Dentists' opinions on using digital technologies in dental practice

Article *in* Community Dentistry And Oral Epidemiology · October 2017

DOI: 10.1111/cdoe.12345

5 authors, including:

Ronald Gorter
Academisch Centrum Tandheelkunde Amster…
97 PUBLICATIONS **1,005** CITATIONS
SEE PROFILE

Josef Bruers
Academisch Centrum Tandheelkunde Amste…
60 PUBLICATIONS **77** CITATIONS
SEE PROFILE

Irene H A Aartman
Academisch Centrum Tandheelkunde Amster…
112 PUBLICATIONS **2,195** CITATIONS
SEE PROFILE

Daniel Wismeijer
Academisch Centrum Tandheelkunde Amste…
190 PUBLICATIONS **3,151** CITATIONS
SEE PROFILE

Received: 22 September 2016 | Revised: 24 July 2017 | Accepted: 5 September 2017

DOI: 10.1111/cdoe.12345

ORIGINAL ARTICLE

WILEY Community Dentistry and Oral Epidemiology

Dentists' opinions on using digital technologies in dental practice

Marieke M. van der Zande[1,2] | Ronald C. Gorter[2] | Josef J. M. Bruers[2,3] | Irene H. A. Aartman[2] | Daniel Wismeijer[1]

[1]Department of Oral Implantology and Prosthetic Dentistry, Academic Centre for Dentistry Amsterdam (ACTA), University of Amsterdam and Vrije Universiteit, Amsterdam, The Netherlands

[2]Department of Social Dentistry and Behavioural Sciences, Academic Centre for Dentistry Amsterdam (ACTA), University of Amsterdam and Vrije Universiteit, Amsterdam, The Netherlands

[3]Royal Dutch Dental Association (KNMT), Nieuwegein, The Netherlands

Correspondence
Marieke M. van der Zande, Department of Social Dentistry and Behavioural Sciences, Academic Centre for Dentistry Amsterdam (ACTA), Amsterdam, The Netherlands.
Email: m.vd.zande@acta.nl

Funding information
ITI International Team for Implantology, Grant/Award Number: ITI Grant 777_2011

Abstract

Objectives: To investigate which opinions among dentists are associated with level of technology use, when characteristics of the dentist and dental practice, as well as motivating work aspects are taken into account.

Methods: A total of 1000 general dental practitioners in the Netherlands received a questionnaire on digital technologies they use, opinions on using technologies and related motivating work aspects. Questions were derived from expert interviews, the Dentists' Experienced Job Resources Scale and literature on technology implementation. Technology use was measured as the number of technologies used, and divided into three technology user groups: low (using 0-4 technologies, mostly administrative and radiographic technologies), intermediate (using 5-7, more varied technologies) and high technology users (using 8-12, including more innovative diagnostic technologies). Opinions on technology use and motivating work aspects were analysed using principal components analysis (PCA) and exploratory factor analysis. Scores on all components and factors were calculated for each respondent by computing the mean of all valid responses on the underlying items. Differences in these scale scores on opinions among the technology user groups were assessed using one-way analysis of variance and Kruskal–Wallis tests. A multiple linear regression analysis assessed the association of scale scores about opinions on technology use with the sum of technologies used, taking into account motivating work aspects and characteristics of the dentist and dental practice.

Results: The response rate was 31%. Dentists who were high technology users perceived technologies as yielding more improvements in quality of care, adding more value to the dental practice and being easier to use, than low technology users. High technology users thought technologies added more value to their work and they reported higher skills and resources. They also focused more on technologies and thought these are more ready to use than low technology users. High technology users derived more motivation from "Immediate results" and "Craftsmanship" than low technology users. Personal and practice characteristics, motivating work aspects, and the opinion scales "Focus" and "Added value to dentist" explained 50% of the variance in the number of technologies a dentist uses.

Conclusion: Opinions on digital technologies among dentists and motivating work aspects vary with level of technology use. Being more focused on technologies and

perceiving a higher added value from using them are associated with using more digital dental technologies, when taking into account motivating work aspects and characteristics of the dentist and dental practice.

KEYWORDS
attitudes of health personnel, clinical decision making, dental technology, diffusion of innovation, health services research

1 | INTRODUCTION

Dental practitioners deal with multiple developments in their work, many of which derive from external changes in wider society. One type of these are changes in work and workplaces as a result of the continuous development of digital technologies.[1] Such technological changes may ultimately change a profession itself.[2-4] For instance, in dental practices, digital administration has in most cases taken over from hand-written and cabinet-filed patient records. Moreover, dental treatment itself is evolving in various aspects by an ever-increasing ensemble of digital technologies.[5-10] With intra-oral scanning, for example, impression taking and planning of restorations are being digitalized, and CAD/CAM technology has enabled dentists to move some of the manufacturing of restorations into the practice.

When using digital technologies, users' opinions[11,12] and the extent of use of technologies[13] differ among professional groups in healthcare settings. This is in part due to the content and organization of the work at hand, to social processes within professional groups, and to attitudes and resources of professionals.[11-14] The use of technologies not only differs among professional groups, but also within them.[11,14,15] Some users adopt technologies—or, more broadly, innovations—early, while others do so much later or not at all, according to the seminal theory of diffusion of innovations.[16] These early and late adopters have distinct characteristics and opinions. Early adopters are often younger, have a more extensive social network and more favourable opinions of innovations. If an innovation is adopted by a substantial number of people, its diffusion becomes more widespread and includes more diverse user groups.

