



Patient-centred eHealth Interventions in Oral Maxillofacial Surgery

Stefanie van den Bosch



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First print © 2026 Stefanie van den Bosch

Cover image: © Dominique Hekner & Stefanie van den Bosch

ISBN: 978-94-654-4022-4

Produced by Proefschrifterij

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Patient-centred eHealth Interventions in Oral Maxillofacial Surgery

Proefschrift ter verkrijging van de graad van doctor
aan de Radboud Universiteit Nijmegen
op gezag van de rector magnificus prof. dr. J.M. Sanders,
volgens besluit van het college voor promoties
in het openbaar te verdedigen op

woensdag 23 september
om 14.30 uur precies

door

Stefanie Clara van den Bosch

geboren op 18 september 1984
te Nijmegen

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1

General Introduction



1.1 eHealth

The emergence of eHealth can be traced back to the advent of the World Wide Web in the nineties of the last century. The internet began as a source of information, i.e. a large worldwide public library. People increasingly started seeking information about their own health on the internet. In 2011 the internet already was the number one source of medical information for over 80% among people in the Netherlands who joined the online Hyves community.¹ Fourteen years later, 73.1% of the Dutch population still use websites or apps to search for information about their health or treatment.² Increasingly, new applications become available about medical information, including short videos lasting a maximum of 60 seconds on social media to complete personal stories with (X-ray) photos and videos in blogs. The accessibility of medical information and the ability to share personal experiences have led to a change in healthcare. From one-dimensional paternalistic care, where the caregiver told the patient what the best treatment would be, to a patient who is actively involved in determining the best treatment, with multidimensional information exchange.

The term eHealth is used interchangeably with terms such as telemedicine, teleHealth, m-health, Care 2.0, Medicine 2.0, remote care, and so on. For many, all these terms refer to digital care: care provided via the internet, mobile devices, and computers. In the past twenty years, eHealth has been defined many times in the literature, with no consensus yet reached.³⁻⁶ However, as early as 2001, Eysenbach stated that eHealth is not just about a technological development but is a way of thinking, an attitude aiming to improve healthcare through the use of information and communication technology. For him, the “e” in eHealth does not just stand for electronic but also for efficiency, enhancing quality, evidence-based, equity, empowerment, education, and encouragement. Particularly, the last three terms point to the changing way of thinking, focused on the role of the patient and the caregiver, where eHealth enables patient-centred care and patient involvement in their own care. The patient becomes an active partner in the healthcare team.

1.2 eHealth and the Role of the Patient

The word "patient" comes from the Latin verb "pati" which means to suffer, to endure, to permit. This implies a passive attitude of the person in question who is bearing pains or trials calmly or without complaints. When we consider the patient as a partner, it means that a certain level of responsibility can and should be expected from the patient, within the individual's capacity. Therefore, it would be more appropriate to speak of an "actient", from the verb "acti", which refers to act, deed or transaction. A term that implies active involvement, a critical attitude, and a degree of control over one's health and the healthcare process. Nonetheless, given that the term has not gained widespread acceptance in academic and clinical discourse, it will be omitted from this thesis in favour of clarity and readability. Instead, we will stick to the term "patient".

The first step for patients to maintain or, as far as possible, regain their health is to take care of their own body and lifestyle. When a person becomes ill or experiences health complaints, (s)he can become a student of his/her own disease/condition and can become actively involved. An important prerequisite for an active involvement is information and power.⁷ A better-informed patient who to participate, can discuss treatment options and weigh what is important for them in their own context.⁷ With the advent of the internet, the availability and accessibility of more comprehensive information has significantly increased. It is crucial, however, that the patient consults the right sources of information, as not all online information is reliable and adequate.

Therefore, guidance in interpreting and referring to the correct information by the healthcare professional is essential.⁸

Of course, we must realize that not every patient can take on an active, directing role to the same extent. Emotions, intelligence, social support network, finances, and other contexts can be limiting factors. Instead of expecting that every patient is always actively involved, patient-centred care implies that for each individual patient, it must be assessed and openly discussed to what extent this active role can be fulfilled, what care is appropriate for them at that moment, and what their own aspirations are in this regard. Patient-centred care asks for a dynamic process and can change for the individual patient over the course of their life.

1.3 eHealth and the Role of the Oral Maxillofacial Surgeon

Empowerment and Encouragement of Patients

The Dutch eHealth monitor 2023 showed that there is a broad availability of eHealth applications and that the use of these applications has increased slowly over the last three years.⁹ However, there are differences between various patient populations. Specifically, the use of digital care has increased among patients with chronic conditions.⁹ It concerns the use of patient portals, e-consultations, websites and apps for their health. In the Netherlands, in 2024, elderly patients and those with a vocational education made less use of digital care options compared to the three years before. Patients with a vocational education have less access to their own medical records and search for health information less frequently.^{2,9} This suggests that it may be important to increasingly offer care processes in a hybrid format, while encouraging and supporting specific patient groups to use eHealth applications. Such applications should be developed with active involvement of patients, ensuring that they are user-friendly and accessible.²

The now widespread application of Artificial intelligence (AI) in eHealth has increased the possibilities of tailoring such applications to patients. AI can tailor health information to individual needs. It can facilitate communication in multiple languages and it can convert information into visual or spoken formats, thereby lowering barriers for patients who are non-native speakers or patients with limited literacy.¹⁰ Promising results are seen in studies where AI is used to improve engagement and self-management by analysing data from wearables (such as heart rate, blood pressure, and glucose levels) to detect trends, and in combination with predictive models it can identify risks at an early stage.^{11,12} AI can, in a hybrid model, support behaviour change by providing reminders, motivational feedback, and appropriate self-help strategies.¹³ And lastly, AI decision-support tools could be able to assist patients in choosing appropriate treatments.¹⁴

Provision of Information

To create optimal information provision, new forms will need to be explored. Visual information in the form of videos and animations is often better understood than text.¹⁵⁻¹⁷ In addition to the role AI can play in providing visual information, emerging technologies such as virtual and augmented reality (VR and AR), as well as serious gaming, can also play a significant role in conveying understandable information.

In VR, a computer simulates an environment, immersing the user in an experience. A well-known example of this is the Oculus Rift, a headset developed in the gaming industry, which makes the user feel like they are in another world. Such headsets are already used, for example, to allow hospitalized children to virtually walk around their homes. This is also used to prepare for treatment and to provide distraction during treatment.^{18, 19}

AR adds computer-generated elements to a live image. This is already known from the interior design industry, where a QR code in the interior on a tablet or smartphone transforms into a new piece of furniture, allowing the consumer to assess whether it fits in their interior. Animated three-dimensional images could also serve as valuable tools for informing patients, such as explaining and illustrating of diseases and treatments. VR and AR can be combined with serious gaming, where the patient receives explanations or is prompted to change behaviour through a game. Examples are the use of AR to motivate oral hygiene practice in children²⁰, an AR application to promote physical activity in children²¹ and an AR game that improves the range of motion and muscle strength in children with spastic hemiplegic cerebral palsy.²²

A Changing Role and Position for OMF Surgeons

OMF surgeons have an important role in transferring knowledge and providing guidance to deliver more patient-centred care. Competencies will increasingly focus on this, and communication training as part of the medical training program will need to be expanded. OMF surgeons need to learn how to guide patients in making treatment choices, conduct consultations via different mediums (screens, tablets, augmented reality, etc.), and handle technical developments. They must also learn how to deal with questions for which the

patient might know the answers better than the surgeon to whom they are addressed.

Additionally, OMF surgeons must have knowledge of reliable and high-quality online information sources. While OMF surgeons can create good practice websites themselves, professional associations also play an important role. The Dutch Association of Oral Maxillofacial Surgery (NVMKA) already facilitates reliable patient information about oral health on its website (Folders en animaties – NVMKA).

