towards RPM technology whilst non-users have ambivalent attitudes. Users positively perceive a positive influence of RPM on their practices through increased efficiency, broad usage, financial and time savings. Non-users perceive lack of patient desire, fixed appliances, public orthodontic setting, cost, time, public perception of profession as barriers. Remote monitoring of oral hygiene of patients with fixed appliances may become imbedded into routine care

Conclusions: This qualitative study highlights the multifaceted nature of RPM as perceived by the participants with a range of facilitators and barriers identified.

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List of abbreviations

AI:	Artificial Intelligence
CA:	Clear Aligners
CAT:	Clear Aligner Therapy
CDC:	Centres for Disease Control and Prevention
CM:	Conventional Monitoring
DM™:	Dental Monitoring ™
HSE:	Health Service Executive
PGHD:	Patient-Generated Health Data
RM:	Remote Monitoring
RPM:	Remote Patient Monitoring
TD:	Teledentistry
TM:	Telemedicine

1. Literature review

1.1 Introduction

Remote patient monitoring (RPM) is a modern-day evolution of tele-orthodontics (Cook *et al.*, 2001; Mandall & Harvey, 2005; Mandall *et al.*, 2005; Maspero *et al.*, 2020; Saccomanno *et al.*, 2020). The term itself is being re-defined within the literature reflecting the continual evolution of digital technologies and change in their intended use (Kravitz *et al.*, 2016; Vegesna *et al.*, 2017). Vegesna *et al.* (2017) defines RPM as, "An ambulatory, non-invasive digital technology used to capture patient data in real time and transmit health information for assessment by a health professional or for self-management'. In simpler terms, "Data created, recorded, and gathered by and from patients often through the use of technology such as smartphones and wearable devices (Lavallee *et al.*, 2019)." Newer technologies are providing opportunistic platforms for remote care; however, the adoption of these technologies amongst orthodontists is unknown (Caruso *et al.*, 2021; Kravitz *et al.*, 2016). Customised treatment with hybrid monitoring consisting of both clinical review appointments and remote patient monitoring (RPM) are a reality and are becoming ingrained in the provision of modern-day treatment. The widespread use of smart phones in modern society along with monitoring applications and cloud-based systems have enabled remote objective treatment monitoring and feedback (Kwon *et al.*, 2022). A better appreciation of the factors underpinning the use of RPM would assist in shaping the evolution of these resources in order to better target their use and development in order to optimise utility and patient care.

1.2 Telemedicine

Telemedicine can be broadly defined as 'the provision of medical services and patient care at a distance, using information and communication technologies (ICT)'. However, there is variation as to what constitutes telemedicine (General Medical Council, 2018). In the past, telemedicine was used broadly to capture data from landlines or videoconferencing interventions (Vegesna *et al.*, 2017). Rollert *et al.* (1999) demonstrated the possibility of using telemedicine technology via real-time systems for

the assessment of patients prior to maxillo-facial surgery under general anaesthetic showing good reliability for patient assessments and suggested its use in future patient

care. This early study when telemedicine was in its infancy provided some low-quality evidence of the potential application of telemedicine for medical assessments.

1.2.1 Methods of telemedicine delivery

Two methods of application have been typically described (Wallace *et al.*, 1998):

1) Real-time systems
2) Store-and-forward systems

Real-time involves the use of telephone or video technology to communicate between the patient and orthodontist, facilitating direct consultation and immediate recommendation or action. Store-And-Forward technology involves the transfer of digital images or videos to the orthodontist to permit review. Patient preference for video technology has been shown due to improve communication and rapport building; however, technical problems are common (Donaghy *et al.*, 2019).

1.2.2 Teledentistry

Teledentistry (TD) is a domain of telemedicine being defined as: "The use of telecommunications to deliver oral healthcare remotely, including diagnostic services, consultations and treatment" (Byrne & Watkinson, 2021; Patel & Antonarakis, 2013; Wallace *et al.*, 1998). In other words, TD can be defined as the remote provision of dental care, advice or treatment through the medium of information technology as opposed to direct personal contact with patients involved (Khan & Omar, 2013). The implications and benefits of TD are significant, potentially offering more advantages for those residing in rural communities, although ethical (Kravitz *et al.*, 2016) and legal (Stanberry, 2006) concerns exist. TD has the potential to identify high-risk patients or high treatment need, aid referral pathways to secondary/ tertiary care facilities and support local based treatment, thereby reducing waiting lists, costs and unnecessary travel (Estai *et al.*, 2018). The potential advantages and disadvantages of TD are listed in Table 1.

Table 1 Advantages and disadvantages of teledentistry

Advantages	Disadvantages
Wide range of use for referrals, assessments or management of emergencies	Clinical assessment/treatment may still be warranted and may only troubleshoot problems
Clinical information instantly available	Poor quality of imaging may hinder diagnosis/treatment plan
Reduce the need for in-office visits	Uncertain/no remuneration for dentists or orthodontists
No risk of transmission of infective pathogens e.g., COVID-19	Practical and logistical Issues regarding internet provider
No travel required for patient and possibly clinician	Potential for data breach online (consent required for data sharing)
Increase accessibility and convenience in rural areas	Digital technology may not be user-friendly for clinician nor patient
Increase efficiency and time	Patient may feel level of care is suboptimum
Efficient usage of resources with less personal protective equipment (PPE) requirement thereby more sustainable	May not be cost-effectiveness
Early interception of developing problems, such as, poor OH, non-tracking aligners, broken appliances or poor compliance which may help reduce treatment times	

1.2.2.1 Telemedicine technologies available

Common technologies which facilitate telemedicine include high-speed internet connection, digital videos and photographs, smartphones and websites, each offering advantages and disadvantages compared to face-to-face care (Parker, 2020). Other proprietary communication services that may be helpful including Skype ™ and Zoom ™. The validity and reliability of these software programmes is uncertain, as they were not specifically designed for medical or dental use. Their functions are primarily limited

to a live virtual consultation in conjunction with a chat feature. Notwithstanding this, they did prove useful during the COVID-19 pandemic (Park *et al.*, 2021). Web-based platforms do not require installation of software; therefore, may be more user-friendly for clinicians and patients. However, websites used should have digital certification and end-to-end encryption to ensure data is protected (Maspero *et al.*, 2020). Furthermore, WhatsApp™ Messenger, an instant messaging application developed in 2009 is widely used by all smartphone users. Given its widespread usage, with the exchange of digital photos or videos, WhatsApp™ and specifically WhatsApp™Business may be used for virtual assistance of emergencies (Caprioglio *et al.*, 2020).

Table 2 Advantages and disadvantages of available communication and monitoring tools adapted from *(Parker, 2020)*

Technology	Advantages	Disadvantages
Broadband	• Instant transmission of data if optimum speed for data transfer	• Data protection risk as some connections are not secure
Website	• Accessed using all computer operating systems • Available online, consuming little computer memory • Compatible on mobile phones • 24/7 availability • Not linked to large corporations • No installation required	• Vulnerability regarding confidentiality of data transferred • Need for maintenance • Dependence on a data base • Slow at times of high demand
Program (MSN ™, Skype ™, Zoom ™)	• Accessible and may be installed by patients	• Linked to large corporations (may change technology or charge for services)

WhatsApp ™	• Readily Available by patients	• Imaging/ quality of video calls may be suboptimum • Good network coverage is required
Mobile Phones	• Smartphones – Email, website access and video conferencing available	• Risk of loss
Digital Photography	• Frequent second opinion instantly	• Quality of images may vary depending on lighting, photographic equipment, operator skill and technical expertise
Silo ™	• Compatible on mobile phones and secure	• Primarily available for clinicians
Dental Monitoring ™	• Smartphone application designed specifically for remote monitoring of orthodontic treatment combining safe TD with artificial intelligence	• Image quality dependent on patient and phone camera used

1.3 Tele-orthodontics

Tele-orthodontics is a further subset of TD and TM. Tele-orthodontics is a broad term that encompasses remote provision of orthodontic care, advice, or treatment through the medium of information technology, rather than face-to-face contact (Hansa *et al.*, 2018; Lo Giudice *et al.*, 2022). Orthodontics has witnessed significant technological advances over the last 20 years. Advancements in computing, smartphones and digital diagnostic imaging have made remote management of orthodontic patients more feasible (Kravitz *et al.*, 2016). Tele-orthodontics can enable consultations, discussion of treatment plans, remote monitoring of treatment, review of emergencies and monitor retention via digital

platforms. The adoption of remote orthodontic care was hastened by the COVID-19 pandemic; whereby new communication systems implemented out of necessity, could become the preferred means of communication (England *et al.*, 2022; Griffeth *et al.*, 2023; Lamb *et al.*, 2023). Estai *et al.* (2018) in a systematic review, provided an objective overview of the benefits of TD integration and overall effectiveness and economic impact, included only two studies pertinent to tele-orthodontics, illustrating the sparse research in this area. Most of the included studies investigated the efficacy, as opposed to effectiveness; as such, the authors were unable to make generalisable conclusions. Given the weak methodology associated with the included studies, they advocated future randomised control trials to investigate further (Estai *et al.*, 2018). Furthermore, investigations were limited to areas in the USA and Europe and not developing countries. Another systematic review by Irving *et al.* (2018) incorporated qualitative research to provide new insight given the large degree of heterogeneity and lack of standardised reporting of outcomes, included four studies relevant to orthodontics. Irving *et al.* (2018) reported that smartphones are most practical for enabling TD services and that synchronous consultations are challenging to organise. There is evidence that TD can reduce costs, providing financial incentives for clinicians; however, implementation challenges exist. Ambitious TD projects will often be abandoned before publication, therefore there is a lack of understanding around barriers to implementation of TD projects. Nonetheless, both systematic reviews highlight digital technology in the field of orthodontics has not been fully explored, with relatively few studies available and most being published within the last twenty years (Maspero *et al.*, 2020). The lack of robust guidance and high-quality evidence to support the use of remote patient monitoring may be a barrier to remote monitoring procurement among orthodontists. Regulatory guidance produced by the General Medical Council in relation to TM, advised that digital and technological advancements offer increased convenience and access for patients and healthcare providers, but it is important that these services do not compromise standards of care and patient safety (General Medical Council, 2018). Therefore, recognition and awareness of potential benefits to patients and clinicians exists but clarity around safe implementation is important and applicable to tele-orthodontics. The key requirements that should be sought to ensure remote care replicates as far as possible as traditional face-to-face care include:

1) Ensuring the standard of care provided equates to face-to-face care

2) Having access to sufficient information i.e., history, clinical notes and records such as models, photographs and radiographs
3) Assessing the appropriateness of remote care having an already established relationship with the patient

1.3.1 Remote screenings and consultations

Technology to allow orthodontic management in primary care settings with remote input from specialists has been researched across different settings (Berndt *et al.*, 2008; Cook *et al.*, 2001; Martin *et al.*, 2020).

1.3.1.1 Remote consultations in dentistry

Remote dental clinical consultations have been evaluated in a UK-based study, which compared a trained GDP using audio-visual technology to assess patients whilst linking to a restorative consultant remotely. The comparator was a traditional physical face-to-face consultation with the restorative consultant (Martin *et al.*, 2020). The study highlights high levels of acceptability among patients and staff, showing a step towards patient-driven care. However, logistical issues with hearing and audio quality were reported and a small cohort of patients favoured face-to-face consultations. Further qualitative studies with exploratory techniques would provide a deeper understanding of the perspectives of clinicians and patients. Remote consultations were slightly longer than an in-person consultation. Consultations were completed remotely in an effort to imitate a real-world scenario whereby the specialist is located offsite; however, in this case the consultant was located within the same building. The efficiency, cost-effectiveness and acceptability by GDPs were not assessed, inhibiting insight for development of a virtual assessment model. Future research designs with a cluster-based randomised control trial with dentists in primary care settings linking with remote secondary care centres would help determine efficacy (Martin *et al.*, 2020).

1.3.1.2 Remote orthodontic consultations

Cook *et al.* (2001) investigated the efficacy of orthodontic referrals by GDPs in a UK-based pilot study using an innovative TD system. The aim was to reduce inappropriate referrals and assist GDPs with suitable cases for orthodontic treatment. Specialist diagnostic advice was provided to assist with treatment planning for simpler

malocclusions. There were 158 patients referred online over an 8-month period and specialist recommendations were returned or videoconferencing arranged to clarify any uncertainties. Structured interviews allowed exploration of possible barriers. GDPs reported logistical issues with transferring large file sizes and the organisation of videoconferences for case-based discussions with senior colleagues. Some GDPs did not see value with videoconferences, in contrast to specialist clinicians who perceived videoconferences as an opportunity to provide informal diplomatic feedback towards GDPs, regarding poor quality radiographs. The time taken to write an electronical referral was reportedly increased (20 minutes per referral) versus traditional postage of a hard copy letter referral; however, this was not quantitively measured. Subsequently, some dentists made less electronic referrals. Interestingly, some GDPs advised they would have preferred to have the technology available to complete in the comfort of their own homes. All GDPs preferred conventional referral methods and it was speculated, this was due to minimal expenses and time taken.

1.3.1.3 Orthodontic screenings

Mandall *et al.* (2005) conducted a randomised control trial which compared the quality of orthodontic referrals using store-and-forward email-based technology for the transfer of digital images to conventional hardcopy referral letters in a randomised controlled trial. In keeping with previous research (Cook *et al.*, 2001), this technology was geared at reducing the number of inappropriate referrals and decreasing waiting times for clinical assessment. The authors found that digital technology did have potential to reduce inappropriate referrals; however, some cases that had been rejected electronically were later accepted following in-person clinical assessment. It was suggested that initial failure to meet eligibility criteria for orthodontic treatment was due to visible poor oral hygiene on digital photos. In cases of uncertainty, acceptance for a full clinical assessment was recommended (Mandall *et al.*, 2005). The sensitivity and specificity of the referral-based system was 0.80 and 0.73 respectively. The inappropriate referral rate for the TD group was 8.2% and 26.2% for the control, thereby demonstrating the potential benefits gained through digital technology in orthodontic assessments/screenings (Mandall *et al.*, 2005). In a complementary questionnaire-based study involving general dental practitioners (GDPs), the perceived benefit of TD pertinent to orthodontic referrals was also investigated (Mandall & Harvey, 2005).

Concerns regarding initial set-up of technology, time spent and uncertainty of remuneration were identified (Mandall & Harvey, 2005). Awareness of these challenges and exploration for possible solutions may enhance the role of TD assisting orthodontic referrals in the future. These linked studies highlight the potential usefulness of virtual consultations to filter orthodontic referrals to practicing orthodontists. However, barriers exist and GDPs would require training and support to implement the programmes or applications. No study has investigated the perception and experiences of orthodontists.

1.3.2 Interceptive treatment

Interceptive treatment during the early mixed dentition can simplify or reduce the overall need for orthodontic treatment (Fleming, 2017). Often it does not remove the need for later treatment but rather reduces the treatment need between the ages of 8 and 12 years. Berndt *et al.* (2008) compared treatment outcomes of a single general dentist in private practice with real-time teleconference (TD Group) versus a control of patients treated by orthodontic residents in Washington under direct supervision of an orthodontic consultant. The PAR scores were improved by 35.6% in the TD group and 44.1% in the directly supervised group. Pre-treatment differences between the treatment groups were present and treatment plans were different. Further methodological weaknesses include, lack of randomisation of the treatment groups and small sample size meaning the study lacked power to detect differences in PAR scores. The single GDP also received modest training through a manual and by shadowing the orthodontist in practice (Berndt *et al.*, 2008). Overall, this study may offer weak evidence of the potential for GDPs to provide limited interceptive treatment in geographically remote areas where access to specialised orthodontic services is restricted. Nonetheless, higher quality evidence with a RCT design with good methodology would be idealistic to assess the outcomes of interceptive treatment by GDPs vs conventional face-to-face treatment by specialist orthodontists. It has been suggested that direct involvement and communication with specialist clinicians may promote continued professional development among GDPs. In relation to interceptive treatment, direct engagement with the orthodontist could reduce the risk of miscommunication between healthcare providers and may provide an opportunity for professional education as GDPs may be involved in interceptive treatments (Martin *et al.*, 2020). It may boost diagnosis of malocclusions, which could benefit from early

intervention such as anterior cross bites, early Class III malocclusions and Class II division 1 malocclusions.

1.4 Remote patient monitoring

1.4.1 RPM in medicine

In the medical field, data collected via RPM has been referred to as Patient-Generated Health Data (PGHD), which can be defined as health-related data generated by a patient, such as biometric data, symptoms, lifestyle choices and treatment history. This data is distinguishable from data collected in orthodontic clinics as the patient takes the primary responsibility for data collection and they can decide how they share it (Abdolkhani *et al.*, 2019). RPM offers opportunities to closely monitor and regulate patients' health. Large-scale integration into clinical workflows has been slow due to numerous challenges and RPM is subject to criticism due to the lack of evidence making it difficult to implement more widely (Vegesna *et al.*, 2017). Clinicians perceive technological barriers and computer systems as barriers to technology adoption (Donaghy *et al.*, 2019). In medical specialities, RPM can be used to monitor blood pressure, heart rate, glucose levels and this concept of remote monitoring has evolved into orthodontics (Alugubelli *et al.*, 2022; Kario, 2020; Su *et al.*, 2019). PGHD can also increase the access to longitudinal data about an individual's health and improve engagement and communication with providers and teams (Lavallee *et al.*, 2019).