Whereas studies of the adoption and diffusion of innovations focus on decisions, other studies are broader than this and look at actual use.[17-21] Technology use is influenced by the following factors: the technology itself, the potential user, the organizational setting and the wider socio-political context.[17,18,21] With respect to potential users, the extent to which technologies align with their professional values is crucial for a technology to be used.[15,18,22] As described by Nieboer et al,[22] opinions on technology use are influenced by such values. Professional values, though used in many studies, are often not further explained and are operationalized in different ways. The Oxford English Dictionary[23] defines a value as "The regard that something is held to deserve; the importance, worth, or usefulness of something." Professional values thus refer to the importance, worth or usefulness which certain aspects of the professional occupation hold for a practitioner. In this study, we investigate professional values primarily in relation to motivation. We will refer to this as motivating work aspects. This pertains to aspects of work, such as doing technical work or delivering high-quality care to patients, that bring motivation, enjoyment and value to dentists' work.[18,24-26]

Dental practitioners' adoption of digital technologies has been investigated in several studies,[27-35] giving valuable insight into dentists' reasons for adopting specific technologies. Other studies have investigated the extent to which dental practitioners use various technologies, and for which purposes.[6-9] These studies usually focused on very specific technologies. This study takes a broader perspective by relating dental practitioners' opinions and motivating work aspects to the extent of use of the ensemble of digital technologies that are available to dental practitioners. This includes technologies for administration as well as for diagnostic and clinical purposes. The aim of this study was to investigate dental practitioners' opinions on digital dental technologies and the relation with their level of technology use. Specifically, we investigated which opinions among dentists are associated with level of technology use when characteristics of the dentist and dental practice, as well as motivating work aspects are taken into account.

2 | MATERIALS AND METHODS

A representative sample of 1000 general dental practitioners in the Netherlands was selected for this study. This group consisted of 92 dentists who participate periodically in surveys carried out by the Royal Dutch Dental Association (KNMT) and a randomly selected group of 908 registered general dental practitioners in the Netherlands. Each dentist received the questionnaire on paper, together with a postage-paid return envelope, and an accompanying letter giving them an access code to the questionnaire online. Respondents could choose which version to complete. The data collection was closed in July 2013, after three reminders. The questionnaire was developed based on interviews with experts in dentistry, dental education and dental technology. These interviews explored which digital technologies are most influential in the dental field and which factors may influence their use. Details about the interviews were reported on in an earlier paper.[18] A pilot to test the questionnaire was conducted among five dental practitioners. Based on their comments, wording was clarified for a number of questions. In addition, a "not applicable" answer category was added to the questions on

opinions (regarding participants' personal situation) on technology use. The questionnaire was approved by an independent research committee of the KNMT. The development, piloting and distribution of the questionnaire were described in more detail in an earlier paper.[36] The questionnaire started with items about personal and practice characteristics, such as age and the number of patients visiting the practice,[35] followed by items measuring technology use, opinions on digital technologies and motivating work aspects.

Fifteen digital dental technologies were identified as presently available and most relevant to general dental practitioners in the Netherlands, based on the views of experts expressed in interviews[18] and discussion between the authors. Items on both recent, innovative digital dental technologies and older, more widely used ones, were included in the questionnaire. Eight were administration and communication technologies. These included, ordered by decreasing frequency with which they were used by respondents[36]: digital patient registration, digital agenda, practice website and digital address and financial administration, digital appointments, information screens in the waiting area, practice supply management, and communication about the practice via social media. In addition, seven diagnostic and clinical technologies were included: digital intra-oral radiography, digital orthopantomograms, intra-oral cameras, intra-oral scanners, digital 3D radiology (eg CBCT), digital CAD/CAM (CEREC) systems and digital colour determination. Furthermore, a final item asked if respondents used any "other technology" (open question). Respondents were asked *Do you use this digital technology*? (yes/no) regarding each technology.

Most studies on technology use in other fields (eg hospital care, businesses) employed either intention to use a technology or whether a technology was used as a measure, often only for very specific technologies. We therefore deemed it appropriate to develop a measure, both to investigate an ensemble of technologies used, and to investigate one adapted to the setting of dental practices. Therefore, in a previous study,[36] we tested whether the number of technologies dentists use could be employed as a measure of technology use. In that study, we looked at whether dentists used a technology, how often they used it, when they had started using it, whether they wanted it if they did not use it and how satisfied they were with the technology. In that study, we could not use the frequency of use of technologies beyond reporting it per specific technology, because for example, digital administration would often be used far more often than a CEREC machine. Therefore, we developed a sum score (number of technologies used), and validated its categorization in three groups (low, intermediate and high TU) by testing whether it was associated sufficiently with dentists' own rating of their technology use compared to others. We found indeed that low, intermediate and high technology use, based on the number of technologies, were consistent with whether dentists thought of themselves as using less, the same amount, or more technologies than other dentists.

The sum of technologies used was calculated as the total number of times a respondent answered "yes" for any of the fifteen technologies or "other technology." This varied between 0 and 12, with an average of 6.3±2.3. The score was divided into three groups, based on the number of technologies used. Low technology users had 0-4 digital technologies of the most frequently used type, and included 22.5% of dentists. One dentist in this group used no technologies, four used 2 technologies and all others used multiple digital dental technologies. Intermediate technology users had 5-7 digital technologies, both very frequently and less frequently used ones (46.2.%). The high technology users had 8-12 digital technologies, using frequently used technologies and one or more less often used ones (31.3%). Technology user group was significantly associated with dentists' own assessment of their technology use.[36] Few respondents used more than 10 technologies; eight dentists used 11 digital technologies and two used 12. Further details were described in Van der Zande et al.[36]

Forty items of the questionnaire measured dentists' opinions on using digital dental technologies. Eighteen statements were included about general opinions, especially perceived relative advantages and perception of innovations, and twenty-two statements measured opinions regarding dentists' personal situation, in particular personal resources, attitudes and interest in technologies. The items were based on the opinions deemed most important by participants from expert interviews,[18] and literature on technology acceptance and implementation. Respondents were asked to think of treatment and diagnostic technologies used in dentistry when giving their response. Responses were given on a five-point Likert-type scale from 1 (fully disagree) to 5 (fully agree). Moreover, the items on opinion regarding dentists' personal situation included the response 0 (not applicable).