OMF surgeons must also keep up with new technological developments, just as they must continue their education to stay updated on specific advancements. Increasingly, scientific literature is publishing on eHealth applications and their feasibility and efficiency. However, given the exponential growth of technology development, staying current solely through traditional means is no longer sufficient. It is, of course, impossible to be aware of all developments due to this rapid progression. Nevertheless, it is important to recognize that patients will present with apps, wearables, and monitoring gadgets that you may not have heard of. This should not be seen as a threat but as an opportunity to engage in discussions and perhaps further explore these technologies, ultimately serving other patients better. This truly exemplifies a partnership between the patient and the OMF surgeon.

1.4 eHealth in OMF Surgery, Aim and Outline of this Thesis

Within the field of OMF surgery, eHealth is expected to be a tool to improve the quality of care, in particular to support patients. As certain patient groups, such as head and neck oncology patients and patients with craniofacial abnormalities and their parents, endure high emotional and psychological impact of their (chronic) condition, one could expect support and information in the form of eHealth to be helpful.^{7, 23-25}

The research presented in this thesis aims to determine the current position of patient-centred eHealth in the field of OMF surgery and to identify the challenges and opportunities in implementing eHealth in the daily practice of OMF surgeons.

The aim of section I is to present an exploration of patient-centred eHealth in OMF surgery, it comprises three studies. In **Chapter 2**, the research on patient-centred eHealth interventions within OMF surgery is systematically mapped through a scoping review. This study aims to assess the detailed composition of these interventions and to evaluate the way in which these interventions were evaluated by patients and healthcare professionals. **Chapter 3** presents a study on the quality of online patient information regarding cleft lip and/or palate (CL/P). The aims of this study are to (1) define quality criteria for online information on CL/P; (2) assess the quality of online patient information on CL/P; and (3) map the potential differences in perspective on the quality of online CL/P information between patients, parents and healthcare professionals. Finally, **Chapter 4** reports on an explorative study assessing patients' knowledge and perceptions of AI in dentistry.

Section II of this thesis aims to present two evaluations of patient-centred eHealth applications in clinical practice. First, in **Chapter 5**, the efficacy, safety and tolerability of wearing audiovisual eyeglasses during third molar removal, as well as their effect on anxiety and stress, are investigated. Second, **Chapter 6** presents patients' evaluation of video consultations in the context of the COVID-19 pandemic.

The aim of section III is to give an overview of (future) applications of AI in the field of OMF surgery (**Chapter 7**).

Chapter 8 provides a general discussion of the work presented in this thesis. It presents the final conclusions, addresses the implications for clinical practice and offers suggestions for future research in this field.

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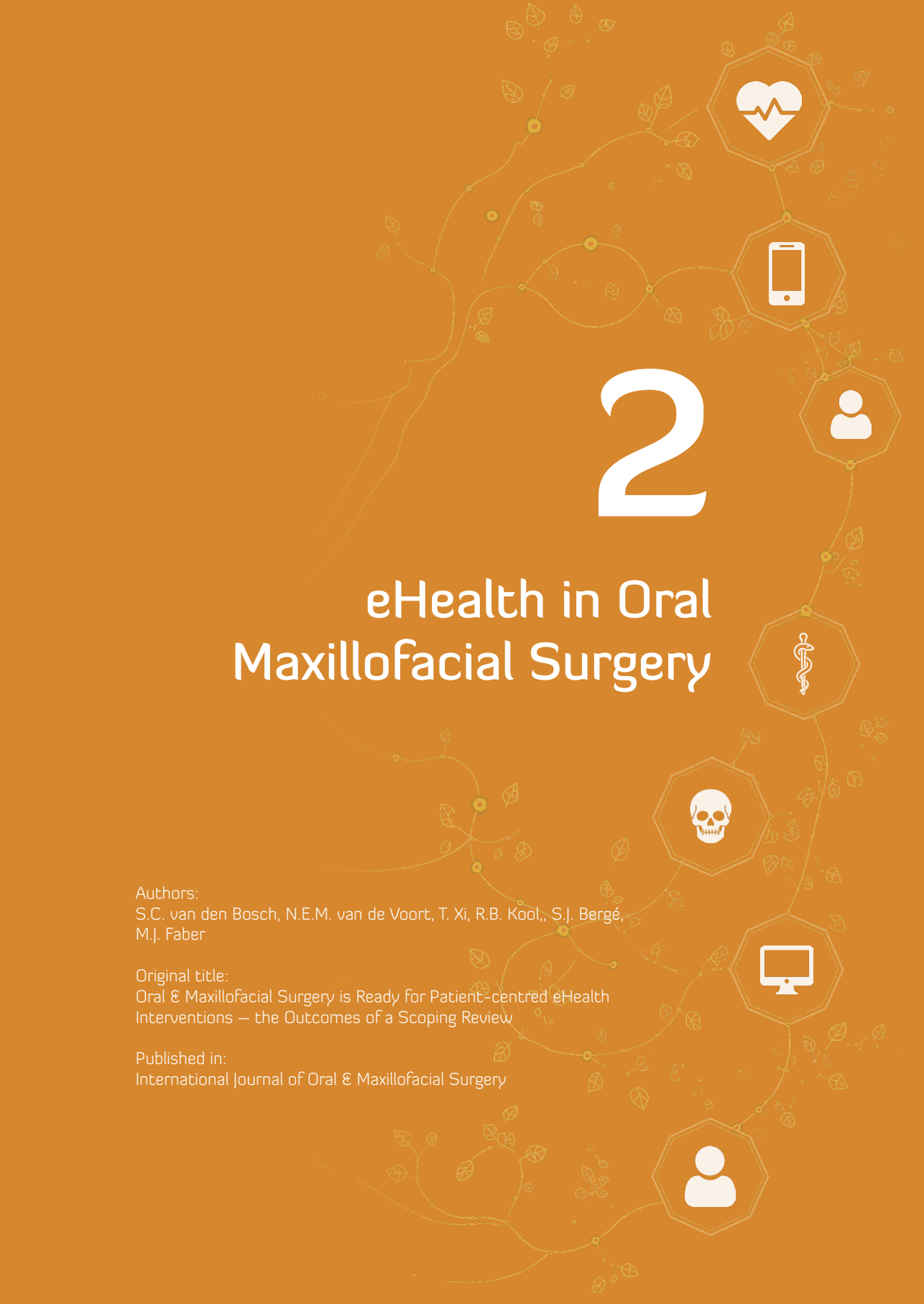
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I Exploration



The background is a solid orange color. A decorative, light-colored line resembling a tree branch or a network path winds across the page. Along this path, several icons are placed inside hexagonal frames. From top to bottom, the icons are: a heart with a pulse line, a smartphone, a person silhouette, a caduceus (medical symbol), a skull, a computer monitor, and another person silhouette. The overall theme is healthcare and technology.

2

eHealth in Oral Maxillofacial Surgery

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Original title:

Oral & Maxillofacial Surgery is Ready for Patient-centred eHealth
Interventions – the Outcomes of a Scoping Review

Published in:

International Journal of Oral & Maxillofacial Surgery

Abstract

Within the field of Oral and Maxillofacial (OMF) surgery, eHealth is expected to be a tool to improve quality of care. The aim of this study is to map the research of patient-centred eHealth interventions within OMF surgery by means of a scoping review.

After a systematic literature search, relevant studies on patient-centred eHealth interventions for OMF-surgery patients were selected. The interventions were mapped based on their key components, target population and outcome measures. To gain insight into the research phase of evaluation, the framework of the Medical Research Council (MRC) was used.

Forty-one papers were included, comprising 34 unique interventions. Nineteen interventions were designed for head and neck cancer patients, 11 interventions concerned video-teleconsultation. According to the MRC framework, 26 papers fitted into the feasibility and piloting phase of research, 8 into the evaluation phase, 7 were in the development phase. No implementation studies were found.