1.4.1.1 RPM during the COVID-19 pandemic

As a result of the recent COVID-19 pandemic, both short- and long-term adaptations to orthodontic practice were enforced (Lamb *et al.*, 2023) Recommendations made by the Centre for Disease Control and Prevention (CDC) during the COVID-19 can be categorised into:

1) Tele-orthodontics
2) Infection control
3) Social distancing
4) Appliance type

Lamb *et al.* (2023) investigated the adaptive measures in orthodontics across the United States using a cross-sectional survey. Participants reported that 68% used virtual

appointments during the pandemic. This was an expected finding, given the health pressures to review patients remotely; however, it does not suggest how effective these appointments were. Only 8% of respondents reported using virtual appointments before the pandemic. Clear aligners (CAs) were monitored remotely more often than fixed appliances and these remote review appointments were scheduled during normal business hours. The results of the survey are situational and time specific. They lack depth in terms of the experiences of RPM among orthodontists. Attitudes towards RPM may have changed and orthodontists may continue to implement RPM as a treatment modality despite the limited evidence available. There is a high demand and preference for treatment with CAs among older females (Saccomanno *et al.*, 2022). The demand for CAs will likely continue to increase due to enhanced aesthetic-based treatment. This is likely to ensure that RPM remains imbedded within orthodontic care. Advanced tools such as wearable sensors incorporated into removable appliances, mobile and monitoring apps enable clinicians to collect data regarding orthodontic treatment and increase the availability of PGHD for orthodontists. There are a limited number of studies collecting data regarding treatment with clear aligners. Proprietary applications, such as Dental Monitoring ™, have been marketed to monitor the progress of customized aligner appliances (DentalMonitoring, 2023; Sangalli *et al.*, 2023). One cohort of patients under active orthodontic treatment were monitored remotely, during the COVID-19 pandemic in Italy, when orthodontic practices were restricted with regards to reviewing patients face-to-face. The study group was small and diverse. There were a range of appliances reviewed with different digital technologies used. The perception and experiences of patients were only assessed using an unvalidated questionnaire (Saccomanno *et al.*, 2020).There was no control group i.e., an in-office visit for each corresponding treatment and each treatment group was not treated equally, with different communication tools used. The communication tools used included videocalls, Align Technology, instant messaging; none of which are designed, for the purpose of reviewing orthodontic treatment remotely. Patient perceptions were positive; however, they used an 'emoji' system which was not clearly defined. Virtual appointments were reported as quicker; however, appointment times were not measured quantitatively. The cost effectiveness is unknown. There were perceptions that functional appliances and CAs could be reviewed remotely and advantages of remote care were less for fixed appliances. Furthermore, there was no in-depth analysis of the perspectives of clinicians which may be different to patients. Moreover, the data provided, is situational; attitudes and perspectives may be

different today (Saccomanno *et al.*, 2020). Limited research during the COVID-19 pandemic, when strict public lockdown measures were in place and remote care was encouraged, provides insight into perspectives on remote orthodontic care (Parker & Chia, 2021a, 2021b). The perceptions of orthodontic patients and clinicians using video technology was assessed using questionnaire methodology. High levels of satisfaction of the provision of remote care were demonstrated by orthodontic patients with over 70% preferring a remote consultation rather than in person. Similar to the experiences of GDPs (Cook *et al.*, 2001), patients did report logistical issues and challenges with audio-quality and videoconferencing tools (Parker & Chia, 2021a). In a complementary questionnaire, the perceptions of orthodontists were investigated and similarly high levels of satisfaction were reported with video consultations; however, satisfaction varied according to the type of appointment. It was perceived by some orthodontists to be more useful for retainer reviews and less applicable for checking fixed appliances (Parker & Chia, 2021b). There are weaknesses associated with the methodology of both parts. Both studies of a quantitative nature, are time specific; patients and clinicians may have been reticent to attend face-to-face appointments due to numerous reasons. The conclusions are specific to the application Attend Anywhere only. The survey design was relatively weak and statements were biased and ambiguous "I was able to assess my patient" with responses of strongly agree, agree etc. The authors acknowledged a yes/no response would have been more appropriate. Furthermore, 'neither agree nor disagree' provides meaningless information and its use should be discouraged from survey designs. The closed responses limit the true understanding of the perceived barriers and experiences of orthodontists.

1.4.2 Dental Monitoring SAS

1.4.2.1.1 Application

Dental Monitoring ™ (DM™) is a smartphone application developed for remote monitoring of orthodontic patients, using an algorithm of artificial intelligence for fixed braces and aligner therapy. It is the first software application for remote monitoring of orthodontic treatment marketed for reducing the need for in-person clinical appointments (DentalMonitoring, 2023; Hansa *et al.*, 2020). It was developed in Paris, France (Caruso *et al.*, 2021). Other products available under the same branding include Smilemate and Vision. DM™ is marketed for improving control, productivity and confidence for patient

care. It is speculated that it may increase patient compliance and engagement with orthodontic treatment, leading to a reduction in appointments, refinements, aligners and treatment duration (Lo Giudice *et al.*, 2022).

1.4.2.1.2 Mechanism of the system

The dashboard is fully web-based and does not require any installation of software. Patients take intraoral photographs with smartphone cameras (iOS or Android) and a special Scan Box, which are uploaded to the server and verified to ensure they are of sufficient quality. The patient uses specific cheek retractors and three sets of images are obtained to monitor tooth movement. The algorithm is claimed to calculate tooth movements with high precision. The software tracks treatment progress and prompts clinicians when specific treatment outcomes have been achieved such as space closure (Lo Giudice *et al.*, 2022). The DM^{TM} system was developed specifically to monitor patients remotely, but it can be adapted to monitor other aspects of care. The software is potentially a useful modality for alerting treating clinicians of emergencies or orthodontic issues such as broken appliances, poor oral hygiene or gingival recession (Caruso *et al.*, 2021; Lo Giudice *et al.*, 2022).

1.4.2.1.3 Cost-Effectiveness and perceptions of DM^{TM} SAS

There is sparse high-quality research supporting the clinical usage of DM^{TM}. A recent RCT by (Lam *et al.*, 2023) aimed to assess the effect of DM^{TM} on the efficiency of aligner therapy. Secondary aims were to assess the number of refinements and total aligners, overall treatment duration and patient experience compared with conventional monitoring (CM) involving face-to-face appointments. This is currently the highest quality of evidence available regarding the use of DM^{TM} to assess treatment efficiency. Treatment was faster in the conventional face-to-face group (time to first aligner refinement) than in the DM^{TM} group by 0.6 months. This was attributed to the additional burden of the task, to retake weekly scans versus solely replacing the aligners. Treatment was provided with Invisalign aligners only on a non-extraction basis. The DM^{TM} group had approximately 1.5 fewer visits over a mean treatment duration of 11.6 months, if patients are recalled every 8 weeks. Therefore, if patients are reviewed more frequently than 8 weeks and treatment duration is longer than 12 months, the difference in the number of visits would likely be greater. There were no significant differences in terms

of number of refinements or aligners. Furthermore, there was no significant difference in patient satisfaction between the two groups. Fewer appointments combined with positive patient experiences are positive findings and may encourage the adoption of RM for some clinicians and patients. The perception of face-to-face appointments among the DM^{TM} group and conventional groups did differ, with the conventional group perceiving more value in face-to-face appointments. Treatment was provided by one clinician in private practice and no operator outcomes, perceptions or experiences were reported. The success of treatment with PAR scores was not assessed in either group and it was cited this was not the intention of the investigation (Lam *et al.*, 2023). Previous retrospective research with weaker study designs, overestimate mean reduction of 2.3-3.5 appointments over a treatment period of approximately 13 months (Hansa *et al.*, 2021; Hansa *et al.*, 2020). Lam *et al.* (2023) did not remotely monitor patients in fixed appliances treated on an extraction basis. Orthodontists may perceive less value with remote patient monitoring of fixed appliance treatment since recurrent visits are required for wire changes or further appliance activation; therefore, it may be more suited for customized appliances such as aligner therapy, which incorporates preprogramed tooth movement (Hansa *et al.*, 2020; Lo Giudice *et al.*, 2022). Impellizzeri *et al.* (2020) advocated the use of DM^{TM} technology to improve treatment efficiency. It was retrospective design, completed over a 10-week period with patients in fixed appliances. Overall, the study is of poor quality and the methodology is unclear, compounding the ability to draw any significant conclusions. Retrospective design and inherent selection bias can overestimate the potential benefits of remote monitoring and adequately powered randomised control trials are required to assess effectiveness.

1.4.2.2 Retention

Research pertinent to orthodontic retainer wear demonstrates that adherence to wear declines with time and often these studies are subject to high dropout rates (Al-Moghrabi *et al.*, 2018; Kacer *et al.*, 2010). Qualitative research has provided further insight, that loss of adherence over time is attributed to the negative impact of retainers on quality of life and pragmatic issues (Al-Moghrabi *et al.*, 2019). It is intuitive that RPM of retention may increase retainer wear through increased patient engagement and motivation. Parker and Chia (2021a) found increased virtual retainer review attendances, with a reported 5.3% 'failure to attend' compared with a control of face-to-face appointments across medical specialities up to 23%. The comparison with a general failure to attend figure of

23% is idealistic and convenient, as data was collected during the COVID-19 pandemic when a working from home culture was predominant. Sangalli *et al.* (2022) assessed the role of DM^{TM} in the retention phase of treatment with intraoral scans at 1-month, 3-month and 6-month reviews. Remote monitoring demonstrated a lower occurrence of ill-fitting removable retainers compared to the control group. No differences were detected in emergency appointments and inter-canine width changes. Limitations include the short duration of less than one year and small sample size. However, it is possible that it may improve compliance with retention in the long-term or identify relapse or maturational dental changes sooner (Sangalli *et al.*, 2021). Ideally, an increased time period of 4 years duration may provide more conclusive findings. The sensitivity and specificity of imaging or videoconferencing software used to identify any relapse should be high. Data in this area is absent. Parker and Chia (2021b) explored perceptions of orthodontists who used the software 'Attend Anywhere' for retainer reviews. Feedback was generally positive but lacked depth regarding confidence in identifying relapse or fixed retainer issues. The qualitative component was limited and one respondent reported, "Good assessment of retainer and post-op alignment." It is likely a face-to-face appointment would be required if there are any retainer problems; however, RPM may identify potential relapse or retainer issues sooner and encourage patients to attend their GDP/ orthodontist for retention concerns. Further exploratory research would help inform the development of future applications or software involved in retention reviews, as clinicians may lack confidence in the reliability to review retention remotely.

1.4.2.3 Monitoring oral health & hygiene

Limited evidence exists regarding the effectiveness of remote monitoring to review oral hygiene during orthodontic treatment. This is important for all forms of orthodontic treatment, including both CAs and fixed appliances. Shen *et al.* (2022) used DM^{TM} to monitor periodontal outcomes following a course of non-surgical periodontal treatment. The DM^{TM} group were assisted with health counselling and showed better periodontal treatment outcomes after three-month period than the control group. Shortcomings include the short duration and absence of clinician- or patient-reported outcome measures. Oral hygiene reminders were not personalised; therefore, in the long-term it may not be effective for modifying patient behaviour. The effectiveness of RPM to modify oral hygiene in an orthodontic group of patients during a full course of

orthodontic treatment is unknown. Patients with fixed appliances, in the presence of poor oral hygiene and a cariogenic diet have an increased the risk of white spot enamel lesions and frank cavitated decay in severe cases (Gorelick *et al.*, 1982; Zachrisson & Zachrisson, 1971). The risk of decay is considered to be lower when treatment is provided with CAs; however, decalcification can still occur. This is attributed to the use of composite attachments, aligner coverage and diet (Bisht *et al.*, 2022; Lynch *et al.*, 2023). Therefore, earlier interception and identification of high-risk spots may help reduce the deleterious risk of decalcification attributed to orthodontic treatment in all orthodontic patients. Sangalli *et al.* (2021) reported statistically better plaque control in the DM^{TM} group and a decreased number of emergency appointments. Over the 6-month review period, there were no cavities detected in the DM^{TM} group while five carious lesions were diagnosed in the control group although this did not reach clinical significance. The authors did not specify the location nor extent of the lesions. Treatment modalities were different in both groups, with the control group consisting of more patients in fixed appliances than CAs. The fixed appliances used were lingual-multi-bracket appliances Win. Labial tooth surfaces have a higher caries risk than lingual surfaces (Van Der Veen *et al.*, 2010). Weekly observation and monitoring of oral hygiene may promote oral hygiene compliance due to the Hawthorne effect. In theory, patients with labial appliances may have a greater benefit from remote monitoring but higher quality evidence is needed with larger sample sizes, to assess the effectiveness of in DM^{TM} reducing the incidence of decalcification with labial appliances.

1.4.2.4 Compliance and wear

Compliance can be defined as ‘the extent to which a person’s behaviour coincides with medical or health advice’(Haynes, 1979). Compliance with orthodontic treatment can relate to the following: maintenance of optimum oral hygiene, diet control, attendance of appointments (face-to-face and virtual) , wear of headgear, aligners, functional appliances and removable appliances or retainers etc. (Fleming *et al.*, 2007). Poor cooperation with treatment is a challenge for orthodontists. Self-reported compliance of removable appliances and adjuncts is generally sub-optimal and patients tend to overestimate their duration of wear (Al-Moghrabi *et al.*, 2017). Techniques used to objectively measure compliance include timers, temperature sensors, wear calendars and keeping track of the number of elastics used. Although these offer clinicians promise,

further research is required for true evaluation. This systematic review by Al-Moghrabi *et al.* (2017) did not include patients treated with CAs. Generally, most patients treated with CAs are adults and compliance may be better as they maybe more highly disciplined due to personal or financial reasons. In a questionnaire survey, orthodontists predicted their use of CAs will increase in the future for patients in mixed dentition (Lynch *et al.*, 2023). Compliance with aligners is still problematic and orthodontists tend to be poor at assessing compliance. Sahm *et al.* (1990) described retrospective patient reports on subjective wear of removable appliances among a younger cohort and the assessment of compliance by orthodontists was poor with an accuracy of less than 43%. Compliance with wear of removable appliances and adjuncts is complex. Self-reporting of stipulated wear is influenced by the patient's perception of wear and their recall, which may be associated with errors of memory or concept of time. Interpersonal relationships with the orthodontist and parents play a key role in compliance. Patients who are non-compliant may not disclose their concerns or true wear pattern with their orthodontist and may try to evade or escape from reality. Therefore, patients may overestimate their actual wear in an attempt to please the orthodontist, to maintain the perception of sufficient co-operation (Sahm *et al.*, 1990). Accurate measurement of compliance is difficult and techniques employed by clinicians in measuring orthodontic compliance are not absolute and are merely indicators of compliance. For instance, indicators include; ease of placement of aligners and removable appliances by patients and cleanliness of the appliance being worn (Fleming *et al.*, 2007). Compliance can be self-recorded by patients using diaries or logs; however, these may be unreliable. An alternative solution is the objective measurement of compliance using information communication technology; for example, sensors incorporated into removable devices can detect wear.

1.4.2.4.1 Monitoring compliance

Mixed results have been demonstrated regarding behaviour modification using reward-based systems. Remote monitoring of care and self-regulation through objective monitoring and feedback may help optimize compliance with treatment. Compliance with mandibular advancement splints used for management of sleep apnoea was improved when monitored remotely. Microreaders were used, in a 12-week study in Korea. Patients received push notifications twice daily, via a smartphone application, if no input data was received (Kwon *et al.*, 2022). A microreader incorporated into a

removable appliance would reduce the patient burden and human error associated with manual entry and data transmission from the device to the centralized data system (Vegesna *et al.*, 2017). Biosensors/microreaders can be incorporated into removable appliances such as Twin Blocks, bite raising appliances or clear aligners. RPM of CAs may help improve compliance with wear protocols and communication reminders may help reiterate the role of the patient in successful completion of their treatment. Timm *et al.* (2021) defined compliant patients as those who self-reported wear time of over 22 hours a day. Only 36% of patients were fully compliant in a retrospective cohort study, which lacked robust methodology. Patients were treated on a non-extraction basis with CAs and compliance was assessed via a questionnaire on a digital app ascertaining patient wear times, aligner change dates and pressure felt. This is reliant on honest responses and is not the most accurate method of compliance assessment. Males were more likely to be compliant than females and those who have never had previous orthodontic treatment, whilst age and self-perceived satisfaction at the start of treatment were not associated with compliance (Timm *et al.*, 2021). In a subsequent trial, e-reminders and digital monitoring were found to reduce poor compliance from 24% to 9% (Timm *et al.*, 2022). There is a high risk of bias with both trials, as the author is affiliated with PlusDental, the digital application used in both trials. Similarly, in further a retrospective cohort study, Crouse *et al*. (2018) defined poor compliance as indications of lost aligners, poor aligner fit, requests to wear aligners more frequently and the need for mid-course refinements or discontinuation and transition to fixed appliances. Poor cooperation was more significant among 14–39-year-old patients than patients older than 39 and males were more likely to be compliant than females. It has been suggested that poor compliance could be linked with certain personality traits and could be used as a predictor for compliance with CAs. Patients with extraversive personalities are more likely to damage their retainers (Xu & Tang, 2017). Invisalign introduced dye indicators, to improve compliance in younger cohorts; however, they are subject to criticism, as the aligner can be manipulated so indicators can only be used as an estimated of actual wear time (Schott & Göz, 2011; Tuncay *et al.*, 2009). Opinion would suggest that the best measure of compliance with CAs is proper aligner fit (Crouse, 2018). A randomised control trial of orthodontic patients treated with CAs assessing compliance of aligner wear , oral hygiene with digital-based apps incorporated with AI versus a control group with no digital-based application would provide higher quality evidence. RPM with digital images and AI provides the orthodontic team an opportunity to closely review

treatment progression between clinical appointments. The Hawthorne effect may positively encourage favourable patient behaviour. It may improve compliance with wear of appliances, oral hygiene, use of auxiliaries etc. with

1.4.2.4.2 Wear protocols for clear aligners

Clinicians may ask patients to wear CAs for 7, 10 or 14 days before progressing to the next aligner (Al-Nadawi *et al.*, 2021). There is little evidence to support that one regime is superior to the other. Al-Nadawi *et al.* (2021) demonstrated that 7-day wear protocol is effective as 14-day wear except for challenging posterior movements where 14-day wear is favoured. Hannequin *et al.* (2020) used DM^{TM} to monitor tracking which notified the clinician on aligner 8 when a button had debonded. Nonetheless, this case report used a 4-day wear regime in conjunction with corticotomy; which is a very short duration and further scientific validation would be required to determine efficiency. RPM incorporated with AI could facilitate the customisation of wear regimes by checking aligner fit and tracking. This would facilitate individualised wear regimes.