To measure motivating work aspects, items were derived from the Dentists' Experienced Job Resources Scale (DEJRS). The DEJRS was developed in a study on job resources—motivating aspects of work—among Dutch dental practitioners.[37] Items from its Dutch translation[38] were included in the questionnaire. Scales "Immediate results/Aesthetics," "Craftsmanship," and a combination of "Patient care" and "(Long term) Patient results" were included as the most relevant motivating aspects of work related to digital technology use.[18] Items from the DEJRS were not included if the item-total correlation in the original study[37] was substantially lower than that of other items on the scales. Respondents were asked *to what degree do you get satisfaction from*. . .. for each item (see Table 4 for details), with answers on a five-point Likert scale ranging from 1 (to no degree) to 5 (to a very large degree; 0=not applicable).

All data were analysed using IBM Statistical Package for Social Sciences (SPSS) for Windows version 21 (released 2012; IBM Corp, Armonk, NY, USA). For all statistical tests, a significance level of .05 was used. Principal components analysis with varimax rotation was used for the opinion items, since, for newly developed questionnaires, this is the most appropriate data reduction technique. Exploratory factor analysis with varimax rotation was used for items on motivating work aspects, as the latter measured latent constructs which were developed and tested in a previous study.[37] Cronbach's alpha was calculated for each component or factor. Scores on all

components and factors were calculated for each respondent by computing the mean of all valid responses on the underlying items. Items with missing values or "not applicable" values were not included in the calculation of the mean scores. Differences among the three levels of technology use in opinions and motivating work aspects were assessed using one-way analysis of variance when the scores on the scales were by approximation normally distributed; if not, Kruskal–Wallis tests were conducted. If the results of these tests were significant ($P<.05$), they were followed by post hoc Tukey's HSD or Mann-Whitney U tests respectively.

To assess to which extent scores on opinion scales are associated with the number of technologies used, a multiple linear regression analysis was conducted controlling for motivating work aspects and characteristics of the dentist and dental practice. Dentist and dental practice characteristics as well as motivating work aspects were included in the model if they correlated significantly with the number of technologies used ($P<.10$).[39] We conducted two types of analyses: (i) each opinion scale separately, adjusted for the included dentist and dental practice characteristics as well as motivating work aspects and (ii) all opinion scales together in the model, adjusted for the included dentist and dental practice characteristics as well as motivating work aspects. In the first analyses, the variables are included in the models using the enter method. In the final model, dentist and dental practice characteristics as well as scores on motivating work aspects were included with the enter method, and the opinion scale scores using a stepwise procedure. This procedure was chosen in order to assess whether one or more of these opinion scales contributed to the prediction of the number of technologies used, in addition to the variables already present in the model.

2.1 | Ethics statement

In the Netherlands, for survey research not involving patients, no medical ethical committee approval is required. The survey included questions to dentists about characteristics of the practice they work in, as well as about their professional opinion and behaviour on non-sensitive matters. On a voluntary basis, they could decide to respond or not to respond to the request to participate in the survey. The survey distribution and data entry of the returned questionnaires were carried out by an independent third party research institute: the Institute for Applied Social Sciences (ITS), linked to the Radboud University in Nijmegen, the Netherlands, and commissioned by the Royal Dutch Dental Association (KNMT). This research project was performed within an ongoing research programme of the KNMT: the Data Stations project. This programme consists of the collection of diverse data on various clinical and nonclinical aspects of practicing dentistry, carried out periodically and mostly in collaboration with other researchers. ITS confidentially collected and managed all research data within this study, in accordance with Dutch law on protection of person-specific information, in such a way that the researchers could not trace any of the data to an individual dentist or practice.

3 | RESULTS

A total of 313 of the 1000 respondents in the sample returned the questionnaire (response rate 31.3%). Two hundred and forty-nine of the 313 returned questionnaires were further analysed, after exclusion of 41 incompletely returned questionnaires and 23 questionnaires of respondents who were no longer working in oral health care. No statistically significant differences in technology use were found between those who replied on paper and online.[36] Characteristics of the respondents are summarized in Table 1 and were described in more detail in a previous paper.[36] No statistically significant differences were found between respondents and the population of registered dentists in the Netherlands[40] for sex ($\chi^2(1)=0.03$, $P=.86$, Cramer's V=0.002), age group ($\chi^2(4)=1.07$, $P=.90$, Cramer's V=0.011) and region within the country ($\chi^2(4)=3.31$, $P=.51$, Cramer's V=0.019). Moreover, a sample of 110 nonrespondents was asked by telephone why they had not participated. Of these nonresponders 43% indicated they had no time, 26% indicated they did not wish to participate in surveys or felt they were approached too frequently, 14% was not interested in the topic, 3% found the questionnaire too long or too complicated, and 15% had other reasons. Moreover, 52 of these 110 nonresponders answered a question on which technologies they used as follows: 92% had digital radiographic technologies, 35% had other diagnostic technologies, and 41% used social media or digital appointments. This indicated that overall technology use of these nonrespondents was not lower than that of respondents.[36]

Analysing the items measuring opinions (general opinions) with principal components analysis yielded three components, which were below the point of inflexion in the scree plot and had an Eigenvalue >1. One item ("the quality of treatment with digital dental technologies in general has not yet been sufficiently proven") was removed, and the analysis was performed again without it, as it showed low communalities and loaded onto all components. Few items had missing responses. The three components explained 57.7% of all variance. Factor loadings higher than 0.40 are shown in Table 2. The component "Quality improvements" comprises seven items on the contribution of digital technologies to improvement of quality of care. The component "Added value to practice" comprises six items on the value that digital technologies add to various aspects of running a dental practice. The component "Ease of use" comprises four items on the ease of use of digital technologies. Principal component analysis of the second set of opinions (opinions regarding personal situation) yielded four components, each with an Eigenvalue greater than 1. Factor loadings and items of each of the components are shown in Table 3. One item ("I have dentists in my surroundings whom I can talk to when digital technologies pose a problem to me") formed a separate component by itself in the initial analysis, and a relatively large number of respondents (30) indicated that the item was not applicable to them. Based on inspection of the point of inflection of the scree plot, this fifth component should not be retained; thus, it was removed from the analysis. The items on the remaining components had few missing responses. Per item, ten or