This scoping review can be a starting point for those who are interested in applying and evaluating eHealth in their practice. Since many feasibility and pilot studies were found on similar interventions, a more extensive collaboration with and connecting to each other is recommended to catalyse the implementation of eHealth in daily practice. Profound involvement of patients in developing and evaluating eHealth interventions is essential to achieve true patient-centred OMF surgery.

2.1 Introduction

The introduction of the internet for citizens in 1993 disruptively changed daily life and thereby healthcare. Not only is the general use of the internet is common ground, also for health and sickness the internet has become an indispensable source of information. The field of medical informatics referring to the organisation and delivery of health services and information using the internet and related technologies is called eHealth.¹ eHealth interventions can concern various levels of interaction between and within the different stakeholders e.g. patient, healthcare professional, caregivers, health insurance etc.² Examples of eHealth can range from electronic health records used by healthcare professionals, to mobile apps for consumers to track their health and online platforms for patients to share their health-related experiences. Since it concerns the delivery of prevention, education, diagnostics and therapy through digital technology, which is independent of time and place, it has the potential to meet the big global challenges in healthcare such as the increasing demand and limited resources.^{3,4}

Within the field of Oral and Maxillofacial (OMF) surgery, eHealth is expected to be a tool to improve the quality of care, in particular to support patients. As certain patient groups, such as head and neck oncology patients and patients with craniofacial abnormalities and their parents, endure high emotional and psychological impact of their condition, one could expect support and information in the form of eHealth to be helpful.⁵⁻⁷ Numerous studies demonstrated the effectiveness of eHealth in education, monitoring and self-management support.⁴ However, systematic and robust empirical evidence of its effectiveness and economic benefits is not yet available.^{4,8} Despite its potential, many eHealth interventions linger in the pilot phase, without being (fully) implemented in daily practice.^{4,8} Difficulties with implementation are explained by the multi-level complexity of implementing eHealth interventions.⁹ It is a dynamic process of change in which people, organisations and technology continuously interconnect and develop. Furthermore, these processes are interdependent.^{4,10}

The aim of this study is to systematically map the research of patient-centred eHealth interventions within OMF surgery in its full scope. A scoping review is the most appropriate approach for this.¹¹⁻¹³ Scoping reviews involve the synthesis and analysis of a wide range of research aiming to summarize findings and identifying research gaps rather than aiming at estimating effectiveness or quality of the included studies.^{11,14} Specific objectives are to (1) assess the detailed composition of these interventions; and (2) assess the way in which these interventions were evaluated by producers and users. With these results, integration of patient-centred eHealth interventions in OMF surgery can be facilitated and failure of implementation processes can be prevented by learning from available accomplishments.

2.2 Materials and Methods

For this scoping review, the methodological framework of Arksey and O'Malley was used, following the five described stages.¹¹

Stage I. Identifying the Research Question

The aim of this scoping review was to map the research of patient-centred eHealth interventions within OMF surgery in its full latitude. To be able to construct a search strategy, both patient-centred eHealth interventions and the field of OMF surgery were defined.

Defining Patient-centred eHealth Interventions

A patient-centred eHealth intervention was defined as “a healthcare intervention delivered over the internet designed and developed for patients”.¹⁵ The intervention always has a two-way interaction component, i.e., patient - healthcare professional, patient - patient, patient - people in their personal environment (e.g. family members and friends) and patient - others (e.g. health insurance companies or patient organisations).² Consequently, studies on online patient information were for example excluded, as sending information to patients is an unidirectional process.

Defining the Field of OMF Surgery

For the definition of OMF surgery, the definition published by the International Association of Oral and Maxillofacial Surgeons in 2015 was used¹⁶:

“Oral and Maxillofacial Surgery is the surgical specialty that includes the diagnosis, surgical and related treatments of a wide spectrum of diseases, injuries, defects and aesthetic aspects of the mouth, teeth, jaws, face, head and neck.”

The scope of this specialty is extensive and concerns the diagnosis and treatment of diseases affecting the oral (mouth) and maxillofacial (face and neck) regions, including the following:

- Preprosthetic surgery (bone augmentation)
- Oral and dentoalveolar surgery (removal of impacted and buried teeth, cysts, etc.)
- Dental implant surgery and associated bone grafting
- Orthognathic surgery (dentofacial deformities)
- Facial trauma surgery (facial bone fractures and related soft tissue injuries)
- Reconstructive surgery of the face
- Cleft lip and palate surgery
- Congenital craniofacial surgery
- Facial plastic surgery (rhinoplasty, rhytidectomy, blepharoplasty, facial implants, etc.)
- Temporomandibular joint (TMJ) surgery
- Snoring and sleep apnea correction surgery
- Tumour/Cancer surgery

Added to this definition were oral pathology and pathology of the salivary glands, since benign oral pathology and pathology of the salivary glands was not completely covered by these topics.

Stage 2. Identifying Relevant Studies

The literature was systematically searched to identify studies on the use of patient-centred eHealth interventions in OMF surgery (see Fig. 1 for the syntax), published up to September 13th 2017. Five electronic databases were

included in the search, i.e., PubMed, PsycINFO, EMBASE, Cochrane Database of Systematic Reviews and CINAHL.

Oral & Maxillofacial Surgery

"Head and Neck Neoplasms"[Mesh] OR "Oral Surgical Procedures"[Mesh] OR "Surgery, Oral"[Mesh] OR "Oral Medicine"[Mesh] OR "Oral Health"[Mesh] OR "Cleft Palate"[Mesh] OR "Cleft Lip"[Mesh] OR "Temporomandibular Joint"[Mesh] OR "Craniofacial Abnormalities"[Mesh] OR "Sleep Apnea, Obstructive" [Mesh] OR "Facial Injuries" [Mesh] OR Stomatognathic Diseases [Mesh] OR saliva*[tiab] OR facial [tiab] OR oral health care [tiab] OR TMJ [tiab]_NOT ear[tiab] NOT laryng*[tiab] NOT nose [tiab] NOT parathyroid[tiab] NOT thyroid [tiab] NOT trachea*[tiab]

eHealth

"Telecommunications"[Mesh] OR "Telemedicine"[Mesh] OR "Cellular Phone"[Mesh] OR "Electronic Mail"[Mesh] OR "Internet"[Mesh] OR ehealth[tiab] OR e-health[tiab] OR health 2.0[tiab] OR mhealth[tiab] OR medicine 2.0[tiab] OR web 2.0[tiab] OR internet[tiab] OR information communication technolog*[tiab] OR web based[tiab] OR online[tiab] OR world wide web[tiab] OR website[tiab] OR teleconsultation[tiab] OR email[tiab] OR e mail[tiab] OR telecare[tiab] OR telemedicine[tiab] OR tele care[tiab] OR tele medicine[tiab] OR website[tiab] OR online[tiab] OR new media[tiab] OR virtual communit*[tiab] OR virtual consultation[tiab] OR wiki*[tiab] OR cell phone[tiab] OR PDA[tiab] OR personal digital assistant[tiab] OR iphone[tiab] OR smartphone[tiab] OR electronic health[tiab] OR ipad[tiab]

Figure 1 Syntax eHealth and OMF surgery

Stage 3. Study Selection

The retrieved titles were first manually checked for duplicates. Next, two of the authors independently screened all titles and abstracts (SCB and NEMV) using pre-defined in- and exclusion criteria (Table 1). Study methodology was not restricted in any way in order to avoid the omission of relevant data in a rapidly changing and expanding field. This was in accordance with the scoping review criteria.^{11,17} Finally, full-text articles of the selected studies were screened. If the relevance of the study was unclear from the abstract, the full article was examined. In all stages, a third reviewer (MJF) solved conflicts in the assessment of studies. The bibliographies of all included studies were checked for relevant titles, to avoid missing relevant publications.