1.4.2.5 Communication

Effective communication is a prerequisite for the provision of optimum patient care. It leads to more comprehensive diagnoses and reduces the frequency of errors, malpractice claims, thus increasing patients' understanding and safety of treatment. Personalised treatment plan and education of the risks and benefits of treatment; including no treatment and helps share the responsibility of oral health (Chauca, 2018). Research has shown that orthodontic images are an effective tool for patient education (Al-Gunaid *et al.*, 2021). DM^{TM} application provides a platform for initiating communication between patient and orthodontist directly. Patients can take photos remotely using the ScanBox^{pro} and send securely to the orthodontist via the DM^{TM} app (DentalMonitoring, 2023). A recent global cross-sectional questionnaire assessing the attitudes of orthodontic patients towards DM^{TM} reported that, overall, 89% of patients felt it was beneficial to be able to communicate with their orthodontist via the DM^{TM} app and 86% felt more reassured. These results are high risk of acquiescence due to the systematic design of the questionnaire (Skafi, 2023).

1.4.2.6 Patient perspectives and perception of remote monitoring

There is a lack of rich available data regarding patient perspectives on remote monitoring of orthodontic treatment. This information is important to demonstrate patient-centred care can be provided remotely. Generally, most orthodontic patients prefer to be seen face-to-face and this is due to the high value placed on face-to-face interaction; however, adults treated with CAs expressed the most interest in TD and remote treatment (Griffeth *et al.*, 2023). This data was collected via a questionnaire completed by over 300 participants between June 2020 to September 2020 when orthodontic offices had reopened. Therefore, given the situation and time of completion, the results may be overinflated but could differ today due to greater acceptance of remote treatment and technological advancements. Perception of remotely monitored orthodontic treatment versus face-to-face conventional treatment for patients in a private clinic was measured using a visual analogue questionnaire. The perception of the clinician was not assessed. Overall, patients reported highly positive responses for both treatment modalities, which is reassuring. However, there was a difference in perception of importance of face-to-face appointments. The group of patients monitored remotely did not perceive face-to-face appointments as important but there was a wide variation recorded suggesting it may be important to give patients the choice (Lam *et al.*, 2023).

1.4.3 Cost

There are no economic analysis' investigating the cost-effectiveness of RPM. Cost-minimisation analysis has been considered by two studies pertinent to teleconsultations, rather than cost-effectiveness or cost utility or cost-benefits in a systematic review. The limited evidence suggests that use of teleconsultation in dentistry can be cost-saving when compared to a conventional consultation (Estai *et al.*, 2018). There is a generalised paucity of economic evaluations of cost-effective analysis in orthodontic studies (Sollenius *et al.*, 2016). The systematic review by Vegesna *et al.* (2017) included limited studies with RPM and found technology to be neutral or cost-saving compared with the control group. No study investigating remote monitoring in orthodontics has involved a cost-effective analysis and this is often postulated as one of the major advantages of remote monitoring. Cost effectiveness analysis can be mathematically challenging for clinicians and this will be influenced by salary, private income, time spent per visit, fuel consumption etc. The complexity and various factors likely explain the lack of good-

quality economic analysis in TD (Daniel *et al.*, 2013). The use of remote monitoring technology incurs an additional charge or fee and these fees include the cost of scan boxes and monthly fees per patient. However, it is plausible RPM would provide a cost saving for both clinicians and patients in remote areas where access to care is a challenge, but this would need further exploration in long-term orthodontic healthcare research. A reduced number of clinical appointments for patients in active treatment, would increase the total number of patients available to be monitored without increasing clinical hours (Lam *et al.*, 2023).

1.5 Direct To Consumer (DTC) orthodontics

The growth of teleorthodontics and digital technology has coincidentally mirrored the emergence of direct-to-consumer orthodontics whereby the orthodontist or general dentist is bypassed. Market disruptors, such as SmileDirectClub, deliver orthodontic aligners directly to patients without a clinician physically examining the patient. Therefore, patients may not be fully informed or aware of the inherent risks involved with treatment (Tarraf & Ali, 2018). As a consequence, the validity of consent is questionable or frankly invalid on the basis that insufficient information is provided (Meade & Dreyer, 2021) Cost, convenience and treatment quality influence patients' decisions to choose between treatment provided by an orthodontist or DTC aligner company. Patients with the highest level of interest tend to prefer orthodontists whereas those with a lesser interest tend to pursue DTC aligners (Olson *et al.*, 2020). The primary reason chosen to embark on DTC treatment is typically the associated low cost in comparison to comprehensive orthodontic treatment provided by an orthodontist (Acosta-Lenis *et al.*, 2022). There is no evidence available investigating the perspectives on DTC orthodontics among orthodontists. However, given the potential market disruption and inherent risks for patients, it seems likely that concerns and reservations would exist.

1.6 Adoption of RPM by orthodontists

Remote technologies are offering orthodontists opportunities to closely monitor treatment; however, implementation requires recalibration of the clinical workflow with appropriate measures to overcome barriers. Broadly speaking, the adoption pattern of digital technology by orthodontists does not seem to be influenced by gender, age or geographical location. Cost may be the most influential factor regarding adoption of digital technology whilst better treatment outcomes and enhanced patient comfort are not frequently cited as incentives (Jacox *et al.*, 2019). RPM is a specific application of digital technology, an adjunct to the provision of orthodontic treatment and an evolution of teledentistry. There has been a rapid advancement of digital technologies over the last 20 years, outpacing the implementation of RPM on a large scale. Our current understanding of the adoption process, perceived barriers and influencers is limited. RPM is in its infancy and there is some low-quality evidence available to support the positive impact for patients and clinicians, such as reduced face-to-face appointments with potential modest savings. Based on the literature review, there is an increasing trend toward using RPM technology and heavy marketing geared towards patients may drive this. There is a lack of familiarity with orthodontists' perspectives of RPM. The focus on orthodontists offers and original perspective in the proprietary concept of RPM. By addressing the knowledge gaps of orthodontists' attitudes, experiences, perceived influence, this will uncover factors on RPM procurement and provide educational guidance on implementation.

2 Aims & Objectives

2.1 Aims

The aim of the study was to explore the attitudes to remote patient monitoring among orthodontists in Ireland.

2.2 Objectives

The objectives were to use qualitative methods to answer the following questions:

- What are the facilitators and barriers relating to the acquisition and implementation of remote patient monitoring?
- What are the attitudes to remote patient monitoring?
- What is the perceived influence of remote patient monitoring on orthodontic practice?

3 Materials & methods

3.1 Qualitative research

Quantitative research is predominant in dentistry; however, there is a growing interest in qualitative research. Quantitative research approach is commonly associated with positivistic (objectively measurable), experimental research and is frequently used to test hypotheses. Attitudes can be defined as 'reinforced beliefs and often strong feelings which may lead to particular behavioural intents" (Oppenheim, 2005). Attitude measurement is complex and traditionally is measured by means of attitude statements in quantitative research. Conversely, qualitative research does not seek to provide quantified answers but tends to be associated with more naturalistic types of research. Methods employed can offer unique insight into personal perspectives and experiences. providing a more comprehensive understanding of participants' beliefs, knowledge and attitudes; for example, factors influencing adherence to removable retainer wear (Al-Moghrabi *et al.*, 2019). It offers greater depth and methodological flexibility than quantitative methods, such as structured questionnaires. Therefore, qualitative research is ideally positioned to explore new areas or proprietary concepts where little is known, or to access personal opinions, which cannot be assessed using quantitative methods. Furthermore, qualitative research can be effective at the start of a project to develop hypotheses in newly emerged areas, such as remote monitoring in orthodontics. Qualitative methods would also be useful if conflicting or ambivalent opinions of RM exist.

3.1.1 Methods of data collection

Methods of data collection used in qualitative research are different to those used in quantitative research. Qualitative research is underpinned by epistemology – the science of knowing. Whilst quantitative research is underpinned by methodology – (a subfield of epistemology) the science of finding out (Silverman, 2010; Stewart *et al.*, 2008) . In healthcare settings, the main methods of data collection are:

1) Focus groups
2) Interviews

3.1.2 Focus groups

Focus groups consist of a group discussion focused on topics provided by the researcher and discussed by participants. The facilitator focuses on a set of issues for discussion rather than just asking questions, The discussion is usually audio or video recorded and the write up is usually qualitative rather than quantitative. Typically group size is between 8 and 12 when conducted in person but can work successfully with as few as three. The hallmark is to produce data and insights that would be less accessible without the interaction found in a group. In this sense, orthodontists would be able to relate to challenges and influencers regarding remote monitoring. On the other hand, focus groups can raise methodological concerns, such as representativeness, which is closely related to purposive/theoretical sampling. Mutual influence of participants raises issues with reliability and the role of the interviewer. Finally, confidentiality and participant welfare could become issues, but this is less likely for individual interviews. However, overall, focus groups have a long history in market research and remain an invaluable research method in exploratory research (Gomm, 2008a).

3.1.3 Qualitative research interviews

There are three fundamental types of research interviews: structured, semi-structured and unstructured (Oppenheim, 2005). Structured interviews are basically verbally administered questionnaires with a pre-determined list of questions strictly adhered to with little depth and no data deviations or exploration of depth. On the other hand, unstructured interviews are performed with little or no organisation and progression is based upon responses. These interviews are employed when knowledge is virtually absent and significant 'depth' is required. Semi-structured interviews consist of key questions or topics that help explore areas to be covered but also allow divergence to pursue a concept or response in greater detail(Gill *et al.*, 2008) . This type of interview is more flexible and offers some guidance to the interviewer and participants, for example, exploration of a space analysis tool among orthodontic trainees (Ahmed & Sharma, 2022)

3.1.4 Reflexivity

Reflexivity can be defined as 'examining how the researcher and intersubjective elements, impinge on, and even transform, research' (Finlay, 2002). It is a concept used in qualitative research as a means of reducing bias and limiting the influence of the prior

assumptions and opinions of the researcher in shaping the collected data. An appreciation of the role of the interviewer is paramount in qualitative research. The interviewer can potentially inadvertently influence the data collection by gender, ethnicity, social class, postgraduate orthodontic status, age, accent and demeanour etc. Interview respondents can be influenced by how questions are posed or phrased. In other words, the bias is to an extent, social desirability (Groves, 1989). Influence of the interviewer effects are shown in Table 3.

Table 3 Interviewer effects (Gomm, 2008b)

Interviewer effects
1) Some circumstances lead to a large interviewer effect: that is, where there are large differences between the responses elicited from the same kinds of people by different interviewers, using the same questions
2) Interviewer effects are greatest when: - Sensitive or emotional topics are investigated - Open, rather than closed questions are used - Questions are ambiguous or difficult to understand - Interviewers have received little or no training - Interviewers adjust their performance to the demeanour of the interviewee - Interviewers disclose themselves personally to interviewees

The role of the researcher during qualitative interviews is being a good respondent in order to obtain new information. A reflexive practice approach will mitigate the effects of the researcher influencing the data (Benson & O'Reilly, 2020). Recognition of roles and not simply stating position leads to more collaborative work, involving participants in production of meaningful interpretations. Interviewers must endeavour to limit any potential influence on collected data by following a prepared topic guide in a neutral and non-leading manner yet ready for possible deviations of rich data experiences. An analytic technique referred to as 'fair dealing' is employed by many researchers to elicit contributions from all participants thereby no participants view is given heightened praise over those of others.

3.2 Study design

This was a qualitative descriptive study investigating orthodontists' perspectives on remote patient monitoring in Ireland. Focus groups and single interviews were chosen as the primary approach to ensure sufficient depth with flexibility to explore unexpected factors and perspectives (Rubin & Rubin, 2005). The focus group discussions were recorded online via Zoom (Zoom Video Communications, Inc.) and transcription of recordings was completed using Sonix ™ software to create anonymous transcripts. One final single interview was complete face-to-face and this was also audio recorded and transcribed using Sonix ™, a transcription software. The data was imported into a qualitative software tool MAXQDA™, which allows for visualisation, organisation and colour coding of the data. Reflexive thematic analysis techniques were used to interpret the findings.

3.3 Ethical approval

Ethical approval for the study was granted by the Research Ethics Committee of the Dublin Dental University Hospital (Reference Number: DSREC2022-06).

3.4 Participants

3.4.1 Focus group discussion

Participants involved in the study were practicing orthodontists in Ireland. Purposive sampling was used for participant selection based on geographical location, orthodontist practice setting and adoption status to remote monitoring technology to obtain a diverse sample of early, middle and late adopters. From August 2022 to January 2023, orthodontists in Ireland were contacted and invited to participate in the study. All participants were registered with the Orthodontic Society of Ireland and on the Dental Council specialist register for orthodontists. Qualtric^{XM} software was used to complete online consent which included questions to ascertain willingness to adopt remote patient monitoring and regular usage (if any). Potential participants were contacted using email contact details available in the public domain, such as, practice websites. Participants were invited to attend the focus groups by the divisional administrator, acting as the gatekeeper, via email. A link to the Qualtrics^{XM} online consent form was provided along with participant information, detailing the purpose of the research and the outline of the

qualitative interviewing approach. Invitees were given one week to consider the information. The lead researcher followed up initial respondents with phone calls after one week to answer any queries. It was emphasised that participation was voluntary and participants could choose to withdraw their consent and participation at any stage. A suitable time for the focus group discussion was arranged with participants. Between two and three participants were involved in each focus group. Participant recruitment was continued and focus groups were run until theoretical saturation was achieved. In total, 15 orthodontists participated in six focus groups and a further single interview. Interviewing continued until saturation was reached characterised by a lack of further emergent themes. The point of saturation was agreed upon by the research team.

3.5 Inclusion and exclusion criteria

The inclusion and exclusion criteria for the focus group participants are presented in Table 4.

Table 4 Inclusion and exclusion criteria

Inclusion Criteria	Specialist Orthodontist
	Member of the Orthodontic Society of Ireland (OSI)
	Field of work in specialist private practice or public orthodontic service (HSE)
Exclusion Criteria	General Dentist who practices orthodontics
	Auxiliary Staff e.g., Orthodontic therapist

3.6 Training and piloting

Formal training was undertaken by the lead investigator with the Social Research Association in the United Kingdom in relation to qualitative interviewing and data analysis. Prior to undertaking the focus group discussions, one virtual pilot group discussion was undertaken within the orthodontic department. The online pilot focus group was carried out via Zoom (Zoom Video Communications, Inc.) The participants included one post graduate orthodontic student and two orthodontic consultants within

the department. The discussion was facilitated by the lead researcher. The pilot discussion helped establish whether the schedule was clear and capable of answering the research questions. Feedback was provided to the lead researcher, regarding style of questioning and clarity of open questions. The discussion was recorded and the topic guide was amended accordingly.

3.7 Topic guide and semi-structured interviews

3.7.1 Topic guide

A topic guide was developed to guide the discussion, explore attitudes and perspectives ensuring adequate coverage of key topics. An initial draft was formulated based on the literature review, anecdotal experiences of senior staff in the department and the supervisors' experience with qualitative research. An iterative approach was adopted and the topic guide revised after each focus group. The topic guide was intended to act as a prompt during the focus group discussion but was not strictly adhered to. However, all aspects were covered and the order adapted to the conversational flow. The topic guide commenced with an introduction to set the context for the discussion and was divided into seven further sections, seen in Table *5*.

Table 5 Main areas discussed in topic guides

Topic guide
1) Introduction
2) Forms of remote communications and experiences
3) Teledentistry
4) Remote patient monitoring perspectives
5) Awareness of technologies
6) Applications such as aligners and fixed
7) Barriers and enablers
8) Regulations and DIY

3.7.2 Semi-structured interviews

Online semi-structured focus groups were carried out via Zoom (Zoom Video Communications, Inc.) and facilitated by the lead researcher (MD). There was no moderator present. Lead researcher was in the final year of his three-year Clinical Doctorate in Dental Surgery (Orthodontics). Focus groups were scheduled in the evening. Following introductions, participants were reminded that the discussions would be recorded and verbal consent was obtained prior to commencing. The focus groups were semi-structured and as such, had no time limit; however, participants were advised they may last from 30 to 60 minutes. Interviews were carried out until the topic guide had been covered and discussion was exhausted. Field notes during the focus groups provided an opportunity to verbally record what the interviewer saw or heard outside the context of the interview which could not be digitally recorded like facial expressions, eye contact, body language for participants. The focus groups were recorded and converted to a VTT file. The audio recording was transcribed by professional transcription company Sonix ™ and by the lead researcher. An automated email was sent to the lead researcher advising when transcription was complete. The duration of automated transcription was approximately one hour. The transcribed data was anonymised and uploaded to a secure folder, accessible to lead researcher only. The anonymised transcript existed as a Microsoft Word document and grammatical errors/incorrect interpretations were amended accordingly.

3.7.2.1 Single semi-structured interview

One single semi-structured interview was completed to explore the attitudes, perspectives and experiences of an early adopter of RPM technology. The single interview was recorded on an encrypted device and transcribed verbatim using Sonix ™, prior to data analysis.

