Dental practitioners and a digital future: an initial exploration of barriers and incentives to adopting digital technologies

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VERIFIABLE CPD PAPER

RESEARCH

Background Digital technologies are proliferating into dental practices. While their technical attributes have often been studied, it remains unclear why some dentists adopt and use these technologies more than others. **Aim** To explore the incentives for and barriers against accepting and using digital dental technologies **Method** Eleven semi-structured qualitative interviews were conducted with experts in dentistry, dental technology and dental education in the Netherlands. **Results** Dentists' acceptance and use of digital technologies are to varying degrees driven by the perceived advantages over analogue methods, perceived influence on treatment quality, dentists' personal and professional orientation, and social influence from peers and external groups. These effects are complemented by personal and dental-practice characteristics. **Conclusions** The findings suggest that there are large differences in motivation to adopt and use digital technologies between early adopters, late adopters and non-adopters, which should be examined in greater detail. We recommend that educators, dentists, and representatives of the dental industry who deal with the diffusion of these technologies take account of dentists' widely different attitudes to digitalisation.

INTRODUCTION

In recent decades, digital technologies have gained ground and now play an important role in the development of dentistry.[1–3] Many processes in dental practices are changing: communication and information handling are increasingly computer-mediated, digital radiology and photography are common in diagnostics, and dental treatments are more often relying on digital methods for processes such as impression taking, treatment planning and implant surgery. Some of these techniques have become integrated into dental practices, whereas others remain relatively unknown to dentists.

Besides dentistry, technological changes are influencing many aspects of life – the so-called 'digital revolution'. The digital future this term refers to can be approached from two different perspectives. On the one hand, it can be seen as full of opportunities and as bringing progress. On the other hand it can be seen as full of known and unknown risks, leading to a critical scrutiny of presumed progress.[4–6] These views influence the way users and developers of technologies act and consequently the impact that innovations have on everyday practice.

Literature on dental education,[1,7,8] expert opinions and descriptive studies[3,9–11] regularly debate the question of what digitalisation in dentistry means for current and future dental professionals. However, most research on digital dental technologies focusses on their technical properties or clinical performance.[2,12] Yet these alone are no guarantee for widespread acceptance among intended users.[13–15] Success of innovations is strongly influenced by dentists' attitudes, expectations, work relationships and interests.[15–17] Only a limited number of studies have investigated dentists' various attitudes to particular technologies,[2,12,18–22] though such research is more common in studies in healthcare.[16,23–25] Most of these build on the 'diffusion of innovations' theory developed in the 1960s by Rogers,[13] who showed that the successful diffusion of innovations results from acceptance by intended users. Overall, users consist of 'innovators' and 'early adopters', who start using a technology when it is still in its early phases of development; 'early majority' and 'late majority', who adopt when diffusion accelerates; and 'laggards', who remain as the last group of non-users. Whether users adopt innovations depends largely on their perceptions, as Rogers and others have shown.[13,23,26–29]

In healthcare literature, innovation adoption is often studied through the lens of barriers and incentives to clinical change in particular contexts.[24,25,30–34] A previous study[18] on barriers to adoption in dentistry found costs, lack of comfort with technology and legislation issues to be the main obstacles. Further empirical data on the ways in which dentists make sense of and act upon the stockpile of available technologies is still limited. The aim of the present study is to explore which factors influence dentists' decision-making on accepting or rejecting digital technologies in daily dental practice.

MATERIALS AND METHODS

As existing research on the topic of attitudes towards digital dental technologies is scarce, this paper takes

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an inductive approach,[35,36] aiming to identify themes that will later be explored in a survey study among Dutch general dental practitioners. Qualitative research methods are particularly suited to such explorative research and to investigations into experiences and views of participants.[37–39]

Data collection

Semi-structured interviews were conducted with people professionally involved in dentistry and dental technologies. Semi-structured interviews have an open character, leaving space for topics and views brought up by the participant, while addressing key questions using a topic guide.[35,40] The topic guide used in this research was developed by the authors based on a review of the literature on diffusion and acceptance of technologies, (science and) technology studies, and observational visits to general dental practices. It included a general part about (1) observed and expected developments in digital dentistry, (2) ways in which dentists deal with digital technologies, (3) barriers and incentives for dentists to accept and use digital technologies and (4) influences of digital technologies on daily practice. The second part included questions adapted to the professional group the participant belongs to, aiming at identifying barriers and incentives to technology adoption, as well as processes that occur alongside technological developments.