Table 1 In- and exclusion criteria for study selection.

Inclusion criteria	The study had to be written in English. The study had to concern patient-centred eHealth interventions. The study had to concern patients with an OMF surgery related condition.
Exclusion criteria	The study concerned patients with strict dental conditions. The study concerned patients with thyroid gland conditions. The study concerned students or healthcare professionals.



Stage 4 and 5. Charting Data and Collating, Summarizing and Reporting the Results

In both stages, a descriptive analytical method was used, in which two authors (SCB and NEMV) independently collected information of each study on the following topics:¹¹

- To create an overview of the studies, study characteristics such as aim of the study, design, study population, aim of the eHealth intervention were collected.
- To map the different types of eHealth interventions, they were classified in one of the six subtypes of eHealth interventions according to the categorization of Barak et al.: web-based education interventions, self-help web-based therapeutic interventions, human supported web-based therapeutic interventions, online counselling, internet-operated therapeutic software and other online activities.¹⁸
- To obtain a full understanding of the interventions, the defined key components of each intervention, also according to Barak et al., were recorded. The key components are: 1. program content, indicating the nature of the information disseminated within the intervention, 2. multimedia use, indicating the use of other options than text to disseminate program content, such as pictures, graphics, animations, video and audio, 3. interactive online activities, indicating whether the intervention offers patients the opportunity to participate interactively within the program and 4. feedback support provision, indicating a

mechanism (automated or by human support) whereby patients can obtain external information about themselves and their progress.¹⁸ With this information the main characteristics of the interventions could be mapped.

- To gain insight into the research phase in which the interventions were evaluated, the framework of the UK's Medical Research Council (MRC) was used.^{19,20} In this framework four phases of research regarding complex interventions are defined: development, feasibility & piloting, evaluation and implementation.
- The intended effectiveness measures and outcomes on usability evaluation of interventions were extracted. Intended effectiveness measures were defined as the main outcome of the intervention, for example the change in quality of life.

Differences in data extraction were discussed until the two authors were confident that all data were coded in the appropriate categories.

2.3 Results

Stages 1, 2 and 3. Literature Search and Study Selection

The literature search provided 7356 unique citations. Screening titles and abstracts yielded 95 relevant citations, of which 41 remained after assessing the full texts.^{5-7,21-58} No additional relevant citations were identified from the reference lists of included citations (Fig. 2).

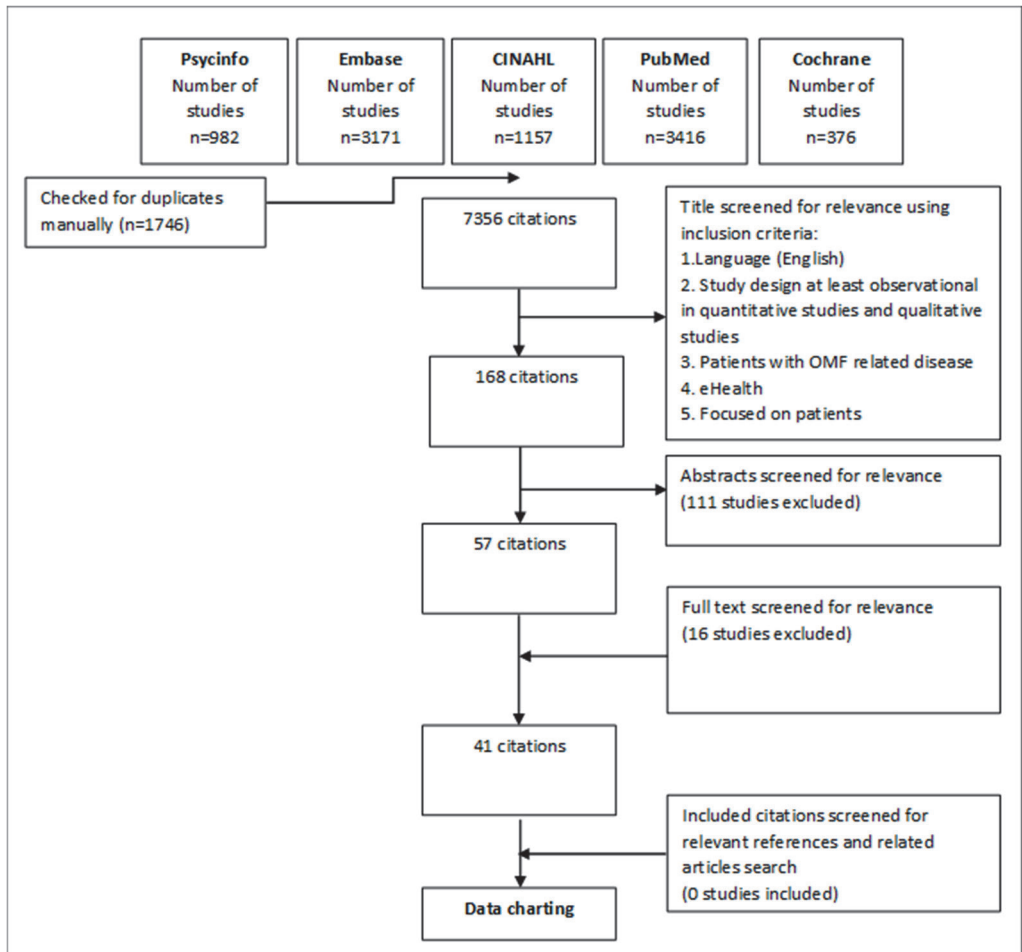


Figure 2 Literature Search and study selection

Stage 4 and 5. Charting Data and Collating, Summarizing and Reporting the Results

An increasing amount of publications from 2000 up until 2017 was found on patient-centred eHealth interventions in OMF surgery (Fig. 3). An overview of the interventions is presented in Table 2. Tables 3 and 4 (appendix A) present the detailed data extracted from the studies in this review.

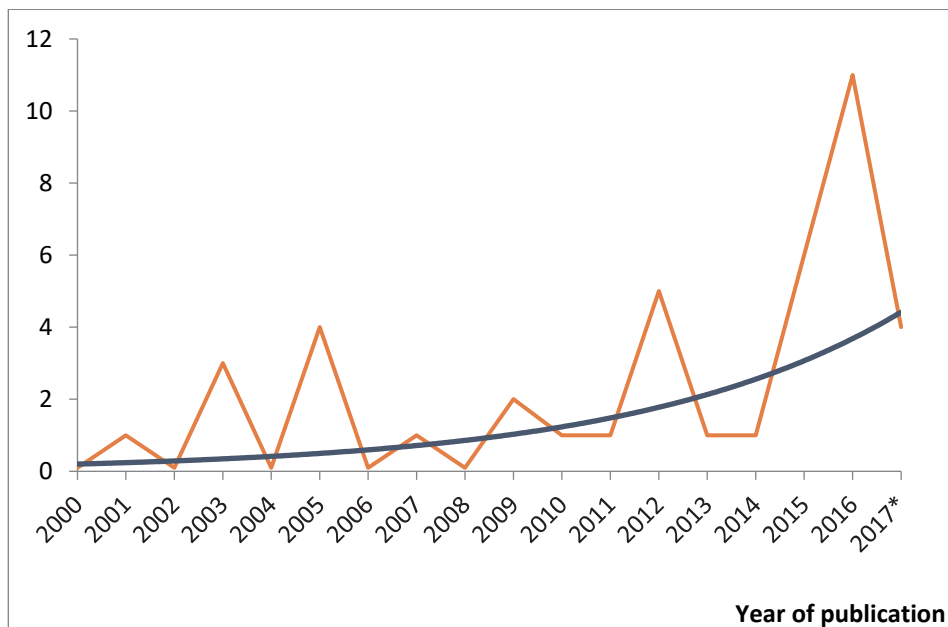


Figure 3 Number of publications on patient-centred eHealth interventions in OMF surgery per year

* For 2017 publications until 13 September 2017 are included

Categorization of Patient-centred eHealth Interventions

The 41 papers presented 34 unique eHealth interventions. The interventions concerned twelve different patient groups. The majority, 19 out of 34, were designed for head and neck oncology patients.^{5,6,22–25,28,29,31–34,38,40,42–46,48,52,55–58} Three interventions focused on cleft patients^{26,39,41}, three on patients with oral lesions^{49,51,54} and two on trauma patients.^{21,47}

The search revealed a rich palette of interventions, ranging from teleconsultation via video and online gaming, to self-management platforms. Most interventions, 21 out of 34, concerned online counselling interventions of which eleven concerned teleconsultation via video.^{21–30,39,44,47–49,51–56} All of these teleconsultations took place at a local health facility where a connection was made to a remote specialised healthcare centre.