3.7.3 Analysis of transcript data

Throughout the study, an inductive approach was adopted being guided by the emergence of key themes in focus groups including any not initially considered. Analysis followed a thematic approach, a key aspect of which is flexibility (Braun & Clarke, 2006). The grounded theory was adhered to by not constructing themes at the outset. The qualitative software programme, MAXQDA™ (Berlin, Germany) was used to aid data organisation,

management and analysis. The software interface for MAXQDA™ is shown in Figure 1.

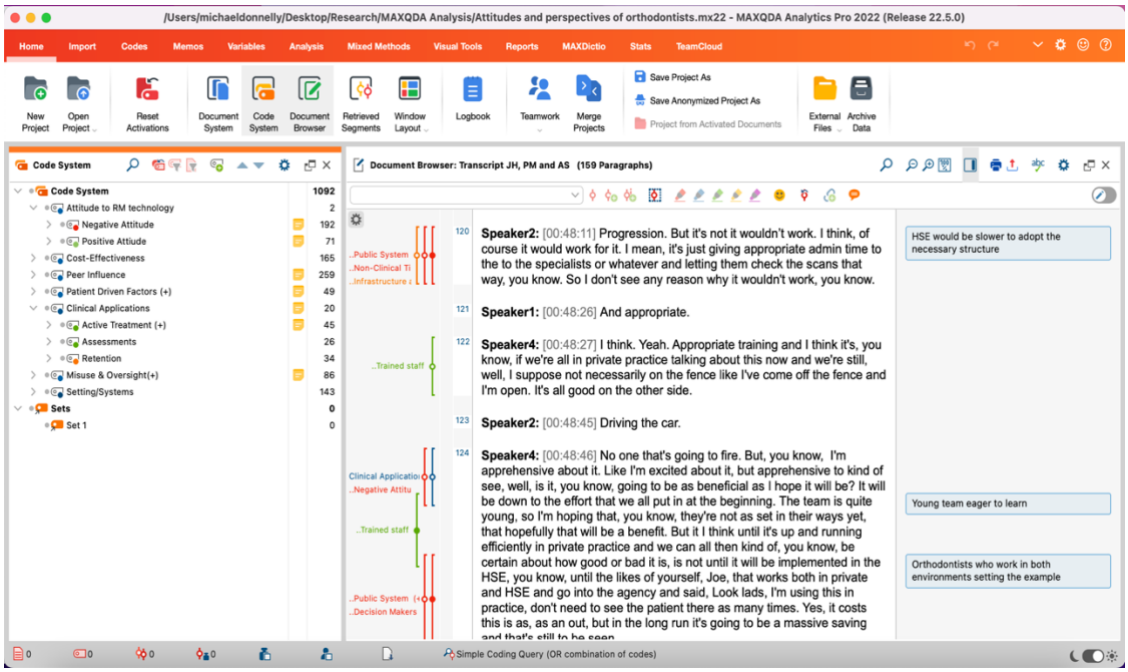


Figure 1 MAXQDA interface

The window displays the following features:

1) A code system window, which allows the creation and assignment of codes to sentences or paragraphs. These codes were both theory-driven (deductive), data-driven (inductive), latent and semantic. The codes are colour coordinated whereby red represented a challenge/barrier or negative aspect. Green codes represent a facilitator/enabler or positive perspective. The codes are arranged in a hierarchical structure, which come under sub-themes or themes. Themes are illustrated in blue.
2) Document browser illustrates the text of the selected document so the codes can be assigned to text segments.
3) Conceptualised annotations made by the researcher are shown in the right column.

The data from the transcribed focus groups and interviews was uploaded into MAXQDA™ and analysed using a pragmatic approach coined ‘reflexive thematic analysis’ using the Framework method. This analysis is a common analytic technique adopted by qualitative researchers and there is considerable variability in how it is

conducted and understood (Braun & Clarke, 2019). The process involves a number of distinct interconnected stages that need not be followed in an exact order. It is a disciplined approach which aims to maximise the outcome of gaining themes and concepts for the next phase of the project (Bryman, 1994). The stages are illustrated in Table 6

Table 6 Key stages to qualitative analysis involved in framework

Stages of framework analysis
1) Familiarisation
2) Identifying a thematic framework
3) Indexing/coding
4) Charting
5) Mapping and interpretation (stage at which the key objectives of qualitative analysis are addressed)

3.7.3.1 Familiarisation

The researcher became immersed in the data and gained an overview of the material gathered. This was aided through the recording of the discussion, transcription verbatim, and reading and re-reading of the transcript. Key ideas were listed and highlighted, along with recurrent themes that emerged (Bryman, 1994).

3.7.3.2 Identifying a thematic framework

During the familiarisation stage an overview of the richness, depth and diversity of the data was gained. The process of conceptualization was also initiated and themes that emerged as important to participants were highlighted. Once the transcript had been reviewed, a thematic framework was created. As only one population was being studied (orthodontists practicing in Ireland), only one index was produced (Bryman, 1994).

3.7.3.3 Indexing/Coding

'Indexing' refers to the process whereby the thematic framework or index is systematically applied to the data in its textual form. Indexing helps highlight associations between possible themes (Bryman, 1994). The index/codes were colour-coordinated and applied to the text **Figure *2***.

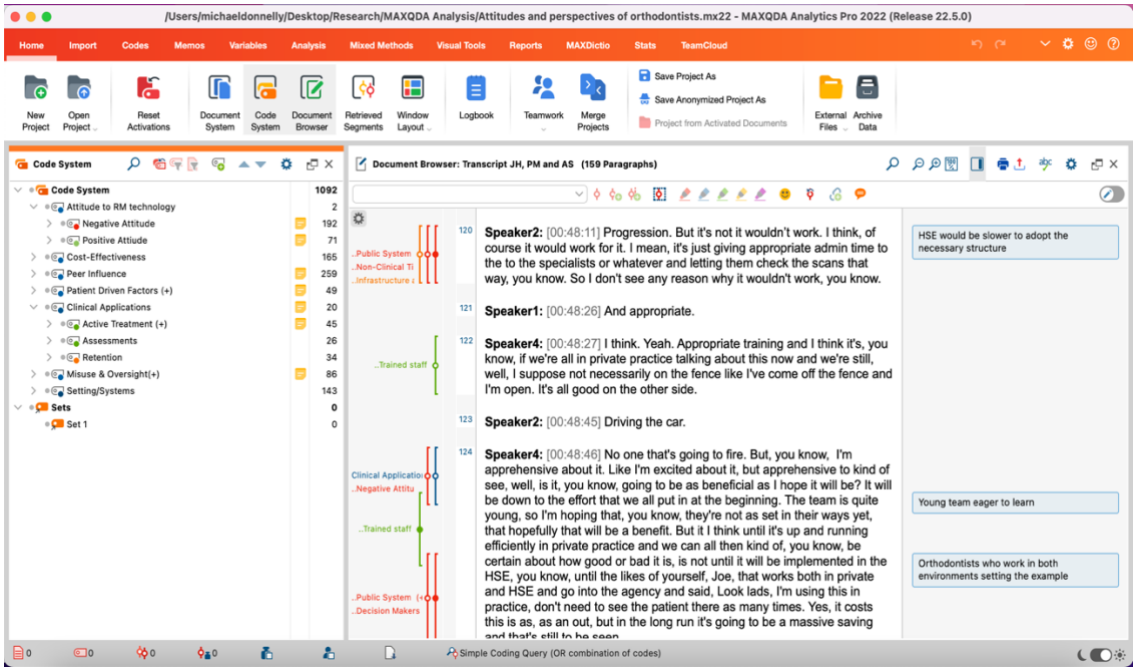


Figure 2. Indexing/Coding

3.7.3.4 Charting

Charts were included headings and subheadings with the data taken from the original context and rearranged according to the appropriate thematic reference (Bryman, 1994). The initial themes and sub-themes were then reviewed and further developed using the 'creating coding' tool **Figure *3***. Duplicate codes were amalgamated and restructured. The transcripts were also sent to an experienced qualitative researcher, who also helped refine the themes. This helped in the consistency and comprehensiveness of the analysis and limited the risk of individual researcher bias.

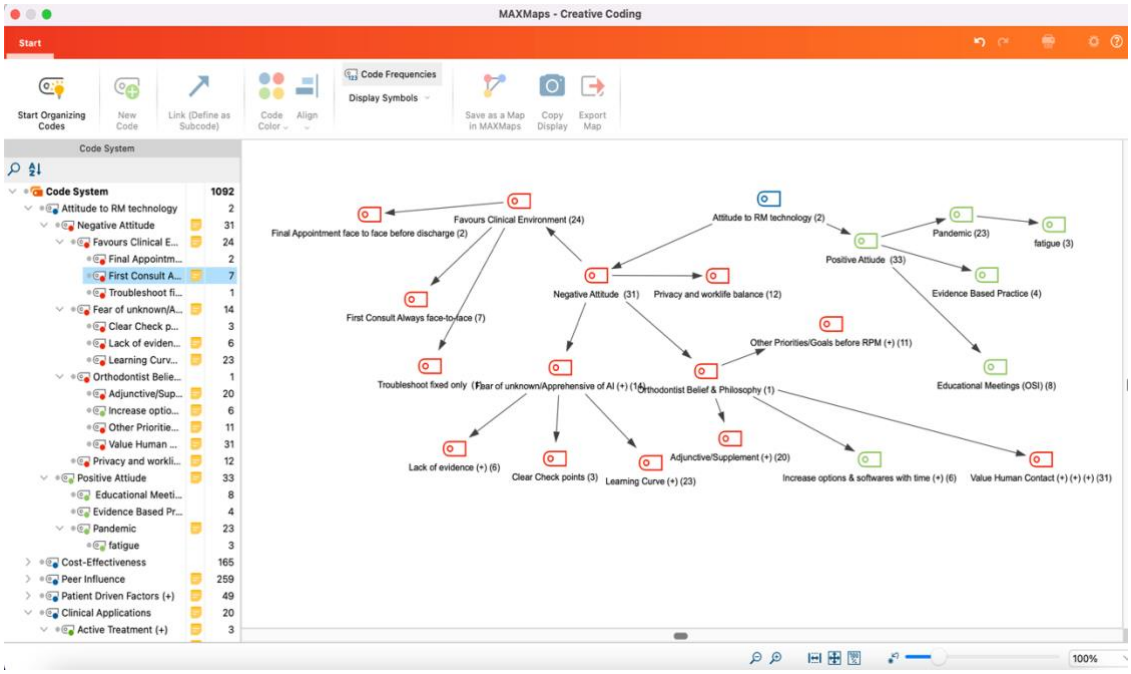


Figure 3 Organising codes and emergent themes

3.7.3.5 Mapping and interpretation

The data was sifted and charted according to the main themes identified. The lead researcher began the systematic process of detection, searched for patterns and sought explanations for the findings. This part of the analysis requires intuition, imagination and interpretative thinking (Bryman, 1994).

4 Results

4.1 Participant details

The total number of invitees was sixty-one and the final sample consisted of sixteen participants. Two participants did not attend their focus group and did not provide a reason for their absence. They did not wish to participate in future interviews. Fifteen participated in online focus group discussions and one single semi-structured interview was undertaken. There were eleven female and five male participants working in private and/or public orthodontic practices, as presented in Table 7.

Table 7 Participant details

Focus group (FG) /Single interview	Participants number	Gender	Work place in either: private/public/ both orthodontic practices	Adopter	Use of RPM
FG1	P1 P2	F F	Public Both	Late Middle	No No
FG2	P3 P4 P5	F F F	Private Private Both	Middle Late Middle	Occasional No No
FG3	P6 P7	F F	Public Public	Late Late	No No
FG4	P8 P9 P10	M M F	Both Private Private	Middle Middle Early	No No Occasional
FG5	P11 P12	F M	Both Both	Late Late	No No
FG6	P13 P14 P15	F M F	Both Both Public	Early Early Late	Occasional No No

Single interview	P16	M	Private	Early	Regular

4.2 Focus group duration

The focus groups varied in length from 30 minutes to 70 minutes. In total, there were 302 minutes of focus group audio data equating to 141 transcribed pages.

4.3 Main themes

Seven main themes were identified with associated sub-themes, presented in Table 8. Each of these are discussed in turn with direct quotations of participant responses presented.

Table 8 Themes and subthemes

Theme	Subthemes
Patient-driven factors	Patient preference and feedback Patient time Public perception of orthodontics
Peer influence	Clinical applications of RM Infrastructure and organisational aspects
Setting/Systems	Public orthodontic systems Logistics Private orthodontic practice
Cost-Effectiveness	Cost Time & Efficiency
Clinical applications	Assessments Active treatment Retention
Misuse and oversight	DIY orthodontics Public perception of DIY orthodontics
Attitude for potential future adoption of RPM	Negative attitude Positive attitude

4.4 Patient-driven factors

4.4.1 Patient preference and feedback

Most orthodontists reported that if patients desired remote treatment or began to express an interest, this would encourage the adoption of remote patient monitoring:

P12 "If a patient starts to look for it, then it's something I might want to provide for their benefit."

4.4.2 Patient time

Another important factor was the time commitment involved in parents bringing children to their appointments and travelling time whilst absent from work. The demands on patients who travel further or find treatment more inconvenient may be a driver to provide remote treatment:

P1 "There's time for the parents to take time off work. And yeah, so there's definitely an economic factor! An advantage there is the time for the child to just take time off school because we have children travelling with parents. So, there are a lot of advantages from that point of view."

Similarly, shorter review appointments were considered better suited to remote monitoring:

P8 "Parents do not want to be taking a kid out of school on a Tuesday morning to have a five-minute appointment to check their expansion, you know, so it would be ideal if it could be checked remotely."

4.4.3 Public perception of orthodontics

The perception of orthodontics by patients could be considered a barrier to procurement of RPM. Non-adopters expressed concerns or apprehension that RPM could negatively impact the perception of orthodontic treatment provided:

P5 "If you're not seeing the patient in surgery, there could be a perception that you know you're not necessary and why would a patient even need to see the orthodontist."

On the other hand, some participants felt that keeping up to date with technological advancements would be perceived positively. Patients may perceive that modern technology correlates with better treatment outcomes:

P9 "Definitely. I mean, you know, it's keeping on trend with the technology. The kids are all about the technology. Young people, probably under 35, are all about high tech, high spec, and you're deemed to probably even be a better clinician if you're embracing it."

Furthermore, others felt the explanation of remote technology was key in determining the perception of patients towards RPM. The key message being that it is "assisted information' that allows us to 'closely monitor':

P10 "I think it's how you portray it or how you explain it to the patient. So, if you explain it to the patient as, oh, here's a box to connect to your phone, it means I don't have to see you as much. Then they're going to walk out and go, well, what the hell am I paying you? We've actually invested in this technology. What it allows us to do is monitor your treatment more closely. We can scan you on a weekly basis or two weekly basis. For parents to hear that, you know."

4.5 Peers and Successful Integration

Another driver of adoption of RPM technology was peer influence. Awareness of peers, who successfully integrated RPM into clinical practice, was a positive motivational factor. They were praised and admired by non-adopters and perceived as a major influencer for adoption.

4.5.1 Clinical applications of RM

4.5.1.1 Aligners

There was universal recognition of the potential benefits of remote images for review of various orthodontic treatment appliances. Non-adopters associated the technology mainly with CA treatment; however, they expressed a keen interest in future developments from alpha-testers who test proprietary systems:

P6 "Yeah, I suppose it's the advantages that I can say at the beginning are less with fixed than they are with aligners, you know. And I think it will be more so with the aligners, but I'm keen to see it in action."

4.5.1.2 Fixed appliances

There was a lack of awareness or a perceived need for remote monitoring of patients in fixed appliances. However, those who were reticent to adopt remote technology for reviewing fixed appliances recognised the potential advantages of this approach. Specifically, they noted that oral hygiene could be reviewed and the possibility of evaluating the activity of wires could, for example, facilitate a longer interval between face-to-face appointments:

P15 "I didn't even know it was something you could do with fixed appliances. I just presumed it was just purely Invisalign."

P8 "It sounds like it's made for that. I mean, the way I was on traditional 0.014", 0.018" and 0.018' x 0.025" NiTi wires. Like I struggle to see how I'd be able to implement it for the fixed cases too."

P13 "But the idea might be that sometimes a kid comes in and you're just looking at the wire because it's still active. So, in a way that's a wasted appointment. Whereas if you had a pre-clinical check with your dental monitoring, you'd be able to say, okay, yeah, no, I still need to see you or no, you can boot it out for another few weeks."

P14 "XXXXX basically uses it to tell patients brush up on their oral hygiene or how to wear elastics, this kind of thing. So, it's handy maybe for the odd thing if there's an emergency or something."

4.5.1.3 Emergencies

There was a perception that RPM would be useful for the identification of overt issues, such as, 'broken brackets' or review of mechanics that are working consistently and require no adjustment. This could lead to forward planning and efficient use of chair-time:

P9 "I use closing coils mostly and if you've closing coils on, you don't have to see them until the space is closed and you monitor them, scan a few times and go, okay, yeah. Still closing sorry, it's not closed. And you know, sometimes it will close up really quickly on one side and not on the other side for whatever reason, occlusal forces or whatever. But the monitoring might be very handy for saying, Oh yeah, look at the very tight contacts on the left and not on the right. We just might need to bring them in and put a ramp on the lower seven or whatever, you know. I think there's definitely some very useful clinical places for it."

P4 "I would see the initial advantages with fixed appliances, for things, such as, broken brackets or wires."

4.5.1.4 Functional Appliances

Participants expressed less confidence in the ability to monitor treatment progression with functional appliances. This was cited due to difficulties associated with postured mandibular positions, inaccurate measurement or perception of overjet reduction and adjustment of functional appliances which may be required:

P5"I suppose with a functional you could check for open bites posteriorly, you know. But the thing is the actual overjet, they could be posturing. And so, you don't know if it's a true overjet reduction. Also, you're going to have to increase the retentiveness of the clasps or maybe add to the block to increase activation as well."