TABLE 1 Personal and practice characteristics of respondents

Variable	% of valid responses (n)	% of population[a]	*P*-value
Sex[b]			
Male	64 (157)	65	.86
Female	36 (89)	35	
Age group[b]			
<30	10 (25)	10	.90
30-39	22 (54)	23	
40-49	21 (50)	19	
50-59	33 (82)	33	
60-65	14 (35)	15	
Region[b]			
South	20 (50)	20	.51
West	56 (140)	51	
East	16 (39)	18	
North	8 (19)	10	
Other or unknown	0 (1)	1	
Specialization			
No	77 (190)		
Yes	23 (57)		
Practice ownership			
Owner	74 (183)		
Nonowner	26 (64)		
Working hours (per week)			
9-24	9 (19)		
25-39	42 (93)		
40-54	44 (97)		
55-70	5 (11)		
Number of patients visiting practice (per year)			
300-1000	6 (13)		
1000-1999	23 (49)		
2000-2999	23 (47)		
3000-3999	20 (42)		
4000-4999	10 (20)		
>5000	18 (38)		
Number of staff working in practice			
0-2	19 (46)		
3-5	21 (53)		
6-9	26 (64)		
10-19	21 (52)		
>20	13 (32)		
Reply means			
Paper	65 (162)		
Online	35 (87)		
KNMT panel membership			
Panel member	18 (44)		
Nonpanel member	82 (202)		
Total (n)	249	8741	

[a]Registered general dental practitioners in the Netherlands on 1 January 2013. Data from the national database of registered dentists in the Netherlands, obtained through the Royal Dutch Dental Association (KNMT).

[b]Chi-square $P>.05$; Cramer's V <0.05.

fewer respondents indicated that the item was not applicable to them, except for five items: one item on the first component ("Added value to dentists' work"), two on the third ("Focus") and three on the fourth ("Readiness"). Together, the components explained 61.5% of all variance. The component "Added value to dentist's work" comprises eight items pertaining to the value that digital technologies add to dentists' work. The component "Own skills and resources" comprises five items pertaining to a dentist's own skills and resources enabling him or her to work with digital technologies. The component "Focus" comprises five items pertaining to the degree to which digital technologies are in focus in the dentist's work. The component "Readiness" comprises three items pertaining to readiness of digital technology to be used, in the perception of dentists. The exploratory factor analysis of items measuring motivating work aspects (Table 4) showed convergence on three factors with Eigenvalues above 1. Together they explained 57.5% of the variance. Each factor contained five items. All items had few missing responses. On most items, none or one respondent indicated that the item was not applicable to them, except for the item "satisfaction derived from being happy to tinker," where six respondents indicated this was not applicable to them. The factor "Immediate results" refers to satisfaction derived from immediate results of work. The factor "Craftsmanship" refers to satisfaction arising from craftsmanship. The factor "Patient care and results" refers to satisfaction obtained from patient care and its results.

Respondents used between 0 and 12 digital technologies. The number of technologies used was normally distributed. Low technology users comprised 22.5% of the respondents, intermediate technology users 46.2% and high technology users 31.3%. The results of the comparisons of these three groups with respect to scores on opinion scales and motivating work aspect scales are presented in Table 5. An overall statistically significant difference among the three groups was found for scale scores on all opinions and motivating work aspects, except for "Patient care and results."

The outcomes of the multiple linear regression analyses are shown in Table 6. First, models are reported for each opinion scale separately, adjusted for dentist and dental practice characteristics as well as motivating work aspects (the number of patients visiting the practice per year, working hours per week, number of staff working in the practice, having a specialization, and the scores on motivating work aspect scales "Immediate results" and "Craftsmanship"). For each opinion scale, these adjusted models showed a statistically significant association with number of technologies used. Second, the

TABLE 2 Outcome of principal component analysis of general opinions on digital technologies in dentistry[a]

Item	Quality improvements	Added value to practice	Ease of use
Digital technologies contribute to diminishing differences in treatment quality between dentists	**0.73**		
Digital technologies contribute to diminishing mistakes	**0.78**		
Treating patients with digital technologies makes treatments more predictable	**0.84**		
Digital technologies improve the quality of treatment in complex, individual cases	**0.80**		
Digital technologies improve the quality of treatment in large groups of patients	**0.80**		
Digital technologies improve the quality of treatment methods	**0.78**		
Using digital technologies yields better precision in diagnostics	**0.46**		
Working with digital technologies enhances productivity		**0.61**	0.44
Digital technologies enable dentists to work more efficiently		**0.59**	0.43
Digital technologies yield more income from patient treatment to the practice		**0.68**	
Working with digital technologies makes the practice more attractive for young dentists		**0.75**	
Working with digital technologies makes the practice more attractive for patients		**0.78**	
Working with digital technologies enable dentist to distinguish themselves from colleagues		**0.60**	
Currently available digital technologies provide less possibilities than their analogue counterparts[b]			**0.65**
Currently available digital technologies require more intermediate steps than their analogue counterparts[b]			**0.75**
Digital technologies that can be used in dental practices are easily compatible			**0.61**
Digital technologies in the dental practice are easy to use			**0.63**
Eigenvalue	4.40	3.05	2.36
% of explained variance	25.9	17.9	13.9
Cronbach's α	.89	.82	.66

[a]Only rotated factor loadings >0.4 per item are included in the table. Rotated factor loadings are shown in bold when included in the component.
[b]Items were recoded, reversing the answer scale.

results of the final model are shown in Table 6. After adjusting for dentist and dental practice characteristics as well as motivating work aspects, the opinion scales "Focus" and "Added value to dentist" appeared to be the only two scales in the model, which explained 50% of the variance in the number of technologies used (r=.709, F (8,164)=20.77, P<.001).