Twenty-three out of 41 papers collected data from patients in the actual evaluation of the eHealth interventions, 24 out of 41 involved healthcare professionals in the evaluation. Thirteen out of 41 papers took both patients'

and professionals' perspectives into account in the evaluation. The level of interaction was mainly between patients and healthcare professionals (28 out of 34). Only five interventions reported on the involvement of family members or caregivers.^{22,23,28,43,49}

In four interventions, all for head and neck cancer patients, peer support was taken into account.^{5,23,31,32,38,43} All of these interventions facilitated interaction with fellow sufferers, in one case by means of a peer joining a teleconsultation session.²³

Evaluation Type of Patient-centred eHealth Interventions

According to the MRC framework, the majority of the papers (27 out of 41) fitted into the feasibility and piloting phase.^{6,22–26,28–30,32,34,35,39,41,44–54,56,57} Seven papers reported on the development of interventions.^{7,21,31,33,38,40,43} Seven papers assessed the effectiveness of interventions and were thereby evaluation phase studies.^{5,27,36,37,42,55,58} Two of these, however, presented a study-protocol for the evaluation study, no results were published yet.^{37,58}

The feasibility and piloting studies mainly evaluated the satisfaction, usability and level of concordance of the intervention. For example, a telehealth messaging device for head and neck cancer patients was satisfactory to 95% of the patients. 65% of patients were even more satisfied with the communication and experienced better care as a result of the device.^{6,33,58} An example of usability outcome can be found in a paper describing the feasibility of a mobile messaging app for post-operative head and neck cancer patients after hospital discharge. It was assessed to be extremely easy to use by 89% of the participants. 95% of them stated that the app helped them to deal more effectively with their health. Three out of five non-enrollers in this study stated that they were concerned about privacy issues.⁵⁶ Finally, pilot and feasibility studies reported on the level of concordance, for example by comparing diagnostic agreement between oral lesions that were assessed via WhatsApp versus clinicopathologic assessment: in 82% of the cases (n = 96) assessments were concordant.⁴⁹ Evaluation studies (n = 7) applied a wide range of measures to demonstrate the effectiveness of the intervention. Three of the seven studies reported on the quality of life.^{5,36,42} For example an electronic health information support system for head and neck cancer patients improved 5 out of 22 quality of life subscales after 6 weeks of using the system. After 12 weeks follow-up,

this effect sustained in one out of 5 subscales.⁵ The remaining four evaluation studies differed widely in their outcome measures, typically closely related to the intervention itself. For example, the efficacy of a teleconsultation intervention between a patient with a local speech pathologist and a speech pathologist at a tertiary centre, time of referral to response, time of response to initial clinical management, the number of contact events per referral and technical difficulties were evaluated.⁵⁵ Whereas the efficacy of an online self-management app for head and neck cancer patients was measured in terms of patient activation, self-efficacy, personal control, perceived patient-physician interaction, mental adjustment to cancer, need for supportive care, health-related quality of life and cost-utility outcomes.⁵⁸



Table 2 Overview of population and interventions.

Target patient population	Aim interventions	Characteristics interventions
Online counselling interventions		
- Children with cleft lip and/or palate (n=2) - H&N cancer patients (n=9) - Patients with facial injury (n=2) - Patients with oral lesions (n=3) - Patients with queries regarding OMF surgery (n=1) - Patients with TMJ disorders (n=1) - Pre-operative OMF patients in prison (n=1) - Surgeons & nurses in H&N cancer care (n=1)	- Communication with caregivers, patients & family - Empower appropriate patient self-care and decompress provider schedules - Peer support - Providing information for patients (Psychosocial) support - Facilitate faster diagnosis and therapy by removing geographic distance - Improve access to (specialist) healthcare - Increase efficiency - Avoid travel - Reduce time and cost - Reduce the waiting time for patients by specific patient selection for referral	Teleconsultation via video (n=11) - Patient consultations and examination by specialist in a remote location - Remote post-operative monitoring of patients - Patients participating in multidisciplinary meetings via videoconferencing - Education of patients and family and local healthcare providers - Peer support for family and patients, consultation and education for clinicians - Case discussions between clinicians - Review of clinical, pathological and imaging data at tertiary centre Teleconsultation via text-messaging (n=6) - Online medical consultation service on which patients can post questions - E-mail contact of patients and family members with surgeons and nurses - Mobile messaging apps to provide motivational support and communication with care providers after hospital discharge

		Web-based and mobile screening and referral tools (n=3) - Radiographs and clinical data are sent to specialist at distant location - Specialist reviews the data and provides input on diagnosis and management - Patient reports information - Tool creates summary report of data and identifies areas of concern
Web-based education interventions		
- Children (5-7yr) undergoing general anaesthesia for tooth extractions (n=1) - H&N cancer patients (n=1) - Orthognathic patients (n=1) - Parents of children with cranial abnormalities (n=1)	- Facilitate communication for patients with professionals and fellow-sufferers - Facilitate early detection of problems by monitoring - Improve coping behaviour - Improve quality of information - Providing information and education	Website for parents (n=1) Electronic health information support system (n=1) - Communication with professionals via messages within the system - Information via specially developed website - Forum for contact with fellow sufferers - Monitoring via electronic questionnaires after discharge with automated e-mail alerts to 2 nurses Online game (n=1) - Contains information, cartoons and videos on general anaesthesia, role modelling, fasting instructions and oral health messages Mobile app (n=1) - Animations on pre-surgical, surgical and post-surgical information on orthognathic surgery

Human-supported web-based interventions		
- H&N cancer patients (n=3)	- Increase patient self-management of symptoms by daily education, guidance, encouragement - Remote monitoring - Improving interaction with the specialists	Telehealth messaging device (n=1) - Encourages self-management by daily questions for patients to answer - Automated feedback and nurse feedback Online platform (n=1) - Collecting self-reported outcomes via questionnaire - Collecting outcomes of home based sensors for weight, blood pressure, and pulse Mobile app for outpatient support (n=1) - Education: information on diagnosis and treatment - Peer support: map with all registered users and useful locations - Monitoring: QoL and symptom questionnaires - E-mail function which automatically sends report of the monitored data to the physician and by which patient can contact the physician
Self-help web-based therapeutic interventions		
- Individuals with visible differences (n=2) - H&N cancer patients (n=4) - Children with cleft lip and/or palate (n=1)	- Facilitate communication - Improve access to care at a distance - Improve self-management and quality of life - Reduce anxiety and appearance related distress - Support patients post-discharge	Web-based cognitive behavioural therapy intervention for individuals with visible differences (n=2) Online self-management (n=2) - QoL questionnaire - Tailored feedback, information and advice as result from the outcomes in QoL questionnaire - Personalized supportive care options based on outcome - Access information; text, quizzes, visual cues and videos