On the other hand, one user felt that with appropriate training of patients to take images in the correct posture, this may be within reach in the near future:

P16 "The funniest thing is you might notice when you ask patients to take a bite is they always posture forward. It requires training."

4.5.1.5 Case selection

Close observation of specific cohorts who would benefit from additional attention or patients with poor compliance with elastic wear or oral hygiene was suggested as a possible advantage. Notwithstanding this, others had less faith in uncooperative patients

and thought this would translate to an empty dashboard whereby images were not taken nor uploaded:

P13 "It would be great to closely watch patients especially those you anticipate being uncooperative, but it's not going to make any difference I feel. They probably won't cooperate with taking photos and you're going to have to see them in the clinic anyway."

Conversely, some felt that the close observation would prove to be advantageous, increasing the patient's awareness, education and overall compliance:

P11 "I think if people know they're under observation or they have to show scans every so often, it's better! They will be like, "Oh gosh, I'd better not break a bracket because I have to send this picture on to the orthodontist." In a way like, you know, and the kids. Then you're right. They can't get away with it. They're not wearing their elastics. You know, if they're not brushing their teeth, you know, if they're eating rubbish, if you break any brackets, you know, and like, there's been a few cases of that."

4.5.1.6 Desensitisation

Interestingly, some saw value in the idea of RPM for desensitisation and making the orthodontic treatment journey more 'patient friendly' for neurodivergent patients with sensory issues. This utility was seen as most appropriate in complementing rather than replacing in-person appointments:

P8 "I mean, I could see we just had the lecture on autism there, and it might be a decent way to introduce the autistic child to the clinician. You know, it might not replace."

It would also be useful for patients who are oblivious to breakages or not aware of any potential problems:

P11 "Some patients come in and the wire is about two inches long extending back beyond the first molar!"

4.5.2 Infrastructure and organisational aspects

4.5.2.1 Protected review schedule

In order to review the additional remote data, time would be required. Orthodontists engaging in remote monitoring regularly have 'protected time' schedules in place to review the remote data, for both the orthodontist and the delegated team members:

P16 "No, I know, because of the way it's worked and it's been integrated into all of our systems. I do my dental monitoring probably on a Tuesday and sometimes on a Thursday for about an hour each. But I have staff members and the total time spent on dental monitoring in my practice every week is 15 hours scheduled between different people."

4.5.2.2 Appropriately trained staff

Participants felt adoption was reliant on a knowledgeable, versatile team and that a resistant team unwilling to embrace modern technology or concepts would hinder a change in clinical workflow. Some participants felt that team members may even perform a task poorly, to avoid responsibility:

P9 "So, for instance, we have a hygienist who just takes horrible photographs because she doesn't want to do it and she's deliberately doing it."

The team should have a clear infrastructure and understanding of their role and know when 'escalation and review by orthodontist' is required. One user referred to the idea of a 'traffic light system' where red illustrates a higher priority task for review by the orthodontist:

P12 "Trained personnel such as reception staff, nurses and/or therapists who are adequately trained and skilled are essential for remote monitoring. They also need to be given an adequate amount of time to review the data."

P16 "The major stuff can be oral hygiene has gone to hell. Something's broken. Patient has had a direct message and that comes to me fairly quickly and it'll go through one of those. So if it gets to you, you don't just get a big load of notes on a foolscap. You get a

prioritized system! , the reds, you need to see them straight away. Then you can have a look at the orange, the greens we can look after unless we can't answer it for you.

4.5.2.3 Protocols

Orthodontists cited a lack of protocols and guidance regarding the timing of review either clinically or remotely. Clinicians recognise that these decisions are individualised on a case-by-case basis; however, there were mixed levels of confidence among orthodontists. Non-users of RPM expressed feelings of uncertainty but users were more assertive and felt more in control with the ability to tailor remote monitoring:

P10 "I think for fixed appliances, a lot of the time it would be, kind of ad hoc. For aligners, I would see it as a case-by-case basis because let's say if you have a long aligner case, you know, 30-40 aligners you're not going to wait till the end of the of the refinement to get them in so you might have every second visit."

P10 "And then what you have is templates where, you know, we all know we say the same thing over and over again. We give the same advice, we have the same spiel, you know, my nurses could just repeat everything that I say. Play, press play. Exactly. So, when it comes to the start it'll take a bit of time at the beginning when it comes to the templates, getting used to what it is that I want to put into it."

4.6 Settings/Systems

The orthodontic setting and environment can positively or negatively influence views on integration of remote monitoring.

4.6.1.1 Public orthodontic systems

4.6.1.1.1 Technology restriction

There was a range of orthodontists working within private practices and public orthodontic settings (HSE in Ireland). Those working for the HSE, voiced the difficulties and challenges with technological advancements or implementing changes. They described 'roadblocks', such as, lack of IT support and cost, which are less restrictive in private practice setting:

P13 "I think I'd say I.T., you know, if they can't get the I.T. system in to get the scanners readily available for the storage of virtual digital models sorted they would not be able to implement remote patient monitoring. It's ridiculous things like server size and they just have a mindset that is completely different to a private practice mindset. Like in a practice, if you want to do it, you trial it, you just do it and it happens. Whereas the HSE, it is more of a cost is an issue, but if they felt they would benefit from it, they may consider it. But it's the I.T. infrastructure as well. You know, getting those emails, all of that and ridiculous concepts of GDPR and all kind of companies that aren't within Ireland and within Europe. Like it's a nightmare, the roadblocks that they're bringing up and where is the data kept and all of that."

4.6.1.2 Unsuitable for complex cases

The cohort of orthodontic patients within the public orthodontic service usually have more complex malocclusions and higher perceived needs for treatment. They are often treated with fixed appliances and these cases were regarded as less amenable to RPM:

P14 "I think the nature of the case is maybe in the HSE, because they tend to be on the more complex end of the spectrum. They maybe do not lend themselves quite as well to remote monitoring, replacing physical visits."

4.6.1.3 Lack of confidence and resistance to change

Negative views were expressed by orthodontists regarding the capability or willingness of the public orthodontic service to embrace technology. This lack of versatility has fuelled a sense of resignation among employees with one participant expressing their frustration with the processing in imbedding clinical records:

P6 "It would need to be ironed out. There would need to be mega, mega savings. Sure look how long it took to implement Orthotrac? It took 15 years! I just don't see this being embraced by the HSE in our working life and that's the bottom line."

Orthodontists or alpha testers, who practice in both public and private sectors, were seen as influential for instigating changes to public orthodontic units. They would have to

pioneer and trial proprietary technologies, such as remote monitoring in private settings before consideration is given for adoption in public orthodontic units:

P9 "Until the likes of yourself …, that works both in private and HSE go into the agency and says, 'Look lads, I'm using this in practice, you don't need to see the patients as many times. Yes, it costs X amount but in the long run it's going to be a massive saving and that's still to be seen.'"

4.6.1.4 IT hack/Cybersecurity

Cyberattacks against the HSE in Ireland in 2021 during the COVID-19 pandemic had a further negative impact on the delivery of healthcare, including orthodontic services:

P13 "The HSE cyberattack was actually more painful nearly than COVID itself! As a result , they now want nothing to do with anyone outside HSE. Can you imagine patient's trying to send photos of treatment or trying to review these. It's a bloody nightmare."

4.6.2 Logistics

4.6.2.1 Remote data quality

Orthodontists expressed mixed perceptions concerning data quality. Data quality was dictated by the smartphone used which most agreed in the current climate is less of an issue, given the higher quality of images, but also the skillset of the person taking the image was considered important. Interviewees also felt that with adequate guidance and cheek retraction, images provided by patients would be acceptable. The use of cheek retraction provided by DM™ has helped to circumvent issues with poor diagnostic images, during the COVID-19 pandemic. Images provided during the pandemic using non-specific remote monitoring software were felt to provide limited information, chiefly helping to troubleshoot issues and manage emergencies:

P13 "And I just found that the only advantage was, you contacted the patient. But, you know, their ability to show you the aligners in and show you the teeth, they weren't good diagnostic pictures. They were just using their phones or the parent was using their phones and you were looking up their nose or into their garden."

P2 "I think if you give quite clear instructions, like for retainers. Well, I would ask depending on if I wanted to see the teeth with or without them in or aligners or whatever it was, or even for seeing breakages with fixed, you would generally know what they're trying to show you and could take a relatively good photo. Cameras on iPhones are really good these days so the quality was pretty good and I was always able to kind of make out what the what the issue was and to give back some advice based on it so they were pretty good."

4.6.2.2 Remote data security

Adopters of remote technology have developed internal infrastructures to review data. The personality of the orthodontist was relevant, regarding their willingness to trust auxiliary staff and delegating tasks, such as, data review by a nurse. Non-adopters fear that the management of reviewing data would be an onerous task and that 'missed data' would have consequences and compromise patient care:

P3 "And then you have the issue of someone who sent a photo, and it wasn't looked at. And if there was something missed, I just wonder where you sit. You know, if say, they're developing decalcification, for example."

4.6.3 Private orthodontic practice

It was thought that private practice is more suited for remote monitoring because patients are more 'tech savvy' and paying privately for treatment and this may lead to improved compliance. Furthermore, some patients may perceive high-tech practices as more appealing and attractive as there is a perception that the use of RM and newer technologies may enhance outcomes:

P8 "More private practice. We're more into efficiency, and I know it sounds pejorative about our colleagues. You have to be efficient if you are charging whatever. It would be very handy to not have to see them as often or and you know, some patients are probably very tech savvy. There are certain people who take very good photos and be very compliant and engage with what is required."

4.6.3.1 Delegation of data management

Given the potentially large volume of data produced from RPM, orthodontists often delegate review of remote data. This is usually split within the orthodontic team and shared between trained dental nurses, therapists and receptionists. The importance of clear delineation of roles and the existence of strict protocol with mechanisms for escalation to the orthodontist are considered important:

P12 "In the case of dental monitoring, if you're training this therapist or whoever, to interpret what comes in from the monitoring software, then to review the scan of the photograph that comes in and make a decision or decide whether it needs to be brought to me for a decision or whether it's a decision they can make. And I think there needs to be probably a fairly rigid algorithm to help with their decision-making"

4.6.3.2 Full-time vs Part-time clinicians

There was a perception that remote monitoring is more suitable for those working full-time in a single orthodontic practice and not for those who work across multiple practices:

P4 "You know, like I think it is slightly different if you're working part time in a practice because you have X amount of time, you know, you don't necessarily have admin time, ringfenced or whatever."

4.6.3.3 Reputation

Although RM was perceived to be more associated with private practices, there was some uncertainty whether the impact on private practices would be positive or negative. There was a perception that if used correctly and in the 'right hands', RPM would not negatively impact reputation:

P5 "You know, for it to continue and to grow and stuff like that and whether remote monitoring would affect that positively or negatively is something I'm not 100% sure about know."

4.7 Cost-Effectiveness

4.7.1 Cost

4.7.1.1 Initial Cost

Cost was perceived as a barrier for both users and non-users. However, it was not deemed significant enough to deter adoption for users. The philosophical beliefs differed for users and non-users. Non-users did not see economical value with the financial costs incurred. Non-users seemed to have some reticence in relation to profitable, proprietary technology offered by large corporations:

P10 "I just seen it as another expense and just something that Invisalign promoted and was linked to a company, and it was just a bit of a gimmick and a bit of fluff, you know, that didn't really have any place in my practice and would just be one of many expenses."

An adopter of DM™ spoke of their strategy to overcome the cost barrier. They included a standard charge for all orthodontic patients to compensate for the additional 'member of staff' i.e., remote monitoring technology:

P16 "We then looked at the potential offset in terms of chair side time and for me, quality of life and we felt that the ballpark figure of approximately €200 per patient over an average treatment plan of 18 months to me mitigated against the potential appointments that we would otherwise be eliminating."

4.7.1.2 Cheaper subscriptions with time

Participants felt that the cost barrier would become less significant with time. They predicted that the number of clinicians using RPM technology will increase with the adoption cycle mirroring that associated with proprietary aligner systems. In particular, they also forecast an increased number of companies, similar to DM™, offering more competitive subscription fees:

P9 "But I think the more it's used, the more companies will come in like you're talking about that other company from the States. You know, there'll be no different than with Invisalign and other aligner systems and things like that. So, the more competition that there is in time with more people using that, the more cost will come down."

4.7.2 Time and Efficiency

Participants agreed that time spent during diagnosis is an imperative. Time constraints in busy orthodontic practices were cited and linked to risk, for example, of overlooking 'periodontal disease' or 'the incisor with recession'. Additional time spent on diagnostics and treatment planning, gained by eliminating unnecessary appointments, may help to minimise risk by allowing reallocation of time. Users spoke of RPM 'filtering' out the mundane tasks of everyday work and improving their treatment outcomes:

P16 "I feel the benefits pay off in terms of redirecting you to your core skills, diagnosis, treatment, planning and monitoring progress and reducing the amount of 'noise' in your practice that stop you from getting to where you need to be in terms of the quality and outcomes that you would like. But it requires a serious recalibration of the dentist."

4.7.2.1 Privacy and work life balance

Some non-users or non-adopters value a conventional work life balance and normal working hours. There were suggestions by some that they prefer working solely in the clinical environment and non-clinical time working from home or in an office would impact negatively on quality of life:

P2 "That you go home and you probably have it all in your laptop or on your phone and they know you're going home and you've more time on your phone and on your computer and not kind of just switching off."

This subset does not believe that remote monitoring may save clinical time and believe that time is also lost elsewhere:

P1 "I think one of the things I thought of, was like with Invisalign, with fixed patients, you do all the work like there and then so, you know, all of the treatments you carry out with them in the chair. So when you leave at 5:00 or whatever your, your day is done, you've treated all the patients. But with Invisalign it says, oh, it saves chair time and it saves clinical time, but it costs you time elsewhere and what you end up doing or what I do and I know a lot of other people I know who use Invisalign too. You do it all in the evening. You do it at other times, you do it at the weekend. There's clinchecks to be done.

You have to check them and you can spend a considerable amount of time outside of your normal working day because you tend not to give yourself that time when you're in clinic, you want to maximize clinical time. But what you do is you end up working more."

Pride was identified as factor prohibiting adoption of RPM. Orthodontists take pride in their work and value being able to close the office door and leave their place of work behind them cultivating a stress-free life with clearer delineation between work and recreation:

P11 "But when do we get the time to do that? Do you say, well, I'm going to take extra admin time, another half day to check all these images? So that that would be my thing, that it's nice to just work your day and go home and be done."

Furthermore, concerns were raised that this could portray an image to patients that orthodontists are contactable and available 24/7 by patients. This would make it harder to 'switch off' and relax:

P4 "I'd be open about trying to cut off and not working all the time. I think remote monitoring encourages or creates the perception that you are constantly contactable or available, which means you never switch off really, because then you're always getting things coming in and maybe that's more people in practice."

4.7.3 Trial Period

Trial and learning periods are often required when embracing newer technologies. Some participants are more willing, than others, to set aside time for acquisition of the skillset required. The speciality of orthodontics is forever evolving and some participants have a range of philosophies and broad spectrum of enthusiasm. Alpha testers displayed a greater hunger than others for adopting newer technologies that become available:

P15 "So I don't know what would facilitate me, until I've kind of passed the learning curve. So, a time to dedicate to monitoring and have that. And as XXXXXX said, having set templates that you can send back to patients. It would definitely facilitate that in terms

of that would reduce the workload and having to type the same thing out for multiple different patients."

4.7.4 Time to build rapport

The establishment of a professional relationship with patients can take time. It was felt that remote consultations would inhibit the establishment of rapport. There was also a perception that a positive patient relationship correlates with good compliance:

P3 "But it takes a few appointments to kind of get a feel of a really good Invisalign patient, you know? So, you'd have to kind of check for the good patients first and then maybe delegate some monitoring there."

4.8 Clinical applications

There was a myriad of applications that could be reviewed remotely. Participants gave their views on various aspects of treatment; however, there were some areas not deemed as suitable for remote monitoring. As participants gained confidence with RPM, the door opened for increased applications.

4.8.1 Assessments

Remote assessment appointments were attempted by some clinicians during the COVID-19 pandemic; however, all participants had returned to face-to-face assessments. Clinicians were using technologies often not designed for orthodontic assessments remotely; therefore, remote assessments were viewed negatively. Explanations provided were due to inability to make a complete diagnosis, not getting a 'feel for the patient' and 'missed information':

P6 "Absolutely. 100% the first appointment in person is the most important appointment!"

P13 "Yeah, I didn't love the virtual appointment and then, you know, took you just as much time, if not more time, because it's like a Zoom call."

It was generally felt that orthodontic assessments should be complete face-to-face; however, remote assessments may be appropriate for checking if patients are 'dentally ready' for an assessment or 'in the pipeline for treatment'. Parents may pursue early treatment for their children hoping to commence treatment at an earlier age. These initial appointments may take considerable chair time and involve long discussions. Parents may seek regular review appointments to check for 'readiness'. Ad hoc photos taken, for instance, every month were considered advantageous and efficient use of time versus a review appointment every three months:

P8 "But you know, I kind of I feel, that those patients sometimes are kind of put to one side a little bit because they're not ready and really actually if they had a little bit of an interaction even. Once every three months, once a month or once every three months, that would be useful."

4.8.2 Active Treatment

4.8.2.1 Emergency Treatment

A lot of value was placed on the monitoring of active stages of treatment. Users perceived RPM as an application with the capability of 'filtering' emergencies and aiding their management. However, non-users were confident in the skillset of their reception staff to decipher this:

P12 "We think the reception staff are pretty good at getting that information on the phone. I think there will be cases where, you know, maybe the patient doesn't strictly need to be seen as an emergency, but the mother is the sort that needs to be seen as an emergency."