4 | DISCUSSION

Scores on opinions on digital technologies, as well as on motivating work aspects involved, vary between low and high technology user groups among dental practitioners in this study. The level of digital technology use is related to the degree to which dentists hold certain opinions on technology use, on top of motivating work aspects and characteristics of dentists and the practices they are working in. Approximately 50% of the variance in the number of digital technologies a dentist uses could be explained by a number of characteristics of a dentist and the practice he or she is working in, satisfaction derived from results of treatment and from craftsmanship, and added value to himself or herself from technology use, as well as focus on technology use.

The response rate for the questionnaire used in this study was 31%. In surveys among Dutch dentists who are regularly surveyed, similar response rates are usually found.[41] The amount of missing response may affect the generalizability of the findings of this study. We investigated the response and missing response in three ways. Firstly, we compared the responses from 41 respondents among these 31% who returned incomplete questionnaires that could not be analysed, as most of their responses beyond personal and practice characteristics were missing, with those from respondents included in the analysis (249). We found that there were no substantial differences in their characteristics, except for their age. More respondents with missing data were in the 30-39 group (32%, compared with 22% of respondents with analysed responses) and fewer in the 50-59 group (22%, compared with 33%). Secondly, a sample of 110 nonrespondents was asked by telephone why they had not participated and which technologies they used. This indicated that overall technology use of nonrespondents was not lower than that of respondents.[36] Thirdly, age and gender distributions of the respondents were consistent with that of all registered general practitioners in the Netherlands.[40] In investigating the missing responses and the characteristics of respondents, we have thus found that respondents and nonrespondents appear to be similar. We can, however, not exclude that the response rate may affect the generalizability of the findings.

A number of studies have strongly argued for the need to develop measures of technology acceptance adjusted to specific healthcare contexts.[20,42,43] Few existing studies were found that assess dentists' opinions on using technologies, and none were

TABLE 3 Outcome of principal component analysis of opinions (regarding personal situation) on digital technologies in dentistry[a]

Item	Added value to dentist's work	Own skills and resources	Focus	Readiness
Digital technologies produce more than what I invest in them	**0.45**			
Digital technologies make my daily work easier	**0.55**		0.41	
Despite potential technical problems, I trust in digital technologies	**0.59**			
I think using digital technologies goes with professional practice	**0.68**			
I find my work more pleasant when I can work with many digital technologies	**0.78**			
I think the benefits of working with digital technologies that colleagues experience also apply to me	**0.77**			
I like to talk to colleagues about the digital technologies that I use	**0.69**			
I am enthusiastic about the digital technologies in my practice	**0.69**			
I have the skills which are necessary to work with digital technologies		**0.79**		
I have the knowledge which is necessary to work with digital technologies		**0.86**		
After participating in a course I usually know enough to be able to start working with digital technologies myself		**0.78**		
I have enough information about digital technologies to know what to expect		**0.78**		
If a digital machine crashes, I can solve the problem myself		**0.60**		
Digital technologies are not a priority to invest in for me[b]			**0.61**	
For the types of treatment I usually do, investing in digital technologies is not cost-effective[b]	0.46		**0.53**	
Working with digital technologies leads me away from what to me is the core of the profession[b]			**0.68**	
Digital technologies complicate choices between treatment options[b]			**0.78**	
Using digital technologies imposes too many procedures[b]			**0.72**	
I only purchase a digital technology when I'm sure I will keep on using it for a long time[b]				**0.85**
I wait before purchasing a digital technology until I know it will be of continued use to me[b]				**0.90**
Only if digital technologies are sufficiently validated, am I willing to invest in them[b]				**0.77**
Eigenvalue	4.08	3.32	2.87	2.65
% of explained variance	19.4	15.8	13.7	12.6
Cronbach's α	.84	.83	.81	.82

[a]Only rotated factor loadings >0.4 per item are included in the table. Rotated factor loadings are shown in bold when included in the component.
[b]Items were recoded, reversing the answer scale.

found that addressed such opinions for the whole range of technologies used in dentistry. Thus, in this study, a questionnaire was constructed based on interviews,[18] and compared with dental literature on adoption of specific technologies and social scientific literature on technology use. It was subsequently tested in a pilot and discussed by an external research committee to minimize bias. The resulting items formed components with satisfactory reliability coefficients and showed differentiation between technology user groups.

In this study, a large number of opinions on digital technology use were combined and adapted to the context of dental practices. Scores on these opinion-related scales vary with level of technology use. Many of the opinions studied here, especially perceived usefulness—the degree to which technologies are thought to enhance job performance[42]—and perceived ease of use—the degree to which using a technology is thought to be free of effort[42,43]—were found to be related to technology use in other populations as well. However, these studies often focused on very specific technologies, whereas in this study the ensemble of digital technologies used was investigated. Among dentists, factors relating to expected improvements to quality of care,[28,32,35] expected added value to the practice and to the dentist,[30,32,34,35] expected ease of use,[32] and own skills and resources[33] were found to be related to use of specific technologies. This study adds to previous studies by showing that scores on a large combination of opinion-related scales differed between dentists with varying levels of technology use.