		- Skill-building by action planning, behavioural monitoring tools, reminders, exercises, relaxation techniques, identify and challenge irrational thoughts - Offer support to peers and each other
		Mobile app with interactive speech game (n=1) - The game facilitates at home practice
		Mobile app for augmentative and alternative communication (n=1) - Provides a communication solution for patients with difficulty speaking in the immediate post-operative setting
		Mobile app to support swallowing practice (n=1) - Assist patients to complete home-practice - Instructional videos, images and text - Capacity to record repetitions - Clinicians were able to customise patient profiles, remotely monitor therapy adherence, and receive communication from the patient

In this table the interventions are displayed per category according to Barak et al.¹⁸

2.4 Discussion

eHealth is a promising remedy for global health challenges and has the potential to improve health systems, safety, quality, accessibility and efficiency in healthcare.^{3,4,59} Since the World Health Assembly resolution in 2005 endorsed these potential benefits and urged the member states to make long-term strategies to develop and implement eHealth services, an increase in eHealth applications and thereby publications is seen.⁵⁹ As scientific results are not merely in favour of the benefits of eHealth, robust evidence is needed to live up to these high expectations.^{4,8,10} An evidence-based overview about the current landscape might decrease unrealistic expectations which hinder long-term progress, and can help to identify areas with the greatest potential of benefit.⁸ This could be useful for clinicians, researchers and policy-makers. Added to this, performing a scoping review reduces duplication of research and guides future research.¹⁴ This study provides an overview of the available research of patient-centred eHealth interventions within OMF surgery. The detailed composition of these interventions and the evaluation of these interventions are mapped.

The vast majority of the interventions was designed for head and neck oncology patients and aimed at supporting these patients. This can be understood by the long-lasting and high impact character of this specific care. Consequently, one would expect that other patient groups who require chronic care with high impact, such as patients with congenital craniofacial deformities, would also benefit from eHealth. Especially since this concerns children, adolescents and their (young) parents, who are very active on online platforms in their daily life. Our review, however, did not confirm this expectation: we retrieved only four interventions that targeted younger populations suffering from deformities requiring long-lasting care. It might be concluded that this is a hiatus in the available scientific output and possibly the care we provide to our patients and their parents.

Video-teleconsultation is by far the most studied type of intervention. Eleven out of 34 interventions concern teleconsultation via video. Notably, most of these teleconsultations were used to enhance or provide access to specialist care. Hence, these teleconsultations did not take place at the home of the patient, but at a local healthcare facility. Both patients and professionals were satisfied with the use of these teleconsultations. Travel time, CO2 emission

reduction and financial cost savings were assessed by six papers. But strikingly, no real cost-effectiveness analyses have been performed. There is a need for thorough research to determine whether teleconsultation in OMF surgery is cost-effective, as for example was done for online paediatric asthma management and an internet-based peri-operative care program for gynaecological patients.^{60,61} In these future cost-effectiveness analyses, the evaluation of the macro-economic effects such as less lost working hours for patients and caregivers and less lost school hours for children are of great importance.

Concerning the level of interaction of the interventions, remarkably only five interventions reported on the involvement of family members or caregivers of head and neck oncology patients in the intervention. This involvement concerned joining teleconsultations, having email contact with healthcare professionals, having a tailored content in an online platform for oral cancer survivors and their caregivers and being able to upload a photo in a mobile messaging app for patients with oral lesions. In two of these five studies family members and caregivers were involved in evaluation of the interventions.^{28,43} Since it is known that support by family members and caregivers is of great importance to head and neck oncology patients, increasing this support to patients might be a real opportunity to improve care.^{62–64} Stronger involvement of family members and caregivers in future eHealth interventions should be considered.

Four papers also incorporated contact with other patients, but this was the least used function within an electronic health information support system.⁵ A needs assessment for an online platform for self-management after oral cancer revealed that 77% of survivors and 75% of caregivers would use the intervention to learn about other survivors' and caregiver's experiences.⁴³ It is questionable however, whether head and neck oncology patients do have the need to get in contact with fellow sufferers. Lang et al. and Bressan et al. did report that support from head and neck oncology peers is of importance.^{62,63} Oskam et al. however found that there was little need for and use of peer contact.⁶⁵ Further research to the needs and actual use of peer support is needed to be able to tailor future eHealth interventions to the specific needs of patients with head and neck cancer.

Regarding the patient-centredness of the interventions, only 23 out of 41 papers involved patients in the evaluation of the eHealth interventions. Even more so, 13 papers considered patients' and professionals' perspectives. A profound shift to collaboration with our patients to achieve true patient-centred OMF surgery, still has to be made.

There are some limitations to this study that should be considered. First of all, the literature search was limited to the English language. This might have caused potentially relevant papers to be missed. Secondly, since technology is developing exponentially, new eHealth applications will arise every day. This might result in a publication bias, since not all eHealth experiments lead to publications, although there is an exponential growth in the amount of papers on eHealth in the last three years (Fig. 3). Thirdly, an evaluation of the quality of the included studies was deliberately not performed, since the primary aim of this study was to map all research on patient-centred eHealth interventions within OMF surgery, regardless of its quality. This is in full accordance with the purpose of a scoping review.^{11,14} However, assessing the MRC phase of the studies gives an idea of the quality of the studies.^{19,20} Nevertheless, it has to be emphasized that caution has to be provided with generalizing findings from the particular studies.¹¹

Mapping successes, failures and barriers of implementation turned out to be impossible with this scoping review, because too little evaluation and no implementation studies were found. Only for three interventions subsequent phases of research were published beyond the pilot & feasibility evaluation. Implementation in daily practice was not assessed in the studies included in this scoping review. Most of the interventions currently evaluated still fit in the feasibility and piloting phase of research. Only seven evaluation studies were identified, which can imply that implementation of eHealth interventions in daily practice is not yet reality. However, it can also signify that eHealth interventions already become part of daily practice after a successful pilot study and some research phases are skipped in this process. Still, it is desirable to perform evaluation studies which take patients', professionals' and family members' perspectives into account. Thereby, results are shared and eHealth implementation in OMF surgery can get to a higher level by making optimal use of each other's experiences.

As Ossebaard et al. state “many promising projects do not survive the pilot phase [. . .] we must shift our attention towards implementation.”⁴ A systematic review of systematic reviews on factors that influence the implementation of eHealth, does give seven recommendations for implementation of eHealth interventions in general.⁹ For example, the selection of an appropriate eHealth system needs careful consideration, taking into account the complexity, adaptability, compatibility with existing systems and costs. Furthermore, key stakeholders and implementation champions should be included as early as possible in the implementation process.⁹ Learning to better implement eHealth and to share the outcomes of high-quality eHealth assessments is mandatory to improve quality of healthcare.⁴ For example, in 2011 a holistic framework for the development of eHealth technologies was developed which was also published as an open Wiki to foster development of sustainable eHealth by means of collaboration.¹⁰ Unfortunately, the results of this Wiki collaboration are not yet available. Conventional controlled or randomized study designs seem less appropriate to evaluate eHealth interventions, because of the complexity and the socio-technological dynamics. A combination of quantitative and qualitative research methods, however, can be used instead to assess the impact of eHealth.⁴ The methodology that is used to evaluate eHealth interventions should be multidisciplinary and thereby capable of untangling the complex factors that may influence the results.⁸

The knowledge gained from this scoping review about patient-centred eHealth interventions within OMF surgery can be a starting point for OMF surgeons who want to use eHealth in their practice. Integration of patient-centred eHealth interventions in OMF surgery is facilitated and failure of implementation processes might be prevented by learning from available accomplishments. Sharing information and experience by collaboration with and connecting to each other will help to get the most out of eHealth interventions in an efficient manner, thereby making sustainable use of resources. Profound involvement of patients in developing and evaluating patient-centred eHealth interventions will lead to a more intensive collaboration between clinicians and patients and the inevitable cultural shift to lift up health(care) to a next level.

Appendix A Supplementary Data

Supplementary data associated with this article can be found in appendix A of this thesis.