P16 "Be trained by dental monitoring and they'll be asked to look at various different things which tend to be triaged according to significance in a traffic light system that will be the minor stuff, for example, he hasn't scanned or is late for a scan."

There was perceived value for monitoring of fixed appliances. Participants felt weekly photographs could be helpful to 'motivate patients to brush their teeth.' One user recalled the identification of an 'open gate' with self-ligating brackets and they were able to

communicate with the patient to correct this. Overall, value was seen in the ability to closely monitor oral hygiene, especially in those who required 'extra attention'. There was a perception that this could safeguard the oral health of the patients and minimise risks associated with fixed appliances. However, it would be less useful for reviewing periodontal conditions; as one participant suggested, you would be 'using it for the wrong reasons'. However, it could help identify early recession. One participant spoke of parents ringing in advance to ensure their children were complying with the necessary oral hygiene measures:

P10 ".I would have parents that would phone up beforehand and say, will you be sure to give out about their brushing, you know, and I'm thinking, well, this surely is something that parents will love because it's not that its handing the responsibility over to us, but there's a bit more of a shared ownership in that and that you can you know, you can, I suppose, help in some way, but also as well they will. I think they will. Like it, I think. But you have to sell it in that way. I think if you say it because you don't want to see them as often, then you're scuttered basically."

P8 "Not sure maybe for a recession, it's not going to show you pocketing really, is it? But perhaps recession. So if you're starting to get some I don't know, defect on a lower incisors for starting to get some attachment loss than that it might be able to flag it. But again, it's going to be a bit nondescript, isn't it, a, you know, those nasty kind of posterior kind of defects that you have and for infrabony defects and fenestrations and furcations which clinically sometimes you just don't see them. And they can be very problematic."

The list of applications is not exhaustive; another participant reported the advantage of being able to review surgical-orthognathic cases prior to surgery and communicating messages:

P1 "Yeah. In that instance, I think things like that, like remote monitoring, we think of it as them sending photos and us not seeing them. But you can use it like that I think, for sending messages. So like that you could probably have a list of all surgical patients, contact them and say that you need to contact us and we'll see you before. Don't forget to let us know if you get a date for surgery or don't forget like you can have these little pop ups and reminders because sometimes patients move and you're sending them back

after they've changed their address. Whereas they usually, if they have an app on their phone, it pops up."

4.8.3 Retention

There were mixed reviews regarding remote monitoring of retention. Participants felt that fixed retainers need to be checked in the clinic as they may debond unknowingly and the patient may be unaware. RPM would be unable to detect a debonded fixed retainer; however, it may alert the clinician when an issue has occurred or 'pick up things earlier', such as, relapse or unforeseen torque change:

P13 "Now very difficult to check that it's adhering, adhering basically to the teeth you have to actually get a probe and check. Like, I mean, a patient can't even tell you if it's come off. So I wouldn't think you're going to see it on a photograph, to be honest. So, you have to get them in to check that."

P5 "Maybe if there are bonded retainers, you need a three in one! I think to see that there are actually any issues because sometimes I'll do a quick check and then I say, Oh, that's fine. And then I get the air and I see, Oh, there's a bit of composite debonded. So, I don't think it's useful for fixed retention, like you pretty much need a three in one."

There was an overall perception of increased value for monitoring wear of removeable retainers; however, for some participants, this takes away the interpersonal contact and opportunity for an orthodontist to showcase an excellent result. The face-to-face appointment was also thought to provide an opportunity to 'sell treatment' and allows siblings to be signed up for treatment in private practice:

P4 "Yeah, I think so. But the thing about seeing somebody when they're in retention is particularly when you have a really nice result, it gives you an opportunity to tell them how nice the result is and to sort of positively influence the whole process of orthodontic treatment and how beneficial it has been for them and give them an opportunity to show their appreciation. You know, it's a bit of a practice builder, you know, talking to people when they're in retention quite nicely and it's nice to meet them again, actually,

particularly if you've built up a relationship with the patient and the parents and the family. And generally, you know, it's a nice human moment in our practice."

Removeable retainers could be reviewed remotely; however, the last retainer check appointment often necessitates impressions for fabricating replacements. As such, orthodontists felt that remote monitoring retention was feasible during the 12-month period post-debond:

P13 "Where it might be a benefit is the four-month check. So, let's say your first post retention check, because most of the time you don't need to fit a new appliance at that stage. And it's a kind of a get back on track, see what you're doing. Just reassurance visit. So technically, that visit could be replaced. But the final visit where often times you need a new set of retainers before you're discharging or you're you really have to kind of I think you have to see the patient."

4.9 Misuse and oversight

There was a feeling of responsibility and safeguarding the provision of orthodontic treatment felt by participants. Artificial intelligence can assist clinicians; however, participants felt that if one relies entirely on remote monitoring technology, they could potentially overlook problems:

P12 "Trusting software to position the teeth and trusting other pieces of software to tell them whether they need to do a new scan and not maybe really be paying a lot of attention to what's actually happening. There is a risk there!"

4.9.1 DIY Orthodontics

Participants expressed concerns that RPM in the wrong hands could be detrimental to patients. Market disruptors, such as, SmileDirectClub™ were cited as an example:

P13 "My concern is that the aligners by mail concept. That is ratifying that people will take their own scans, take their own impressions, do the thing and they'll be bypassing potentially the orthodontist. Now, obviously you can't have IPR or you can't have

attachments, but, you know, it would be a concern that it'll be used by non-clinicians to start and see, let's throw in a few aligners to move some teeth."

Participants spoke of 'SmileDirectClub™ victims' and one participant recounted her experiences of one such patient, who was provided with failed DIY orthodontic treatment. It was felt that RPM should have clear check points, which are lacking with DIY orthodontics:

P3 "I know there's been stories, of course, and everything I've seen maybe like two or three patients. One lady I came by in the very early days. She had no attachments and there was zero activity. She had been wearing SmileDirect aligners for about two years. It was the most frustrating experience for her and then there's nothing to be done. Like I say, there's so well underwritten all of the contracts. And it's so, you know, there's a legal framework obviously, behind it that I don't know, and that's really what happens with business as such. She came back and she just had to go in and like I know you feel bad. She paid 2000 or whatever it is, and nothing happens but obviously I provide comprehensive treatment because that's what it was. And yeah, it was like, you know, I think that's kind of bad for adults and quite frankly, probably a lot of what we get with fixed appliances as well. Everything is totally down to the person planning it and the amount of time and attention they pay and the education of the person using it."

4.9.2 Patient perception of DIY Orthodontics

Concerns were raised that the public may have the wrong perception, that orthodontic treatment provided by a specialist orthodontist equates to the same standard as DIY orthodontic treatment. It was noted that large corporates can successfully market themselves as attractive and valid, safe providers of orthodontic treatment. The lack of accountability for treatment was a serious concern raised with increased 'policing' of DIY providers being urged. Notwithstanding this, orthodontists were not concerned in relation to the effect of DIY orthodontics on market share:

P9 "Yeah, exactly. Exactly. These operators who aren't even dental professionals, I think they could. And again, we're talking about perception, you could easily package something and you could gloss it up with these kinds of technologies to make it look very,

very attractive for a patient or a layperson who wouldn't be aware of differences between what SmileDirectClub™ *offers compared to what a specialist offers."*

4.10 Attitude for potential future adoption of RPM

4.10.1 Negative attitude

Participants strongly felt that remote technology is adjunctive in the provision of orthodontic treatment; however, attitudes towards the concept were positive and negative. It was clear that non-users of RM technology displayed primarily negative attitudes. Negative perceptions were cited due to various concerns: uncertainty regarding value for money, a resistance to change in work flow pattern, uncertainty around delegation of tasks and logistics. Non-users expressed a sense of security and satisfaction when in control and leading treatment provision. They displayed insecurities towards RPM technology and perceived it as a foreign entity, potentially opening doors to unfavourable outcomes or additional stressors. There is reticence to change clinical workflows among non-users as they do not see adoption of RPM as a necessity:

P6 "I mean, there's different ways to get to the same endpoint and yes, your digital technology and all that has its advantages, but there's more than one way to skin the cat and it just it probably won't be something the HSE will opt for."

Notwithstanding this, there was an ambivalent attitude expressed by non-users. It became apparent that there was a change in mindset towards RPM allied with the realisation that orthodontic treatment can be provided remotely:

P2 "I wouldn't have ever reviewed anything remotely before. But since then, now I have had the odd patient who was unwell or couldn't come in or and were in an accident and a kind of a prolonged time. And I've gotten them to send in photos like that of retainers or things like that."

A plethora of clinical applications suited to remote review were referred to. The pivotal change in attitude among orthodontists was attributed to the enforced changes due to the COVID-19 pandemic, interactions at national educational events and successful

integration of RPM by colleagues. Non-users welcomed the potential changes to workflow and recognition of perceived advantages; however, they would require assistance, support and time supported by available evidence to instigate practice changes:

P9 "Now, what's interesting, I think there will be a paradigm shift towards using these technologies more. I think you're dead right on to just embrace it like and, you know, you're kind of setting it, kind of setting a marker out there as well for your patients that I embrace technology I use. I'm sure you have a Invisalign scanner. You might have a printer. Patients actually like all that kind of stuff."

P8 "I mean, even doing what we're doing right now really is like it's become so normal to have zoom over everything, you know? So, you know, there's not too many things that we can have conversations with. See, I know for sure I think the pandemic has changed most jobs. This is no different."

P12 "I hope there are some or sorry, there are some limited retrospective studies for using it, for monitoring overheads and things like that, because I think that would reassure me the best"

4.10.2 Positive attitude

Adopters of RPM feel that good care can be delivered remotely in certain clinical situations and view remote technology more positively, as an additional "member of staff' that will facilitate achieving treatment goals. They are more willing to venture into the unknown and test new things if they believe there are benefits associated with them. They expressed a sense of satisfaction by using efficient and novel ways of providing treatment:

P16 "For me, it looked like just another expense with no clear clinical benefits because I didn't really have a comprehensive understanding of how it works in practice, whether it be better suited in a university, institute or private practice. The importance of practice and the patient journey or the flow of patients, how important that is to your ability to manage a practice. It's very easy for your staff just to book someone in to see the doctor

and to change that around requires convincing the doctor, retraining them, training staff, getting them on board. People don't like change."

5 Discussion

This project offers an original addition to the field of remote patient monitoring by presenting the views and experiences of orthodontists working across Ireland. It focuses on their perspectives within a range of practices thus shedding light on barriers and facilitators of RPM. The inclusion of users and non-users facilitated an in-depth appraisal of the factors affecting uptake of the RPM technology.

5.1 Discussion of research methods

5.1.1 Qualitative vs Quantitative

The objective of quantitative research is typically to accept or reject a hypothesis via a hypothetico-deductive approach. The decision to place this project within the qualitative research paradigm was guided by the literature, which is sparse regarding remote monitoring and perspectives of clinicians which challenges the deduction of objective hypotheses. Qualitative research is informed by interpretivism, focused on understanding the subjective experiences and personal beliefs of the participants and allowing the exploration of novice concepts, such as remote monitoring. Whilst traditional quantitative research has been labelled 'masculine', qualitative has being criticised as being 'feminine' and less valid due to the degree of subjective interpretation (Oakley, 2015; Sandelowski, 2000; Westmarland, 2001). The quantitative research lacks depth and the data is situational (Parker & Chia, 2021b). Quantitative methods draw upon larger sample sizes to make generalisations that are representative but may fail to provide detailed understanding of these perspectives (Jacox *et al.*, 2022). Conversely, qualitative research has smaller sample sizes involving large amounts of information with a higher chance of gaining a good understanding of behaviours, experiences and decision-making in relation to remote patient monitoring. This benefit may come at the expense of uncertainty with regards to representativeness. As such, no single approach is necessarily superior and even hard quantitative methods can never be purely objective and are not immune to some degree of subjective interpretation (Gomm, 2008b; Westmarland, 2001).

5.1.2 Exploratory interviews

Qualitative interview goals are about reaching depth and generating rich and nuanced data. Aiming to obtain the perspective of the participants and challenge long-held

assumptions. Qualitative interviews can vary in their overall purpose and can be described as either investigative, narrative or exploratory. Exploratory, in-depth semi-structured interviews are the most commonly used methods in qualitative research and were adopted in this study. They provide contextual detail and follow an iterative-inductive approach. Whereas investigative techniques follow a more deductive approach and narrative follows a more inductive approach. Exploratory interviews do not aim for representativeness but aim for a diverse sample. Topic guides followed in an open manner facilitate this. As William Foot Whyte argued, "the whole point of not fixing an interview structure with pre-determined questions is that it permits freedom to introduce materials and questions previously unanticipated" (O'Reilly, 2009). Structured interviews or questionnaires primarily consist of closed questions with little opportunity for exploring depth and interpretation. The questions are generally uni-dimensional and very focused; hence, this approach would have been less useful for understanding unknown barriers and facilitators. To date, this has been a common weakness in survey methodology assessing the perspectives of remote appointments (Parker & Chia, 2021b; Saccomanno *et al.*, 2020)

5.1.3 Purposive sampling and epistemology of numbers

Non-probability purposive sampling was used to invite a mix of perceived users and non-users of RPM, irrespective of frequency of participants. This ensured that participant had the 'rich' experiences required. There is little agreement in the literature for the minimum sample size to achieve data saturation with sample sizes in allied orthodontic studies typically being of the order of ten to 32 (Donaghy *et al.*, 2019; El-Huni *et al.*, 2019; Johnson King *et al.*, 2022; Perry *et al.*, 2018; Richardson *et al.*, 2023). Focus groups were scheduled online in the evening to facilitate greater uptake (Kitzinger, 1995; McNair *et al.*, 2006; Oppenheim, 2005; S. E. Baker, 2012). It was agreed that the size of focus groups would be capped at a maximum of six participants. Including more than six participants risked limiting the time for each participant to contribute or complicate the

discussion, making elements impractical. However, focus group size was influenced by participant availability.

Data saturation is defined as the level at which the process of data collection provides no more new themes and this was met after recruiting 16 participants (5 males and 11

females). With regards to perceived adoption status to digital technology, seven perceived themselves as late adopters, five as middle adopters and four as early adopters. Twelve described themselves as non-users of RPM, three as occasional users, who described themselves as being in the transitional phase. One regular user had successfully imbedded RPM into their clinical practice and used the application DM™ for every patient. Orthodontists with different perceived adoption status were recruited in order to provide authentic information on the perceived barriers and facilitators of RPM technology and their experiences.

5.1.4 Reflexivity

Qualitative interviews are informed by interpretivism and phenomenology i.e., understanding and making sense. It is impossible to be entirely detached from the interview process and reflexivity is an important concept. Awareness of the role of the interviewer in shaping and potentially biasing the data collection process was recognised. Prior undertaking the interviews, the researcher felt that orthodontists may have had mixed reviews regarding remote orthodontic assessments. The researcher also felt that remote management of orthodontic emergencies would be viewed as a means of trouble shooting issues solely. The researcher did not consider that the list of potential applications of remote monitoring was countless and orthodontists were exploring more opportunities to monitor remotely, for example, reviewing of oral hygiene. The researcher felt remote monitoring of clear aligners would be more feasible than monitoring of fixed appliances. Furthermore, the researcher anticipated the views towards direct-to-consumer orthodontics would be primarily negative. The interviewer tried to mitigate these bias' by showing unconditional positive regard for participants and adopting 'fair dealing' approach.

5.1.5 Rigour and trustworthiness

Qualitative research can be subject to scrutiny due to its subjective nature and the variability in conducting thematic analysis. Qualitative reporting is hampered by conventional quantitative research methods that emphasise method over substance, numbers over words (Sandelowski, 1986). A bespoke software (MAXQDA^{TM}) was used to organise data and facilitate coding. The advantages of computer assisted qualitative data analysis include the facility to organise data and display in a more systematic and

accessible way (J.Ritchie, 1994; Ritchie *et al.*, 2013). Thematic analysis is also subject to criticism as it informs the reader more about what was in the mind of the researcher than about what was in the mind of the interviewee. To mitigate this dilemma, the researcher has endeavoured to ensure transparency throughout the report to enhance the audibility i.e., clear, logical progression of the steps taken. The 32-point checklist developed by Tong *et al.* (2007) was used to establish this (Appendix 3). All transcripts were reviewed with the research supervisor and an experienced qualitative researcher to clarify any ambiguity and ensure comprehensive coding along with data saturation.

5.2 Discussion of findings and practical considerations

Orthodontics is a rapidly evolving profession with various new appliances and modern treatment mechanics becoming available. Treatment is non-binary; often there is generally no definitively correct treatment. Participants expressed different beliefs and aspirations dependent on their line of work. They shared the same belief that RPM provides ‘assisted information’. However, not all participants are willing or ready to embrace RPM.

5.2.1 Patient-driven factors

The subthemes that arose were as follows:

- Patient feedback
- Patient time
- Public perception of orthodontics

Patient preferences and feedback were found to be particularly influential for non-users to make adoption decisions. Most participants freely reported that when patients began

to enquire for CA treatment, this acted as a motivator for orthodontists to provide CA as a treatment modality. Current evidence suggests there is a high demand and preference for CAs among older female patients (Saccomanno *et al.*, 2022). There has been an increase in adult populations seeking aesthetic appliances and this has been allied with advancements in CAT over the last 20 years (Weir, 2017). The early evidence for CA was weak comprising mainly of expert opinion and case studies. However, the weak evidence base did not deter early adopters (Rossini *et al.*, 2015). Patient influences may have played a role in encouraging adoption. Based on a survey of orthodontists during

the COVID-19 pandemic, 42% reportedly increased CA therapy in response to patient demand in 91% of cases. Whilst only 32% increased their use due to 'easier remote monitoring'. This highlights that patient desire can lead to changes to the delivery of orthodontic treatment. For users, patient desire was not a reason for embracing RPM technology as many of their patients had no prior knowledge or interest in remote care during the 'trial' phase. Users felt it would foster a positive orthodontist-patient relationship when RPM was available for patients who perceived orthodontic appointments as more inconvenient. It was suggested that the provision of remote appointments would offer time savings for patients and this would also be perceived positively by patients. This is more likely if the patient perceives a face-to-face appointment of less value or inconvenient (Lam *et al.*, 2023). Participants expressed mixed views regarding the perception of orthodontics by patients if one is deemed to be associated with remote monitoring. However, patients undergoing CAT reviewed remotely with DM^{TM} reported positive experiences (Lam *et al.*, 2023). Users expressed confidence and no concerns if used appropriately to 'closely monitor', ensuring optimum patient care and maintenance of welfare.