In the final model, focus on technologies, as well as the value dentists think they add to their work explained part of the variance. "Focus," which refers to compatibility with a dentist's professional preferences and mindset, is a determinant of adoption among professionals often found in other studies.[11,16,32] Dentists who thought that using technologies adds more value to their work were also likely to use a higher number of technologies, which is in line with studies showing that "perceived usefulness" of technologies influences technology adoption in many sectors.[15,16,42,43] Other determinants sometimes found in other sectors, such as perceived ease of use, did not contribute significantly to explaining technology use in our final model, although results of technology use studies are inconsistent. The contribution of such factors to explaining technology

TABLE 4 Outcome of factor analysis of motivating work aspects among dentists[a]

Item Satisfaction from...	Immediate results	Craftsmanship	Patient care and results
Delivering beautiful pieces of work	**0.65**		
Making a successful restoration	**0.68**		
Seeing a good treatment result	**0.76**		
Delivering high-quality work	**0.77**		
Good diagnosis and treatment	**0.58**		
Doing technical work		**0.75**	
Working manually		**0.80**	
Being happy to tinker		**0.77**	
Being creative		**0.69**	
Combining medical and technical aspects		**0.47**	
Keeping company with people			**0.50**
Satisfaction or gratitude shown by patients			**0.60**
Relieving patients' pain			**0.63**
Gaining patients' trust			**0.79**
Long term satisfaction from work: the positive effects of treatment on patients' oral health			**0.68**
Eigenvalue	2.98	2.98	2.66
% of explained variance	19.9	19.8	17.7
Cronbach's α	.88	.87	.81

[a]Only rotated factor loadings >0.4 per item are included in the table. Rotated factor loadings are shown in bold when included in the factor.

use thus remains open to question.[15,16,42,43] Both "focus" and "added value to dentist" are a part of dentists' opinions regarding their personal situation, whereas their general opinions, such as quality improvements or the added value to dental practices did not remain in the final model. This suggests that using more technologies has more to do with dentists' opinions of what technologies do for themselves, rather than with their opinions of technologies' more general effects. The higher technology users often used more innovative technologies, and evidence on the general effects of these, such as the influence on quality of care, is often more contradictory and difficult to find than that of more established technologies.[15,18] Thus, opinions regarding the personal situation may play a more decisive role in the use of innovative technologies.

Motivating work aspects were intended to measure how much value is derived from specific facets of work[18]: satisfaction derived from doing technical work ("Craftsmanship"), from quality of treatment ("Immediate results") and from patient care ("Patient care and

TABLE 5 Distribution of scale scores on opinions on digital technologies and motivating work aspects by technology user (TU) group

Variable	n	Mean	SD	*P*-value
General opinions				
Quality improvements				
Low TU	55	3.0	0.6	.001*,b,c
Intermediate TU	115	3.1	0.7	
High TU	77	3.4	0.7	
Added value to practice				
Low TU	56	3.4	0.6	<.001*,a,c
Intermediate TU	115	3.7	0.6	
High TU	78	3.9	0.6	
Ease of use				
Low TU	55	3.4	0.6	.002*,a,c
Intermediate TU	115	3.7	0.6	
High TU	78	3.7	0.6	
Opinions regarding personal situation				
Added value to dentist				
Low TU	53	3.1	0.7	<.001*,a,b,c
Intermediate TU	114	3.4	0.6	
High TU	77	3.8	0.6	
Own skills and resources				
Low TU	53	3.2	0.8	<.001*,a,c
Intermediate TU	113	3.6	0.7	
High TU	77	3.8	0.7	
Focus				
Low TU	53	2.9	0.7	<.001*,a,b,c
Intermediate TU	113	3.6	0.8	
High TU	77	3.9	0.7	
Readiness				
Low TU	54	1.9	0.9	.001*,b,c
Intermediate TU	109	2.0	0.8	
High TU	74	2.3	0.9	
Motivating work aspects				
Immediate results				
Low TU	55	4.3	0.2	.030†a,c
Intermediate TU	115	4.5	0.5	
High TU	77	4.5	0.5	
Craftsmanship				
Low TU	55	3.6	0.7	.007†,a,c
Intermediate TU	115	3.9	0.7	
High TU	77	4.0	0.7	
Patient care and results				
Low TU	55	4.3	0.6	.823†
Intermediate TU	115	4.3	0.5	
High TU	77	4.3	0.6	

Distribution of scale scores on opinions on digital technologies and motivating work aspects by technology user (TU) group.
*One-way Analysis of Variance with post hoc Tukey HSD test.
†Kruskal–Wallis H Test with post hoc Mann–Whitney *U* test.
[a]Low TU- Intermediate TU *P*<.05.
[b]Intermediate TU – High TU *P*<.05.
[c]Low TU – high TU *P*<.05.

TABLE 6 Results of multiple linear regression analysis on the number of digital dental technologies used

Variable	B (unstandardized)	β (standardized)	*T*	*P*-value	*R*	R^2
Separate models per opinion scale						
Quality improvements	0.71	0.21	3.30	.001	0.62	0.38
Added value to practice	0.80	0.21	3.23	.001	0.62	0.38
Ease of use	0.70	0.17	2.76	.006	0.61	0.37
Added value to dentist	1.14	0.32	5.12	<.001	0.65	0.43
Own skills and resources	0.74	0.24	3.66	<.001	0.63	0.40
Focus	1.03	0.36	5.93	<.001	0.67	0.45
Readiness	0.48	0.16	2.50	.013	0.62	0.38
Final model				<.001	0.71	0.50
Number of patients visiting the practice (per year)	0.00	0.23	3.11	.002		
Working hours (per week)	0.03	0.11	1.78	.078		
Staff working in practice (persons)	0.04	0.17	2.29	.023		
Specialization	0.65	0.12	2.01	.046		
Motivating aspects: Immediate results	0.05	0.01	0.17	.864		
Motivating aspects: Craftsmanship	0.49	0.15	2.03	.044		
Opinions: focus[a]	0.71	0.24	3.13	.002		
Opinions: added value to dentist[a]	0.65	0.18	2.32	.021		

Results for models per opinion scale are corrected for the number of patients visiting the practice per year, working hours per week, number of staff working in the practice, having a specialization, and the motivating work aspect scales "Immediate results" and "Craftsmanship".
[a]Opinion scales entered stepwise into the final model. All other opinion scales were excluded by the final model.

results").[37] Scores on craftsmanship and immediate results were higher among higher technology users, indicating that these aspects were more motivating for those with higher technology use. This is in line with the findings of other studies.[21,22] However, being more motivated in general is also related to use of a technological application.[44] The relatively lower scores on motivating factors among low technology users could be related to lower job satisfaction in general, which might result in lower motivation to invest in improving workplace conditions, including the use of digital technologies.