Funding

None

Competing Interest

None

Acknowledgements

We would like to thank the colleagues of the medical library of the Radboud university medical centre for their effort to help us compose the search syntax for the online search strategy.



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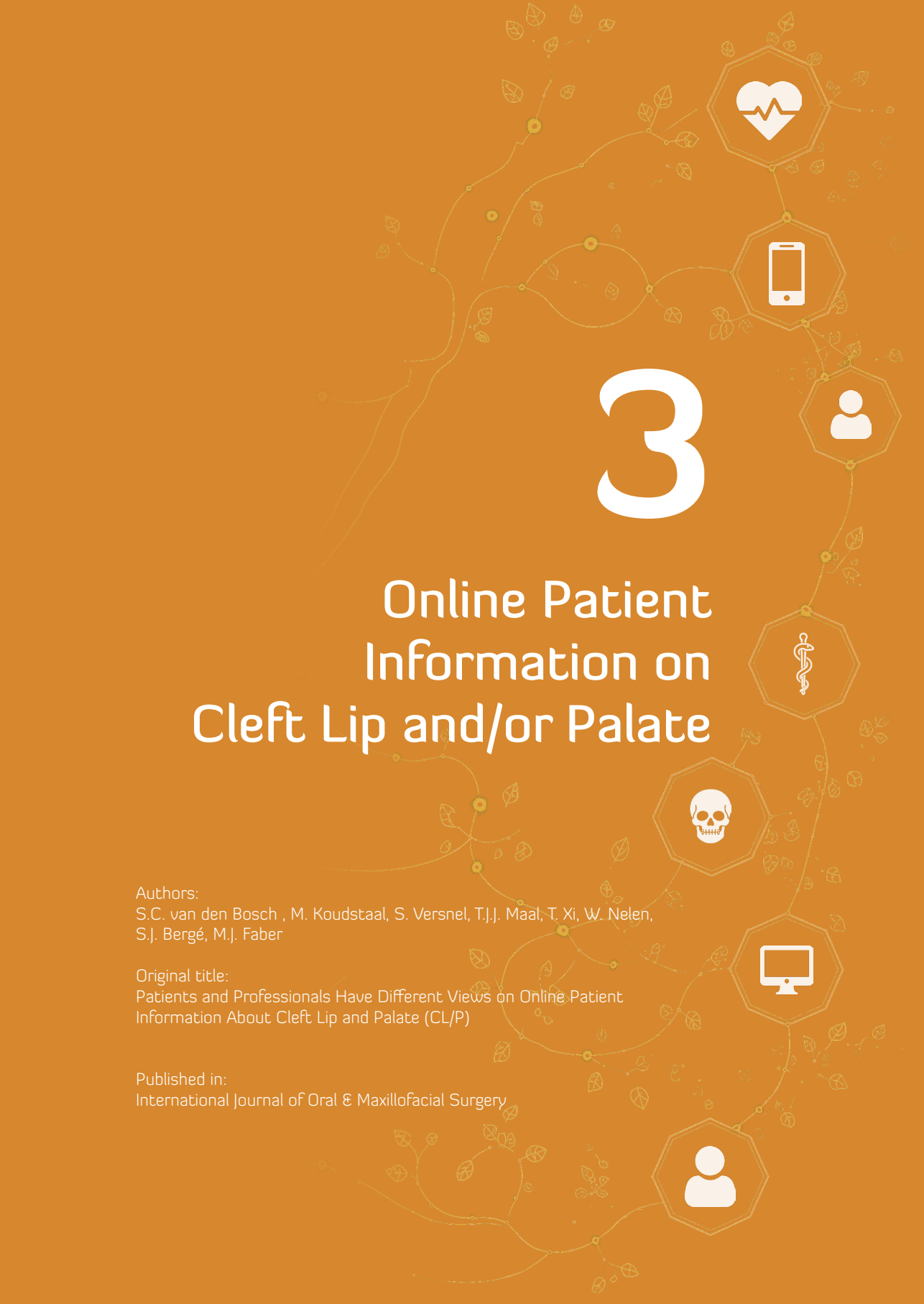
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The background is a solid orange color. A decorative, light-colored line resembling a tree branch or a network of connections winds across the page. Along this line are several small, stylized leaves and circular nodes. Interspersed among these are white icons inside hexagonal frames. The icons include: a heart with an ECG line, a smartphone, a person silhouette, a caduceus (medical symbol), a skull, a computer monitor, and another person silhouette.

3

Online Patient Information on Cleft Lip and/or Palate

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Original title:

Patients and Professionals Have Different Views on Online Patient
Information About Cleft Lip and Palate (CL/P)

Published in:

International Journal of Oral & Maxillofacial Surgery

Abstract

Parents of children with a cleft lip and/or palate (CL/P) and patients with CL/P actively search for online information about CL/P. The quality of this information has not been sufficiently evaluated. The aim of this study was to define quality criteria for online information about CL/P and assess the quality of frequently accessed websites. Patients, parents, and professionals were equally involved in all stages of this study. A literature review was performed to obtain known quality criteria for online information. These criteria were prioritized by patients, parents, and professionals. The most important criteria were used to rate the quality of four websites on CL/P. Forty-two quality items were extracted from the literature. Patients, parents, and professionals agreed on the importance of 16 of these items. New groups of patients, parents, and professionals assessed four websites on CL/P. Although the groups were like-minded in their overall assessment of the quality of the websites, distinct differences emerged between the groups in relation to certain items. This study shows the importance of patient participation in healthcare research, as well as a feasible approach to do so. Involving patients in composing online health information will set different priorities, which is necessary in establishing high-quality information.

3.1 Introduction

The internet has become a valuable source of health information. For example, 59% of European citizens used the internet to search for health information in 2014, and similar numbers have been reported for the USA.^{1,2} As a consequence, physicians are increasingly facing patients who use the internet in general and also more specific online forums to seek medical information. Unfortunately, the quality of online patient information varies widely, although the variation is similar to that seen in other media.^{3–7} Professionals might be reluctant regarding the internet-acquired knowledge that patients bring to the clinical encounter. Since the quality of this online information varies widely, it may cause a feeling of professional devaluation on the one hand; on the other hand it may challenge the professional, and in the end it could make the consultation less time-efficient.^{7–10} However, patients expect their physicians to acknowledge the online information patients bring to the consultation, and want the professionals to discuss, explain, and contextualize it.^{8,9} Such an interaction can improve the physician–patient relationship.^{8,9}

To maximize the benefits of online information, the quality of the information is key. There are numerous quality assessment checklists that define the quality of online information, such as the DISCERN quality criteria, the JAMA (Journal of the American Medical Association) benchmarks, and the Health on the Net Foundation (HON) principles.^{11–15} Remarkably, patient perspectives on the definition of quality did not form part of the developmental process for these checklists. Since patients are the main users of online patient information, it seems wrong to consider only the professionals' perspective.⁷ The first aim of this study was to define quality criteria for online information on cleft lip and/or palate (CL/P). A systematic process of developing and validating a quality assessment checklist for online patient information about CL/P was applied, in which patients with CL/P and the parents of children with CL/P, as well as professionals in CL/P care, were equally involved in all phases. Secondly, the quality of online patient information on CL/P was assessed. Finally, potential differences in perspective on the quality of online CL/P information between the three stakeholders were mapped and the value of involving patients and parents in this study was evaluated.

3.2 Materials and Methods

This study consisted of four phases (Fig. 1). Three groups of participants were involved in all phases: patients with CL/P (>16 years of age), parents of children with CL/P, and professionals in cleft care from different specialties (ENT surgeons, geneticists, maxillofacial surgeons, orthodontists, plastic surgeons, psychologists, specialist nurses, and speech therapists).