A total of 11 participants were selected using purposive sampling.[35,38] Participants included: dental technicians (two), a representative of dental technological apparatuses (one), teachers involved in dental education (two), and practising dentists (six). The group of dentists included participants in various positions within the profession: specialist (one), involved in research in technology (two), involved in a professional organisation (one) and working in insurance evaluations (one). All participants were contacted through the networks of the authors and all agreed to participate.

A pilot interview with two general dental practitioners was conducted and evaluated. All interviews were conducted in Dutch by the first author, and ranged between 40 and 70 minutes each. They were recorded and subsequently transcribed. Quotations used in this article were translated into English by the first author.

Analysis

The transcribed interviews were coded using thematic content analysis.[41] The topics addressed in the interviews, as drawn from the topic guide, were included in the thematic analysis, alongside themes that emerged from the interviews. The thematic coding structure thus developed was evaluated by four assessors; the first and second author and two independent dental practitioners. Each of these assessors coded the interview data independently. The purpose of this method was to increase inter-rater reliability,[41,42] and to increase intersubjective judgement across different disciplines by selecting assessors from different backgrounds. After the independent coding assessments were compared, they were combined to construct a final coding structure that was checked by two assessors who proposed no changes.

RESULTS

Digitalisation in dentistry: current and future technologies

Digital technologies in dentistry comprise a large set of different applications. The experts generally agree that digital administration and communication systems are used in the vast majority of Dutch dental practices. Digital radiographic technologies are also in use in many dental practices, but other technologies such as intraoral scanners and CAD/CAM systems have not been widely accepted today, let alone more specialised treatment devices such as CBCT scanners and implant planning technologies. When discussing the use of digital ICT systems or digital intraoral or 3D radiology, most experts displayed a fair grasp of the systems' use, quality and effects, while with the lesser-diffused technologies such as CBCT or intraoral scanners, a lack of information about their use and consequences of use were often noted.

The way forward? Benefits and drawbacks of digital technologies

The majority of the experts noted that the main motivators to accept or reject technologies are the relative advantages that they offer to dentists, compared to the (analogue) methods they replace.

Similar types of advantages were noted, summed up by one of the experts as '*time advantage, financial advantage, and clinical advantage*' (Interview I). In terms of time, benefits encompass shorter treatment or administration time and transferring tasks to non-dentists. Financial benefits are based on the costs of purchase, maintenance and learning, set against increases in efficiency and revenue. Moreover, technologies increase revenue when incorporating work that was performed outside the dental practice, or enlarging the scope of treatments performed.

Even if dentists reason that a technology promises benefits, adoption is often postponed if they believe that '*prices will drop and the benefits will become clearer*' (Interview B). For some this was a reason to postpone adoption decisions. To others, who were generally more involved in innovative technologies, these considerations do not lead to postponing adoption as they expect higher returns later on. As one dentist stated '*You will never get to the ultimate point anyway, the moment you buy it it's already falling behind*' (Interview B).

Quality, standardisation and evidence

As mentioned in the first paragraph, advantages of digital over analogue techniques were incentives, clinical advantages being one of these. Specifically, increasing precision and accuracy, standardising processes and reducing error sensitivity in dental care were indicated as important advances in quality when digital technologies are considered. While discussing standardisation, several experts pointed to a tension between desiring standardised processes and reluctance among dentists regarding the transparency that goes with it. Choosing 'quality tools' was also mentioned as a motivator. Perceptions of what quality means vary. '*For example, you place 100 implants. With limited diagnostics 95% of the cases were okay. With a bit more elaborate diagnostics it's 97%. Then the last 3% you say that's because we don't have enough diagnostics. And at a certain point the added value is hardly improving at all*' (Interview H). Another aspect mentioned by some experts is that technologies are often marketed before their quality is known or tested. They note that dentists want more insight

into the effects of using technologies before adopting them.

Barriers to change

If the aforementioned advantages are absent they may become a barrier to adoption, but additional barriers also exist. When ease of use of technologies is lacking in the eyes of users, this constitutes a barrier to adoption. The main barriers to adoption concern awareness and emotional aspects. As one interviewee stated: '*If the consciousness changes then nearly everyone will switch over at the same time. While the technology may be there people may still be unaware that it is already available*' (Interview G). This is linked to cautiousness, which increases when technologies in an early stage of development are perceived as suffering from inadequate efficiency and ease of use. It is often intensified by the fear that benefits will not last and disuse might ensue: '*that is the biggest fear, the cupboard full of clutter, so the more expensive it is, the more security people want*' (Interview K).