Two variables that are related to the size of a dental practice—the number of patients visiting a practice, and the number of staff working in a practice—explained part of the variance in the number of technologies used. Similarly, various studies have shown that physicians working in larger practices have higher rates of adoption of digital administration systems than those working in smaller ones.[45] This may be because larger practices have more available resources. Investments may be more feasible in larger practices, where adequate training and support may be organized more easily, and more management resources may be available. However, the exact influence of organizational size on technology use has not been researched sufficiently to identify which of these or other mechanisms could explain the effect of organizational size.[36,45] The findings of this study cannot account for all variance in technology use. Other factors not included in our study could contribute to a fuller explanation.[20,21,42] Social influence and sociopolitical factors, for example, play a large role here, in the context of dentistry as well as in other health care professions.[4,14,20,32] Furthermore, developments in health care in terms of financing and juridical measures, changes in the workforce and in the size and organization of dental practices, can be expected to impact on technology use as well. This leaves technology use as a phenomenon that should be viewed in a larger context, and one that should be studied through multiple lenses.[4,20]

5 | CONCLUSION

Summarizing, opinions on digital technologies and motivating work aspects involved differed between dentists with lower and higher technology use. Opinions on technology use, together with characteristics of a dentist and the practice he or she works in, as well as motivating aspects, explained a large part of the variance in the number of technologies a dentist uses. The questionnaire used in this study was developed for use in a sample of dentists in the Netherlands, but the results indicate that it can be recommended as a basis for other studies. Differences in adoption factors and opinions, between those who are focused on technology use and those who are reluctant or opposed to their use, need to be taken into account by those who are guiding technology adoption in their own practices or who are educating future dentists. As digital technologies continue to develop further and as in the wider society digital methods are increasingly available, their use by dental practitioners can be expected to rise further. This increasing availability of digital technologies and their development in terms of quality and usability may affect opinions on technology use. Furthermore, as digital technologies are increasingly part of the education of future dentists, it remains to be seen how technology use and the opinions on digital technologies of dentists educated at present and in the future will

develop. Sustaining the aspects of work that motivate dentists, and those that contribute to quality of care and well-functioning work settings, need to be in focus when technologies are implemented. To achieve this, more research is needed into the consequences of technology use, and which approaches to implementation are likely to lead to realizing the benefits that users expect from technologies, and which to unexpected or unwanted outcomes. Dentists' opinions on digital technology use point us to what is important in their decision-making, but much remains to be investigated about the effects of technologies once they are used.

ACKNOWLEDGMENTS

The authors would like to thank all those who participated in this study, especially the respondents to the questionnaire, and the Royal Dutch Dental Association (KNMT) and ITS Nijmegen for facilitating and supporting the data collection. The study is part of a research project funded by the International Team for Implantology (ITI Grant 777_2011), to whom the authors wish to express their gratitude.