5.2.2 Peer influence

This theme was discussed in relation to colleagues who had normalised remote care into their clinical practice. The subthemes included the clinical applications of RM and infrastructure. Admiration of non-users was expressed for colleagues who had incorporated remote care into their clinical workflow due to the recalibration required. As such, non-users demonstrated a sense of reliance on users to test proprietary technology and learn from the mistakes of 'alpha-users'. This has been reiterated in

previous qualitative research (Jacox *et al.*, 2019). It is not uncommon for orthodontists to communicate and advise colleagues of new technologies available on the market. Jacox *et al.* (2022) reported 72% of orthodontists gain awareness of proprietary technology from other orthodontists. A survey investigating attitudes to evidence-based practice by Madhavji *et al.* (2011) confirmed that advice from experts has been reported to be more influential than clinical journals for instigating philosophical changes for orthodontists under the age of 40. Those over the age of 40 were more likely to choose clinical journals over expert advice. Explanations offered for these findings include that younger orthodontists are more familiar with the literature and have an increased

awareness of the skillset required for effective appraisal. Non-users typically associate RPM technology, such as DM^{TM}, with clear aligner treatment only. This is not unreasonable, given during periods of enforced RPM during the early stages of the COVID-19 pandemic, orthodontists found limited value in conjunction with fixed appliances (Lamb *et al.*, 2023; Parker & Chia, 2021b). These views were also mirrored in the current study.

Non-users were very interested in the idea of monitoring oral hygiene remotely in fixed appliance cases and this was not reported in previous investigative orthodontic research due to the limited depth explored (Parker & Chia, 2021b). Sangalli *et al.* (2021) reported better plaque control over six months in an orthodontic cohort and Shen *et al.* (2022) reported better periodontal outcomes in a periodontal cohort of patients who did not receive orthodontic treatment. Both studies involved the use of DM^{TM} to review photographs on a weekly basis. The improved periodontal outcomes are most likely due to the Hawthorne effect. Users highly valued RM of fixed appliances in relation to breakages and emergencies.

No participants were confident in the use of RPM for functional appliance therapy. Users of RPM felt remote monitoring of functional appliance treatment may be considered in the future to monitor treatment progression or assist with compliance. Qualitative research has helped to ascertain factors which influence compliance with removeable twin block appliances. El-Huni *et al.* (2019) highlighted the importance of the patient-clinician relationship and the development of good rapport by being supportive which will positively influence compliance. RPM applications may offer platforms for

communication and foster positive relationships in the future thereby improve compliance.

The substantial number of remote images requiring review and action was considered a major barrier for non-users. Users allocated protected time for reviewing data and have delegated team members for assistance. The additional task involved, accompanied with the time commitment has not been previously reported in the literature. However, if participants perceive remote monitoring as onerous and time consuming, it is likely to deter adoption. Similarly, GDPs did not continue online orthodontic referrals in previous research due to the increased time allied with cost (Mandall & Harvey, 2005). In relation

to data delegation, it was apparent that orthodontists who work closely with orthodontic therapists are already accustomed to delegating tasks. Therefore, they were more likely to delegate reviewing of remote data which would help mitigate the voluminous task. A versatile team was described as an essential component for embracing RPM. Some non-users had less faith in team members to embrace new technology. A similar view was reported by decision makers in Jacox *et al.* (2019) with practice owners adopting technology without staff input due to the belief they would be resistant to change. Moreover, users expressed satisfaction in the ability to dictate tasks within their team but also confidence in tailoring protocols. Some non-users expressed feelings of anxiety and apprehension with individualised monitoring regimes.

5.2.3 Setting/Systems

This theme relates to logistics, private and public orthodontic settings. The public orthodontic setting was perceived as a barrier and private orthodontic practice was perceived more positively as an influencer. The public sector barrier was described, by some non-users, as grown greater, due to COVID-19 pandemic and security breaches. This seems to mirror a survey by Jacox *et al.* (2022), whereby most non-adopters of digital technology work in corporate offices. As a result, they may lack purchasing autonomy which was also described in the current study. Given the perceived difficulties, some non-users in public units described their difficulties in purchasing simpler amenities, such as digital scanners for clinical records. There was a perception that a large discrepancy in technology exists between public and private orthodontic sectors.

Hence, RPM technology was considered too great of a technology advancement for public orthodontic sectors. Users in private practices tend to agree with the views of non-users in this matter. Non-users described 'roadblocks' within public sectors, such as IT support, which was regarded as less of an issue in private practices. Logistical challenges and IT support have been cited as common difficulties in teledentistry and telemedicine (Abdolkhani *et al.*, 2019; Cook *et al.*, 2001; Mandall & Harvey, 2005). Non-users expressed concerns over data security and this was not a major concern for users in private practices due to encryption and security measures.

5.2.4 Cost-effectiveness

This theme was subdivided into cost, time, and efficiency. Costs was perceived differently by users and non-users. Non-users perceived RPM technology as a barrier for adoption, but users did not. Some users described mitigation of expenses by incorporating additional fees into treatment provided whilst others felt in the long-term, clinical time saved compensated for the cost. Users judged cost savings by weighing up the fees generated per appointment, against the cost of RM technology, as well as the additional non-clinical time spent reviewing data. There are no analogous economic analysis available likely due to the complexity and variation in costs. It was evident that users had strong views that RPM improved the efficiency of orthodontic practice. Users strongly believed that RPM "saved clinical time'; however, it was also hard to quantify the clinical time saved. They believed that time gained could be utilised to effectively plan complex cases or allocated for other tasks. They also reported that RPM assisted in management of unexpected visits and emergencies by identification of broken brackets/wires or highlighting the imperfect fit of CAs. Sangalli *et al.* (2021) reported fewer emergency appointments over a 6-month period with patients reviewed with DM$^{TM.}$ Both groups contained patients with fixed and CAs; however, the control group has more patients with fixed appliances. Studies tend to approximate the number of clinical visits saved, as opposed, to measuring clinical time saved in minutes. There was a perception that RPM in conjunction with CAs may reduce the need for clinical face-to-face appointments. Lam *et al.* (2023) reported 1.5 fewer appointments over an average period of 11.6 months. Whereas retrospective research reported 2.3-3.5 fewer

appointments over a period of 13 months (Hansa *et al.*, 2021; Hansa *et al.*, 2020). Users report having designated time for reviewing remote data; whether that task is delegated or not. Time was perceived as highly valuable for all participants. Non-users expressed uncertainty regarding location of 'free time' to complete data reviews. Non-users were less willing to change the clinical workflow required due to the time and effort required. Non-users believed it was harder to ring-fence time whilst working in the public orthodontic service or if working part time in private practice. Users did not report reviewing data outside clinical hours and this was a common fear for non-users should they decide to adopt. Ultimately, it would have a negative impact on quality of life. There is no literature available discussing the positive or negative impact of remote data

management on quality of life for clinicians. In the present study, users praised the positive impact, whereas non-users' perceptions were negative.

5.2.5 Clinical applications

With regards to applications, this encompassed the following:

- Assessments
- Active Treatment
- Retention

Collectively, orthodontists felt strongly that remote consultations using remote digital technology were insufficient and not appropriate for making a diagnosis and treatment plan. It was considered more appropriate to complete assessments face-to-face in the clinical environment. It was felt this would limit the possibility of 'missing information' and will facilitate rapport building. Remote assessments with images or radiographs alone is challenging and this has been shown in the literature with regards to orthodontic screenings (Mandall *et al.*, 2005). In this study, where the diagnosis was uncertain, the patient was ultimately reviewed in the clinic face-to-face. In addition, a recent teledentistry law has been passed in the US State of Nevada (Nevada Legislature, 2023). The new law states the requirement of "an in-person visit before the patient begins using an orthodontic appliance." Nevada is the first state in America to pass such teledentistry

laws. With regards to active treatment, participants felt that RPM with AI is useful for CA therapy. In relation to fixed appliances, participants felt RPM was beneficial for reviewing oral hygiene and as a method to share collective responsibility between patients and parents. They believed this may reduce the incidence of carious white spot lesions; however, evidence to support this is lacking. Sangalli *et al.* (2021) investigated the effectiveness of DM^{TM} to monitor oral hygiene in patients treated with fixed appliances and CAs. There were more carious lesions accounted for in the control group; however, this did not reach statistical significance. This can be explained as the groups did not match in terms of pre-treatment equivalence. There were more patients with fixed appliances in the control group but these patients were wearing lingual appliances. Remote monitoring of patients with labial appliances could be more beneficial due to the higher risk of labial surface decay. In relation to retention, orthodontists felt RPM was more suited for reviewing the fit of removeable retainers. Limited research has

demonstrated that DM^{TM} can identify ill-fitting retainers (Sangalli *et al.*, 2022). This is promising and could mean earlier identification of relapse or positively influence patient retainer wear compliance. However, some participants within the study felt it was impractical and not cost effective for patients to take images for RPM once a month. Previous research regarding remote retainer review appointments did not reveal this depth of knowledge due to weak survey design (Parker & Chia, 2021b). There was a perception that RPM was less suited for reviewing fixed retainers due to their lingually placed position and the requirement to dry the fixed retainer for full visualisation. Although, it may be useful for detection of aberrant torque changes, an unfavourable complication associated with fixed retainers and bone dehiscence or fenestrations (Katsaros *et al.*, 2007; Malik *et al.*, 2022). There is ambiguity regarding the responsibility of maintenance of fixed retainers between GDPs and orthodontists due to poor communication respectively (Molyneaux *et al.*, 2021). The mechanism of retainer activation is not fully understood but it can occur early or many years after the patient has been debonded (Abu Arqub *et al.*, 2023). RPM has been advocated as a strategy alongside dual retention and frequent follow up appointments to promote early detection of adverse changes (Abu Arqub *et al.*, 2023).

5.2.6 Misuse and oversight

All users expressed concerns pertinent to DIY orthodontics and the negative perception and image this may portray to the orthodontic profession. These feelings were underpinned by what some participants described as the personal experiences of 'victims' who sought DIY orthodontic treatment. They reported that patients were influenced by the reduced cost but in their opinion, this came at the expense of poor treatment planning and a compromise of patient welfare. Often, patients seek DIY orthodontic treatment due to the reduced cost (Acosta-Lenis *et al.*, 2022). Participants hoped for stricter laws and tighter regulations to protect the safety of the public from DTC orthodontics. A recent law passed in Nevada was met with strong opposition by DTC orthodontic representatives, such as SmileDirectClub (Nevada Legislature, 2023). One participant discussed her experience with a patient who was unsatisfied with her DIY orthodontic treatment outcome. This required a further course of comprehensive orthodontic treatment and the participant felt very strongly that this should have been provided from the outset. The AAO released a pamphlet to increase patients awareness and

shortcomings of treatment provided by DTC Orthodontics (American Association of Orthodontists, 2021). There is a public recognition in America that the provision of treatment by orthodontists is superior because often adults with children will choose orthodontic treatment provision with a specialist for their children. But they are more inclined to choose DTC orthodontic treatment for themselves (Olson *et al.*, 2020). Equally, in the state of Florida, a bill was passed to increase awareness and accountability of DTC orthodontic companies. It is a requirement that DTC companies keep a record of a dentist provided to a patient should they be required and to prevent irreparable damage (Florida State Legislature, 2023). Given the concerns raised by orthodontists within this study and the concept of 'SmileDirectVictims" reported, it is plausible that stricter laws will soon be approved in Europe.

5.2.7 Attitude for potential future adoption of RPM

The attitudes of participants can be described as positive or negative. Users of RPM displayed a positive attitude towards RPM whilst non-users displayed negative orambivalent attitudes. By describing the attitudes of participants as primarily positive or negative, we are placing attitudes on a hypothetical straight line or linear continuous

scale. Furthermore, some non-users were positioned within the 'in between' space described by Temple (2010) – a space which is not static or stable but subject to shifts according to events and influences beyond one's control. This epitomises the ambivalent attitude of non-users as they displayed both positive and negative perceptions. Attitude scales are not designed to yield subtle insights in individual cases but chiefly divide participants into broad groups and allow the study of a range of interwoven variables associated (Oppenheim, 2005). It became apparent that there is a paradigm shift in attitude towards the concept of RPM and this is attributed to success of alpha users exploiting the benefits of proprietary technologies. The change in mindset was also influenced by the COVID-19 pandemic and national education events which have increased awareness of RPM. Peers who have successfully integrated RPM technology have been influential in shifting the focus of RPM as being solely affiliated with CAs. The positive influence of peers has been cited in similar qualitative research (Jacox *et al.*, 2019). There is an increasing recognition, among some alpha adopters, of the usefulness of 'assisted information' provided by remote monitoring. All participants anticipate broad adoption of RPM and anticipate increase remote monitoring across all areas in orthodontics. Those with a positive attitude were more likely to adopt futuristic changes.

5.2.8 Implications for research

Qualitative knowledge is seen as situational and the findings elicited are unrepresentative when judged against a broader sample of orthodontists in various situations. The research does not give an indication of the proportion of orthodontists in Ireland either using or planning to use RPM. Nonetheless, there are no previous studies exploring the attitudes to remote patient monitoring among orthodontists. The in-depth interviews have explored the complexities and attitudes of RPM among a cohort of orthodontists in Ireland. This qualitative research has provided insight into facilitators and barriers in a novel area which can complement future research. Within the context of this present study, lack of patient desire, public orthodontic settings, logistical issues, orthodontic philosophies, cost, attitude and lack of high-quality evidence regarding efficiency were

identified as barriers to remote patient monitoring procurement. On the other hand, interest expressed by patients, a motivated capable team, IT support, future high-quality evidence in conjunction with reduced costs and a positive attitude have been reported as influencers. Future research could focus on the perspectives of regular users of RPM as the researcher felt less confident in reporting these views due to the small number of participants; however, overall it was felt data saturation was met.

Further quantitative research would enable further inferences to be made. More specifically, the attitudes and perceptions elicited are emotional and can be used to formulate items for future quantitative research, such as, questionnaires. Furthermore, the are situational and may change in the future if broad adoption patterns increase as anticipated.

5.2.9 Limitations

Focus groups were conducted until the researcher felt data saturation was reached. The conduction of a one-to-one interview helped ensure saturation was reached and exploring

the views of regular users of RPM. There was a small number of alpha users within the sample and this likely reflects the current adoption trend of regular users of RPM in Ireland. The researcher endeavoured to recruit more participants who are regular users of RPM; however, this was an ongoing challenge due to current trends and time constraints. This illustrates the importance of investigating the associated barriers and influencers. Moreover, the presence of a moderator during the focus groups for observation of group dynamics, behaviours, non-verbal cues and speaking order would aid the transcription analysis and minimise the risk of bias. However, this may have affected the participation rate and ability of participants to speak freely. Exploration of the credibility of the results (member-checking) whereby the results are returned to participants to check for accuracy and resonance with their experiences was planned; however, due to time constraints this did not occur (Miles, 2014). The key barriers and facilitators to adoption among orthodontists appear to be multi-faceted and contingent upon setting, support, staff, patients, philosophy and perceived advantages. In other words, the adoption patterns of RPM like most phenomena do not obey the traditional

laws of linear dynamics, where outputs are proportional to inputs. RPM uptake is organised in a non-linear way to some extent. The scientific dealing with non-linearity is complexity theory, of which the more profiled ‘chaos theory’ is a branch. There is no accepted definition of the complexity theory and it remains ambiguous (Gomm, 2008a). This theory describes phenomena as complex, ‘everything influences everything subsequent, but not consistently, and how things turn out differently every time’. In other words, it would be unwise to assume, phenomena cannot be regarded as closed systems.

6 Conclusions

In this qualitative study, several pivotal factors underpinning adoption of RM technology were identified. This qualitative study highlights the multifaceted nature of RPM as perceived by the participants with a range of facilitators and barriers identified. Orthodontists anticipate broad adoption of RPM technologies in the future allied with an increased range of applications and available technologies. Users of RPM technology view RPM as a future standard of care; however, not all non-user participants appear willing to embrace this. Semi-structured qualitative interviews of Irish Orthodontists in private and public workplaces revealed the following:

1) Users of RPM technology have a positive attitude towards RPM technology whilst non-users have ambivalent attitudes;
2) Users perceive RPM influence positively on their practices through increased efficiency, broad usage, cost and time savings;
3) Non-users allude to a lack of patient desire, less use in conjunction with fixed appliances and in public orthodontic settings, cost, time, and public perception of the profession as barriers; and
4) RPM of oral hygiene of patients with fixed appliances may become imbedded into routine care

List of Appendices

Appendix 1 Original Topic Guide 1

The topic guide below will help guide the discussion with the aim of gaining ample rich data. The interviewer Dr Michael Donnelly will need to be unaffected by circumstances that may arise, attitudes and beliefs felt by participants or by personal involvement. The job of the depth exploratory interview is *not* data collection but *ideas* collection. The primary objective is to maintain spontaneity. With the following questions, I will be listening to not only what is being said but also what is omitted and explore what lies behind them. expressions.