On a personal level characteristics such as age and the number of working years left may discourage investing in digitalisation. Lack of skills in using digital applications can be a barrier that may be especially salient in those trained in a less digital environment. Crucial barriers pertaining to the dental practice are its size and the number of co-workers, as smaller practices have less leeway to invest. Additionally, treatments that a technology enables are in some cases only performed a limited number of times. Ethical and juridical responsibilities may be a concern when technologies lead to more information and the availability of more choices. These oblige the practitioner to make decisions on aspects that often remained unnoticed with analogue methods and dentists may feel unprepared for such decisions.

Professional orientation and innovativeness

When asked about their reasons for using digital technologies, many of the respondents mentioned aspects that bring motivation and enjoyment to their work. Innovativeness, with a preference for working with digital technologies outside of work, as well as the wish to keep upgrading work and skills, characterises many. Professional orientation may prevail over simple cost-benefit analyses: '*If my wife would calculate how much time I've invested in things that in the end did not work you cannot but observe that it's been a hobby. So, justly, people usually wait and see*' (Interview I).

In the opinion of some of the experts, dentists with a technical, artisanal orientation avoid digital technologies, seeing them as contributing to developments in the profession that deemphasise their priorities. Business and entrepreneurship-orientated dentists may adopt technologies when considering them beneficial for efficiency and practice management. Focus on quality of care was perceived to be an important motivator, especially among specialised dentists: '*The dentists who work digitally are those very engaged in their work. It needs the input of someone who is motivated to make it better or more constant*' (Interview E). However, professional motivation based on quality of care may also lessen willingness to adopt digital technologies when dentists doubt technologies' effectiveness or when other aspects such as preventive care are prioritised.

Social influence

Contact between dentists with and without experience in using digital technologies is an important prompt to their use: '*It gets known and then it trickles into this class. And then there's all the differences between them. One gets a kick out of it, the other thinks something new – nah. but at a certain moment they turn and then it's introduced. There, to facilitate introduction, commercial and financial interests, insurance companies, patients play a role*' (Interview H). Furthermore, credibility of the persons recommending the use of technologies is a pivotal factor. Especially fellow dentists who base their experience in research are mentioned as influential and trustworthy. Pressure and incentives from external groups contributes to social influence, especially government policies and incentives, the dental technology industry, dental laboratories, and developments in universities. These encompass tax deduction for environmentally friendly technologies and subsidies by technology providers.

Future directions

So far, factors that influence acceptance of digital technologies among dentists have been discussed. The implications they have for the ways the profession develops was also discussed. To some of the experts digital technologies are but a small force of change among many others, changing at most the means of providing dental care. Others view the transformations that digital technologies give rise to as profoundly altering the profession, now and in future years.

The relationship between the development of the dental profession and other professional groups in the field of dental care was brought up, pointing to increasing task delegation and a need for cooperation. Additionally, if technologies take over complicated tasks, this may also change the role of dentists: '*I think in 20 years from now the dentist himself will not be doing anything in the mouth, but will leave it to others. Then things will go from doing to thinking. This will happen partly due to digital techniques, partly due to other changes*' (Interview K). Wider changes that are likely to influence willingness to digitalise mentioned by the interviewees include the rise of larger practices, more part-time work, and more protocols regarding disinfection and other processes.

DISCUSSION

Dentists find themselves faced with a stockpile of digital technologies and the focus of this study was on their acceptance and rejection, focusing on barriers and motivating factors encountered along the way (Table 1). In line with studies on barriers and incentives to innovation in the wider health care sector,[33] we distinguished four levels of barriers and incentives. These go far beyond the technical properties of digital dental technologies. Adoption of dental technologies varies for each individual and for each technology, yet overall tendencies can be distinguished, which should be investigated in detail in further research.

From the interviews it appeared that perceptions of relative advantage – financial aspects and time saving foremost among these – and quality effects were the most frequently identified factors. Many studies on the diffusion and acceptance of innovations similarly showed that such perceptions of innovations are crucial in explaining users' intentions.[13,23,26,43]

In studies within dentistry,[2,18,19] aspects primarily influencing technology adoption are perceptions of: (1) relative advantage and (2) ease of use. The latter was mentioned less often in our study, possibly because we discussed technologies in general and not one specific technology. Studies on healthcare innovation adoption[44,45] point out that another crucial barrier is the influence on quality of care.[31,44] The issue came up as a central concern for the adoption of digital technologies in dentistry, while in new technologies evidence on quality effects is difficult to determine, as technologies are marketed before quality is known, or they are used in many more cases than intended. Several studies[31,34] from the literature on healthcare innovations confirm that evidence on these effects is usually contradictory and difficult to find, complicating adoption decisions. Other barriers to innovation adoption in healthcare have also been found and several reviews point out that a wide range of barriers may be present; while which of these play a role varies according to personal, organisational and socio-political context.[16,30–33,45]