ORCID

Marieke M. van der Zande http://orcid.org/0000-0002-6117-6531

REFERENCES

1. Went R, Kremer M, Knottnerus A, eds. *Mastering the Robot: The Future of Work in the Second Machine Age*. Den Haag: WRR; 2015.
2. Petrakaki D, Barber N, Waring J. The possibilities of technology in shaping healthcare professionals: (re/de-)professionalisation of pharmacists in England. *Soc Sci Med*. 2012;75:429-437.
3. Masys DR. Effects of current and future information technologies on the health care workforce. *Health Aff*. 2002;21:33-41.
4. Webster A. Innovative health technologies and the social: redefining health, medicine and the body. *Curr Sociol*. 2002;50:443-457.
5. Flores-Mir C, Palmer NG, Northcott HC, Huston C, Major PW. Computer and internet usage by Canadian dentists. *J Can Dent Assoc*. 2006;72:145.
6. John JH, Thomas D, Richards D. Questionnaire survey on the use of computerisation in dental practices across the Thames Valley Region. *Br Dent J*. 2003;195:585-590; discussion 579.
7. Schleyer TKL, Thyvalikakath TP, Spallek H, Torres-Urquidy MH, Hernandez P, Yuhaniak J. Clinical computing in general dentistry. *J Am Med Inform Assoc*. 2006;13:344-352.
8. Song M, Spallek H, Polk D, Schleyer T, Wali T. How information systems should support the information needs of general dentists in clinical settings: suggestions from a qualitative study. *BMC Med Inform Decis Mak*. 2010;10:7.
9. Tay KI-P, Wu JM-Y, Yet MS-S, Thomson WM. The use of newer technologies by New Zealand dentists. *N Z Dent J*. 2008;104:104-108.
10. Van Noort R. The future of dental devices is digital. *Dent Mater*. 2012;28:3-12.
11. Vedel I, Lapointe L, Lussier M-T, et al. Healthcare professionals' adoption and use of a clinical information system (CIS) in primary care: insights from the Da Vinci study. *Int J Med Inform*. 2012;81:73-87.
12. Kyratsis Y, Ahmad R, Holmes A. Technology adoption and implementation in organisations: comparative case studies of 12 English NHS Trusts. *BMJ Open*. 2012;2:e000872.
13. Ferlie E, Fitzgerald L, Wood M, Hawkins C. The nonspread of innovations: the mediating role of professionals. *Acad Manag J*. 2005;48:117-134.
14. Fitzgerald L, Ferlie E, Wood M, Hawkins C. Interlocking interactions, the diffusion of innovations in health care. *Hum Relat*. 2002;55:1429-1449.
15. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: systematic review and recommendations. *Milbank Q*. 2004;82:581-629.
16. Rogers EM. *Diffusion of Innovations* (5th ed.). New York: Free Press; 2003.
17. Fleuren M, Wiefferink K, Paulussen T. Determinants of innovation within health care organizations: literature review and Delphi study. *Int J Qual Health Care*. 2004;16:107-123.
18. Van der Zande MM, Gorter RC, Wismeijer D. Dental practitioners and a digital future: an initial exploration of barriers and incentives to adopting digital technologies. *Br Dent J*. 2013;215:E21.
19. Robert G, Greenhalgh T, MacFarlane F, Peacock R. Adopting and assimilating new non-pharmaceutical technologies into health care: a systematic review. *J Health Serv Res Policy*. 2010;15:243-250.
20. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O, Peacock R. Storylines of research in diffusion of innovation: a meta-narrative approach to systematic review. *Soc Sci Med*. 2005;61:417-430.
21. Lau R, Stevenson F, Ong BN, et al. Achieving change in primary care—causes of the evidence to practice gap: systematic reviews of reviews. *Implement Sci*. 2016;11:40.
22. Nieboer ME, van Hoof J, van Hout AM, Aarts S, Wouters EJM. Professional values, technology and future health care: the view of health care professionals in The Netherlands. *Technol Soc*. 2014;39:10-17.
23. OED. Oxford english dictionary online [Internet]. Oxford University Press. 2016. http://www.oed.com/. Accessed Jun 1, 2016.
24. Gorter RC, Te Brake HJHM, Hoogstraten J, Eijkman MAJ. Positive engagement and job resources in dental practice. *Community Dent Oral Epidemiol*. 2008;36:47-54.
25. Hakanen JJ, Bakker AB, Demerouti E. How dentists cope with their job demands and stay engaged: the moderating role of job resources. *Eur J Oral Sci*. 2005;113:479-487.
26. Berthelsen H, Hjalmers K, Pejtersen JH, Söderfeldt B. Good work for dentists – a qualitative analysis. *Community Dent Oral Epidemiol*. 2010;38:159-170.
27. Bjørndal L, Reit C. The adoption of new endodontic technology amongst Danish general dental practitioners. *Int Endod J*. 2005;38:52-58.
28. Molander A, Reit C, Dahlen G. Reasons for dentists' acceptance or rejection of microbiological root canal sampling. *Int Endod J*. 1996;29:168-172.
29. Parashos P, Messer HH. The diffusion of innovation in dentistry: a review using rotary nickel-titanium technology as an example. *Oral Surg Oral Med Oral Pathol Oral Radiol*. 2006;101:395-401.
30. Locke M, Thomas MB, Dummer PMH. A survey of adoption of endodontic nickel-titanium rotary instrumentation part 1: general dental practitioners in Wales. *Br Dent J*. 2013;214:E6 1-10.
31. Rindal DB, Rush WA, Boyle RG. Clinical inertia in dentistry: a review of the phenomenon. *J Contemp Dent Pract*. 2008;9:113-121.
32. Matthews DC, Mcneil K, Brillant M, et al. Factors influencing adoption of new technologies into dental practice: a qualitative study. *JDR Clin Trans Res*. 2016;1:77-85.
33. Flores-mir C, Palmer NG, Northcott HC, Khurshed F, Major PW. Perceptions and attitudes of Canadian dentists. *J Can Dent Assoc*. 2006;72:243.
34. Kruger E, Estai M, Tennant M. Perceptions of Australian dental practitioners about using telemedicine in dental practice. *Br Dent J*. 2016;220:25-29.

35. Patel RN, Antonarakis GS. Factors influencing the adoption and implementation of teledentistry in the UK, with a focus on orthodontics. *Community Dent Oral Epidemiol*. 2013;41:424-431.
36. Van der Zande MM, Gorter RC, Aartman IHA, Wismeijer D. Adoption and use of digital technologies among general dental practitioners in the Netherlands. *PLoS One*. 2015;10:e0120725.
37. Gorter RC, te Brake JHM, Eijkman MAJ, Hoogstraten J. Job resources in Dutch dental practice. *Int Dent J*. 2006;56:22-28.
38. Te Brake J. Tandarts en Burnout: Kansen en bedreigingen in de tandheelkundige praktijk - Project Movir/ACTA II Tandarts en Burnout Volledige projectbeschrijving [Dentist and Burnout - internal research report]. Amsterdam; 2003.
39. In Lee K, Koval JJ. Determination of the best significance level in forward stepwise logistic regression. *Commun Stat Simul Comput*. 1997;26:559-575.
40. Royal Dutch Dental Association (KNMT). *Staat van de Mondzorg [State of Oral Health Care] [Internet]*. The Netherlands: KNMT; 2012. http://www.staatvandemondzorg.nl/.
41. Bruers J, den Boer J, van Dam B. Project Peilstations: monitor van de tandheelkundige beroepsuitoefening in Nederland [The Data Stations project: a monitor of dental practice in The Netherlands]. *Ned Tijdschr Tandheelkd*. 2014;121:345-352.
42. Holden RJ, Karsh B-T. The technology acceptance model: its past and its future in health care. *J Biomed Inform*. 2010;43:159-172.
43. Yarbrough AK, Smith TB. Technology acceptance among physicians: a new take on TAM. *Med Care Res Rev*. 2007;64:650-672.
44. Mertz E, Bolarinwa O, Wides C, et al. Provider attitudes toward the implementation of clinical decision support tools in dental practice. *J Evid Based Dent Pract*. 2015;15:152-163.
45. Boonstra A, Broekhuis M. Barriers to the acceptance of electronic medical records by physicians from systematic review to taxonomy and interventions. *BMC Health Serv Res*. 2010;10:231.

How to cite this article: van der Zande MM, Gorter RC, Bruers JJM, Aartman IHA, Wismeijer D. Dentists' opinions on using digital technologies in dental practice. *Community Dent Oral Epidemiol*. 2017;00:1–11.
https://doi.org/10.1111/cdoe.12345