Research Questions

1. What are the attitudes and perspectives of remote monitoring
2. Digital technologies utilized
3. Factors influencing adoption or inhibiting non-adoption i.e. barriers and facilitators
4. Perceived areas of usefulness

Introduction

Thank you very much for taking part in this study. As you will be aware, my name is Michael Donnelly and I'm a current orthodontic postgraduate in Trinity College Dublin. As you know, we are carrying out some research on remote patient monitoring. This discussion is informal and completely confidential. The discussion will be recorded and transcribed into an anonymous transcript. No one else except me will have access to the audio-recording. Your name will not appear in anything we write. With your permission, I would like to record the interview. This is so that I can concentrate on what you are telling me rather than spending the whole-time taking notes. Is that OK? As soon as we have completed the transcription, the audio recording will be destroyed within thirty days.

Some of the headings/hidden agenda to guide the interview are:

- Evolution of Teleorthodontics into Remote Patient Monitoring
- Digital technologies available
- Routine use of RM
- Obstacles and facilitators

Main Questions	Possible Probes
What forms of remote communication do you all use at present? Why do you not use it? Why do you not adopt remote technologies?	What are their initial thoughts? Adopter? Early, mid or late? When did you first hear of RM? What are your experiences? **<u>Did you always hold these views or did that change and why?</u>**
Where is it not useful and why?	<u>Potential useful areas</u> Treatment Progress Compliance e.g. TBAs, URAs, Aligners Oral Hygiene Retention – motivation decrease after one year Emergencies? Why do you feel it is useful in these areas and is not? etc
What technologies are you aware of and what are your thoughts of these? Scope of RM	(Diverse sample of technologies reflected in the literature) Please give some examples. WhatsApp, Videoconferencing tools, Dental Monitoring Real time vs store and forward How did they hear of these technologies? What information did they consult if adopted? What are your thoughts around the newer technologies or increased demand/uptake/acceptance by patients and providers?
Clear Aligner Therapy What are they seeing patients for face to face when using? Scheduling of records review: when is this done? How do patients make direct contact?	Customized appliances and can allow remote monitoring (not feasible with fixed appliances) Concerns with fit of aligners Replace traditional review appts or as an adjunct What do you inform patients or what differs between this form of treatment and face-to-face? Are they informed it is a medical procedure? Direct guidance and ongoing supervision Actively monitored Ideally visits the practice or clinic for fitting of initial clear aligner appliances by a dental professional How do the manage if they need to be seen in person? Communication with patient and when is this done? Should not be totally reliant on AI functions and records

	Adjunctive?
<u>Data Concerns</u> What information/data is obtained? How reliable do you feel the data generated is? How confident do you feel in relying in patient generated data? What concerns have you with collecting patient data?	Patient generated health data: Data Reliability Sensor data relates to wear Visual images provided? In/out, tip, torque, overjet, and OB Review of retainers (removeable and fixed) Raw data collection (outside the clinic) and interpretation of this? Confidence in doing so? To explore the systems needed to ingrain. Who views images? When? Time/support implications
Barriers/Obstacles for implementation	Cost May be diplomatic and say lack of evidence available etc. Would this deter from adopting this technology in the future? How could these be addressed? Unmet technologic needs
Factors or influencing adoption of remote monitoring Cues for willingness of change	Do you they see potential benefits or believe in the benefits? What areas of improvement do you think would be required (if any)? Is this something you will embrace/consider increased use or adopting in the future?
Regulations	Do you feel there is potential for misuse of this technology which may impact patient safety, treatment outcomes and public confidence?
Direct to consumer orthodontic treatment	Supervision of care by orthodontists or suitably trained dentists Services direct to patients using clear aligners

THANK YOU VERY MUCH FOR TAKING PART

ASSURANCES ABOUT CONFIDENTIALITY

Reassurance regarding confidentiality

Thank you

Do you think there is anything else I should have covered or you think we may have missed?

Appendix 2 Revised Topic Guide 2

Introduction

Thank you very much for taking part in this study. As you know, we are carrying out some research on remote monitoring. The discussion will be recorded and transcribed into an anonymous transcript. No one else except me will have access to the audio-recording. Your name will not appear in anything we write.

With your permission, I would like to record the interview. This is so that I can concentrate on what you are telling me rather than spending the whole-time taking notes. Is that OK? As soon as we have completed the transcription, the audio recording will be destroyed within thirty days.

Provisional themes to guide the single interview

Remote Patient Monitoring

1) Applications: Appliances and stages of treatment
2) Facilitators
3) Barriers
4) Efficiency: Cost and Time
5) Logistics: Infrastructure and Data
6) Misuse of technology

Note: Exploratory discussion may not go in the ordered format given
Conversation may flow in other directions

Main Questions Adopter	Possible Probes
General What forms of remote communication or monitoring do you use at present? What are your views of remote monitoring? Can you describe your experiences of remote monitoring?	*Do you see it as adjunctive or an essential? (i.e. used every day in modern orthodontic practice and would struggle without it)*
Applications/stages What areas or stages of treatment to do find RM useful? What cases do you use RM for? What patient factors would influence you to use RM (if any)?	What stages or appliances would you be happy to review remotely? -Fixed, aligners, removeable, functional, expanders, elastic wear - L+A, OB reduction, space closure, retention? *May say all cases but need to probe types of appliances vs stages of treatment vs case selection e.g. certain cohort of patients – personality types?* Trying to probe case selection. E.g. high risk of WSL
Facilitators Why did you did decide to embrace or adopt remote monitoring in orthodontics? When did your attitude change? What factors were important for you that facilitated adoption?	What was the appealing aspect of it? *Alpha tester – did you know anyone else using this technology or what reasons did you have for trialling it?* *Presuming he wouldn't use 10-20 years ago* *Pinpoint the pivotal moment!!!* *Practice builder – does it attract patients? Reputation builder? (this guy does RM. He's high-tech modern vs he's lazy and never wants to see me)*
Barriers What are the main hindrances or setbacks initially? What are the challenges associated with RM?	*Non-adopters talk about the trial period, lack of support and IT support, the lack of clarity around regime or protocols.* *Cost implications also* *In terms of efficiency, for part time (work one day in a practice) do not see the benefit as book is already filled)*

Logistics: Infrastructure & Data What are your protocols (if any)? What are your set 'check points' to review in the clinical setting? How do you schedule virtual appointments or manage time to review?	Remote monitor all patients routinely? See aligners for IPR , see fixed as planned for wire changes? Ad hoc *When or how do you review data? Time set aside e.g. 2-4pm weekly or whatever.*
Data What are your experiences with the remote data?	*Data delegation* *I.e. who reviews what data?* *When is the data reviewed? Are you satisfied with the data?* *Check points for escalation?*
Future – role of AI? What future developments do you see?	Trends?

THANK YOU VERY MUCH FOR TAKING PART

Appendix 3 Participant information leaflet (PIL)

Part 1 – The Study

'Exploration of attitudes and perspectives to remote patient monitoring'

Why is this study being done?

We are doing exploratory interviews (single and focus group discussions) to explore the attitudes and perspectives of remote patient monitoring (RPM) in orthodontics among orthodontists. The discussion will provide insight into the views of orthodontists, filling knowledge gaps in the literature, exploring potential facilitators and barriers for RPM procurement and assist with development of educational guidance and future projects in relation to RPM.

Why have I been invited to take part?

You have been invited as you are registered on the orthodontic specialist list in Ireland and a member of the Orthodontic Society of Ireland (OSI). We aim to conduct 30 semi-structured interviews.

Do I have to take part? Can I withdraw?

Participation in the exploratory discussions is entirely **voluntary** and a decision not to participate will have no consequences on future relations with the OSI nor DDUH. You can change your mind at any stage during the process and you will not have to provide a reason for withdrawing your participation.

What happens if I change my mind?

You can change your mind at any stage by contacting Dr Michael Donnelly (Michael.donnelly@dental.tcd.ie). If you choose not to participate in the focus group discussion, this will not affect your relationship with the orthodontic society of Ireland (OSI), DDUH or other colleagues. If you change your mind during or after the focus

group discussion, you will be able to erase the data (if you wish) up to 30 days after the focus group discussion. Dr Michael Donnelly will be able to listen to the file and remove contributions made. However, it will not be possible to do this after the audio file is destroyed and the anonymous transcript remains. However, this may flaw the discussion therefore if you do not wish to contribute it is more practical and less challenging to decline participation.

How will the study be carried out?

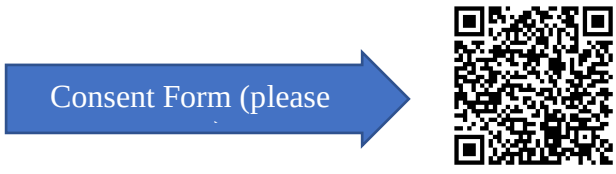
Participants will receive this PIL and a link for an online consent form (included at the end of leaflet) The researcher Michael Donnelly will contact if you are interested in participating and schedule a future date. The discussion will take place via Zoom and if all participants are happy to record, the discussion will be recorded. Your name will not be linked with any of the discussion. The audio file will be **destroyed** when transcription into an anonymous transcript has been completed.

YOUR NAME WILL NOT BE LINKED WITH ANYTHING YOU SAY

What will happen to me if I decide to take part?

The discussion will take place over one session on Zoom in November (date and time to be confirmed and may last 30-60 minutes). If you decide to participate you will join an online discussion on Zoom with approximately five other orthodontists, Dr Michael Donnelly (lead researcher). Single interviews will be employed to explore some areas further if required. Participants will be invited to join the interview via zoom. The discussion will be semi-structured and may revolve around the following topics:

Remote Monitoring in Orthodontics
Useful areas
Applications
Factors influencing uptake or barriers
Data and regulation



Discussions will be audio-recorded and transcribed by transcription service Sonix to generate an anonymous transcript. This will be used to identify themes for analysis. The

audio-recording will be destroyed approximately once transcription is complete (within 30 days).

Are there any benefits to taking part in this research?

Taking part in this study will not directly benefit you. However, research performed with the information provided may provide a better understanding of the facilitators and barriers to remote monitoring in orthodontics. It will help fill knowledge gaps in the literature and assist with development of future trials/applications relating to remote monitoring.

Are there any risks to me or others if I take part?

There are no anticipated risks in partaking in the study. If any sensitive information is brought up during the study, the individual can be removed from the virtual room and should the participant feel inclined, access will be made available to a counsellor. There is a risk that a connection to your identity could be made given the distinctiveness of individual voices. The audio file will be stored on a password protected computer and Zoom iCloud storage. The audio file will be kept for a limited time only, approximately 30 days until the transcription process is complete. Care will be taken to ensure the confidentiality of all audio-recorded data and will be available to lead researcher Dr Michael Donnelly solely. You will receive an email to confirm destruction of the data. The risk to participants of a breach of confidentiality is considered very low.

Will I be told the outcome of the study?

The thesis will be published with interpretations of the exploratory interviews and will be available within the Dublin Dental University Hospital Library. No information which reveals your identity will be disclosed. The results may be discussed for educational purposes at future OSI events

Part 2 - Data Protection

What will happen to my data?

All audio recorded data will be interpreted using the framework method to identify recurrent themes. The data will be transcribed by third party transcription service Sonix to create an anonymous transcript. Your name will not be linked to anything you say. The original audio-recording will be destroyed upon transcription (within 30 days). Lead researcher Dr Michael Donnelly will be responsible for ensuring data security with the use of password protected account.

Who will have access to my data? What will happen to my data?

All the data from the exploratory discussions that we collect will be kept strictly confidential and will only be accessible to member of the research team Dr Michael Donnelly. The data will be stored on personal computer of Dr Michael Donnelly and Zoom iCloud Storage. It will be transcribed by Sonix Transcription service. The audio-recorded data that could possibly identify you will be kept for 30 days until transcription is complete. After this time, the recorded data will be destroyed – Dr Michael Donnelly will be responsible for this. You will receive a confirmatory email of when this is complete.

Will my personal data be kept confidential? How will my data be kept safe?

Your privacy is important to us. We take many steps to make sure we protect your confidentiality and keep your data safe. Here are some examples of how we do this:
Any information or data which is obtained during this research which identifies you will be treated confidentially. All the audio-recorded data collected will be stored on the researcher's laptop in an encrypted password protected file. The audio-recorded data will be transcribed into an anonymous transcript. The original audio file will be destroyed from Zoom and Sonix after a period of approximately 30 days.
All online consent forms will be retained for a period of 7 years with the Supervisor Professor Padhraig Fleming in line with GDPR regulations.

All individual researchers involved in this project have been trained in data protection law and are bound by professional code to maintain confidentiality.

Part 3 – Costs, Funding and Approval

Has this study been approved by a research ethics committee?

The study has been approved by the Dublin Dental University Hospital Research Ethics Committee Approval was granted on 12th May 2022 (DSREC2022-06).

Who is organising and funding this study? Will the results be used for commercial purposes?

The research will be conducted by Dr Michael Donnelly Orthodontic Postgraduate student and funded by the Dublin Dental University Hospital. No grant is being provided for completion of the project. The research is for the purpose of fulfilling the requirements of D Ch. Dent Doctorate in Orthodontics. No remuneration is being provided to the lead researcher. The results will not be disclosed for commercial purposes.

Is there any payment for taking part? Will it cost me anything if I agree to take part?

No, we are not paying participants to take part in the study. It will not cost you anything to participate except approximately 60 minutes of your time.

Part 4 – Future Research

The anonymous transcript will not be used for any other future research.

Part 5 – Further Information

Who should I contact for information or complaints?

If you have any concerns or questions, you can contact:

- Principal Investigator:

Dr Michael Donnelly

Orthodontic Registrar

Email: Michael.donnelly@dental.tcd.ie

Mobile: 00447464399076

- Data Protection Officer of Dublin Dental University Hospital:

  Colette Kinsley

  Colette.kinsley@dental.tcd.ie

- Data Protection Officer, Trinity College Dublin: Data Protection Officer, Secretary's Office, Trinity College Dublin, Dublin 2, Ireland. Email: dataprotection@tcd.ie. Website: www.tcd.ie/privacy.

Under GDPR, if you are not satisfied with how your data is being processed, you have the right to lodge a complaint with the Office of the Data Protection Commission, 21 Fitzwilliam Square South, Dublin 2, Ireland. Website: www.dataprotection.ie.

Will I be contacted again?

If you would like to take part in this study, you will be asked to sign the online Consent Form (link in email). You will be given a copy of this information leaflet. If you consent, we will contact you to arrange a time to conduct the focus group discussion.

Part 6 - QR Codes for convenience (please scan)

Participant Information Leaflet

Consent Form

Appendix 4 Consolidated criteria for reporting qualitative studies (COREQ): 32-item checklist

Consolidated criteria for reporting qualitative studies (COREQ): 32-item checklist

Developed from:
Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 2007. Volume 19, Number 6: pp. 349 – 357

No. Item	Guide questions/description	Reported on Page #
Domain 1: Research team and reflexivity		
Personal Characteristics		
1. Inter viewer/facilitator	Which author/s conducted the interview or focus group?	Methods Page 39
2. Credentials	What were the researcher's credentials? E.g. PhD, MD	Methods Page 39
3. Occupation	What was their occupation at the time of the study?	Methods Page 39
4. Gender	Was the researcher male or female?	Methods Page 39
5. Experience and training	What experience or training did the researcher have?	Methods Page 38
Relationship with participants		
6. Relationship established	Was a relationship established prior to study commencement?	No
7. Participant knowledge of the interviewer	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	Methods Page 38 PIL Appendix 3
8. Interviewer characteristics	What characteristics were reported about the inter viewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	Methods Page 39 Discussion Page 70

Domain 2: study design		
Theoretical framework		
9. Methodological orientation and Theory	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	Literature Review Page 31 Discussion Page 68
Participant selection		
10. Sampling	How were participants selected? e.g. purposive, convenience, consecutive, snowball	Discussion Page 69
11. Method of approach	How were participants approached? e.g. face-to-face, telephone, mail, email	Methods Page 38
12. Sample size	How many participants were in the study?	Results Page 44
13. Non-participation	How many people refused to participate or dropped out? Reasons?	Results Page 44
Setting		
14. Setting of data collection	Where was the data collected? e.g. home, clinic, workplace	Methods Page 39
15. Presence of non-participants	Was anyone else present besides the participants and researchers?	Methods Page 39
16. Description of sample	What are the important characteristics of the sample? e.g. demographic data, date	Methods Page 38
Data collection		
17. Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	Methods Page 39
18. Repeat interviews	Were repeat inter views carried out? If yes, how many?	No
19. Audio/visual recording	Did the research use audio or visual recording to collect the data?	Methods Page 39
20. Field notes	Were field notes made during and/or after the interview or focus group?	Methods Page 39
21. Duration	What was the duration of the inter views or focus group?	Results Page 45
22. Data saturation	Was data saturation discussed?	Discussion Page 70
23. Transcripts returned	Were transcripts returned to participants for comment and/or correction?	No
Domain 3: analysis and findings		
Data analysis		
24. Number of data coders	How many data coders coded the data?	One (The author)

25. Description of the coding tree	Did authors provide a description of the coding tree?	Methods Page 43
26. Derivation of themes	Were themes identified in advance or derived from the data?	Methods Page 42 Themes were derived from the data
27. Software	What software, if applicable, was used to manage the data?	MAXQDA™ Page 41
28. Participant checking	Did participants provide feedback on the findings?	No
Reporting		
29. Quotations presented	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number	Results Page 46
30. Data and findings consistent	Was there consistency between the data presented and the findings?	Yes
31. Clarity of major themes	Were major themes clearly presented in the findings?	Yes Results Page 45
32. Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	Yes Discussion Page 71

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