Perceptions of relative advantage and ease of use of technologies in dentistry are not easily ascertained. For dentists who start using technologies at an early stage, relative advantages are often unclear, while costs and skills needed are high. Over time, if early adopters foster development of technologies, such investments decrease and advantages increase and become more visible. Many dentists therefore wait. However, without early users the development of technologies stagnates.[13] Consequently, we suggest that further studies take this into account by studying the differences between early and later adopters in detail. Furthermore, relative advantages and quality effects impacts not only dentists but also other groups. Using a technology can benefit patients, dentists, dental practices, or others such as dental technicians or industry partners, and each of these consequences may play a different role in dentists' deliberations.

Colleagues and other groups have a strong influence on dentists' attitudes to technologies. Previous studies showed that opinion leaders are especially influential in healthcare innovation,[13,43,46] distinguishing between peer and expert opinion leaders.[46]

Table 1 Barriers and incentives to adopting digital technologies				
Level	Innovation	User	Dental practice	Socio–political context
Incentive	Time advantages Financial advanatges Quality Predictability and standardisation	Age and education Innovativeness Technical orientation Entrepreneurial orientation Quality of care orientation	Task division Communication	Peer influence External influence Opinion leadership: peer, expert
Barrier	Investment Usability and ease of use	Skills Mindset	Practice size Frequency of treatment performance	Ethical and juridical concerns Skills and knowledge lag

The interviews showed that pivotal opinion leaders are dentists who are perceived as experts in their field, university researchers and educators. Moreover, contact with colleagues is crucial. Often opinion leaders are distinct from later adopting groups,[13,34] and sufficient attention needs to be given to the differences between concerns of each group.

This study took place in the Netherlands among a selected sample of experts. The setting is thus specific and the aims of the study exploratory. Thus, our results point to processes that are likely to influence technology adoption. Similar processes of technological change can be expected to occur in other advanced economies, though national variations in adoption may exist. Barriers and incentives to technology adoption that resemble those found here are therefore likely to play a role elsewhere, though national policies, for instance tax-deductibility, or dental practice size and organisation, vary.

This study set out to explore barriers and facilitators that dentists may encounter regarding the adoption and use of digital technologies. Based on interviews with experts in the field of dentistry, dental education and dental technology in the Netherlands, we identified a variety of these. Further research needs to address which of these actually influence dental practitioners' decision-making, taking into account the context of providing dental care. At a time when the development of dental technologies is getting up steam, understanding the ways in which dentists adjust to these changes can help the dental profession to adapt to the changes lying ahead.

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Appendix 1 Topic guide semi-structured interviews on digitalisation in dentistry

Part 1. General questions

1. Can you give an example that comes to mind when you think of digitalisation?

2. Which developments in digitalisation in dentistry.....
   - do you notice?
   - do you expect in the coming 5 years?
   - that you find important do you hope to see in the coming 5 years?

3. *(Possible overlap with question 1)*
   What has been an important digital development for you in your work?
   - What was important about it to you?
   - What had you expected of this beforehand? What did you not expect?

4. Can you describe how you use digital developments? How do you feel (other) dentists handle digital technologies?

5. In your view, what could be an impediment for dentists to use digital technologies?
   - What could be a driving force?

6. What influence would you say digitalisation has had on work in dental practices (/in your practice)?

Part 2. Questions specified to the interviewee's field of work
Questions to dentists (general dental practitioners)

1. Which digital technologies do you use in your dental practice?
   a. Why did you start using this (these) digital technology (technologies)?
   b. Did you notice any changes with the use of these technologies?
   c. Why did you start using this technology specifically?
   d. What does using the technology bring you?

2. Which new concerns arose for you when using these digital technologies?

3. Do you still use the digital technologies you acquired in the past 10 years in your practice?
   a. IF NOT: was there a change in the past 10 years in how you evaluate digitalisation?
   b. IF YES: did any changes occur in the ways in which you use them?
   c. What does this imply for how you think about digital technologies?

4. Were there any developments that you felt disappointed about?

5. How do you get to know what you wish to know about digital technologies?
   a. How do these sources of information/ knowledge weigh in your decisions regarding digitalisation?
   b. Do you attend study meetings or courses? To what degree do these provide you with information about technologies?