Phase I

The aim of phase I was to construct a draft questionnaire with all known quality items for online information. A literature review was performed to determine which quality items on online information are known in the literature. The search was performed in August 2012, in PubMed, using the following search terms: health [tiab] information [tiab] internet [tiab] (quality [tiab] OR assessment [tiab]) NOT “quality of life” [tiab]. Papers were selected by two reviewers in a three-stage approach: title, abstract, and full text. In the case of discrepancies between the reviewers in the selection of full texts, a third reviewer facilitated the discussion until consensus was reached. The inclusion criteria are summarized in Table 1. Quality items and checklists used, such as HON and DISCERN, were obtained, and the quality items were categorised and listed.

Table 1 The inclusion criteria for the literature review of Phase I.

1	Published between 2000 and 2012.
2	Publication written in English or Dutch
3	Publication has to evaluate health-related information (there is no restriction in type of information).
4	The publication has to evaluate online health-related information, meant for patients.
5	The quality of information has to be evaluated with a list of quality criteria. This can be a pre-existing and validated instrument or a self-selected list of quality criteria.
6	The source and ways to create the quality criteria has to be recorded in the paper.
7	The applied list with quality criteria has to be published in the article.
8	More than one website has to be evaluated with the applied quality criteria list.
9	Search strategy for online patient information and motives why specific websites are evaluated has to be recorded.

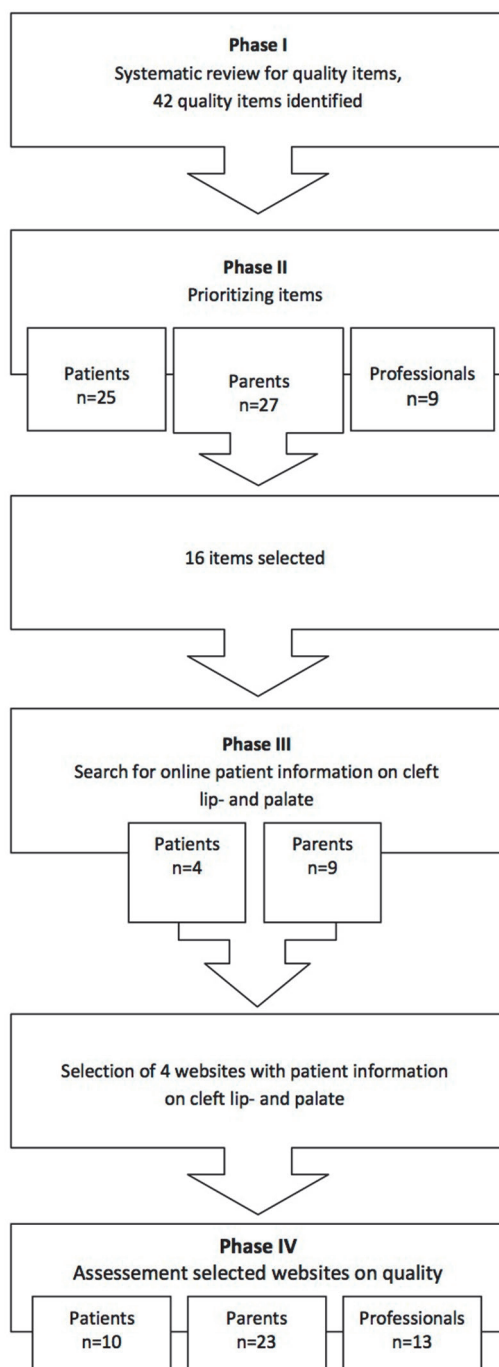


Figure 1 Overview of the patient-centred development and evaluation process to address the quality of online patient information. Patients, parents and professionals could only participate in one phase of the study.

Phase II

The aim of phase II was to construct a final questionnaire with relevant quality items, which the three groups could use to evaluate the quality of online patient information on CL/P in phase IV of the study. Patients, parents, and professionals were asked to prioritize the items in the draft questionnaire constructed in phase I. For this questionnaire, the participants first had to indicate to what extent the quality items were of importance to them when looking for online information about CL/P. A four-point Likert scale was used: very important, important, less important, and not important. Next, the participants were asked to prioritize the quality items by selecting their top five most important quality items. A summary importance score was calculated per item per group: the percentage top five rankings per item were multiplied by the cumulative percentage of the 'very important' and 'important' scores per item.¹⁶ An example of two items scored by the professionals and how this leads to the summary importance score is presented in Table 2.

Quality items were selected if the summary importance score was ≥ 5 for all three groups. Items for which at least one of the three groups scored < 5 were excluded. Hence, only quality items on which all three groups agreed to be of importance were selected.

Table 2 Phase II: Examples of the calculation of the summary importance score per item, as scored by professionals.

Quality item	Importance score % ^a					Top 5 Ranking % ^b	Summary Score
	Very Important 1	Important 2	Less important 3	Non Important 4	Cumulative % 1+2		
No use of complex words	44,4	55,6	0	0	100	33,3	33,3
No use of medical terms	22,2	33,3	44,4	0	55,5	11,1	6,6

- Importance score %: percentage of professionals who scored the quality items as very important, important, less important, or not important.
- Top 5 ranking %: percentage of professionals who ranked the quality item in their top 5

Phase III

The aim of phase III was to select four frequently used websites with patient information on CL/P. These websites were used in phase IV to evaluate the quality of the online information. For the selection of frequently used patient websites, parents and patients were asked to surf the internet at home for information about CL/P. Respondents were asked to write down the full URL of the websites viewed. Websites were selected for phase IV if they were visited more than once and originated from academic or non-academic hospitals, or other CL/P-related organisations.

Phase IV

The aim of phase IV was to evaluate the quality of four websites with patient information on CL/P. Three new groups of respondents evaluated the four websites selected in phase III. Fifteen patients, 15 parents, and 15 professionals from two different academic Dutch CL/P centres used the questionnaire produced in phase II to evaluate the websites. The respondents marked to what extent they agreed that a website met the different quality items, again on a four-point Likert scale: strongly agree, agree, disagree, and strongly disagree.

Two comparisons were made:

1. A comparison of the results between websites by group: the cumulative frequency agreement was calculated by summing the frequencies of scores 'strongly agree' and 'agree'. An overall mean score by website was obtained, allowing for a comparison between websites. This was done separately for the three groups.
2. A comparison of the results by quality item between groups: the distribution across the answer categories was calculated for all items. Agreement was defined as $\geq 60\%$ of participants agreed (strongly agree + agree) that the websites met a quality item. A χ^2 test analysis was performed to assess the differences in agreement between the three groups. A p-value $< 0,01$ was considered significant, as we corrected for multiple testing with 16 quality items. IBM SPSS Statistics 20 was used for all analyses.

All patients and parents for phase II, III and IV were recruited in subsequent routine outpatient cleft clinics of university medical centres until required numbers were reached. Per patient, one of the involved parents was invited to participate in this study.

All professionals for phase II and IV were invited by email. For phase II the authors made a selection of professionals from different cleft centres with a different specialty background. For phase IV professionals of the two participating academic cleft centres were invited.

Patients, parents and professionals could only participate in one phase of the study.

Patients and parents were given a token of gratitude (€15,-) for taking part in phase II, III and IV of the study. This was funded by research funds of the Department of Oral & Maxillofacial surgery of the Radboud University Medical Centre Nijmegen.

3.3 Results

Phase I

The literature search resulted in 1096 articles, which were screened on title. Subsequently 449 articles were screened on abstract and 307 screened on full text. Finally 108 articles were included. Forty-two quality items were extracted from these articles, which were divided into 14 categories in accordance with the categories found in the literature (Table 3). The most used quality evaluation tools were HON, DISCERN, LIDA, and JAMA, as well as readability indexes.¹⁷⁻¹⁹

Table 3 All quality items obtained from the literature in phase I.

Category	Quality item
Authoritative	Origin of the information on the website: the source is a private clinic
	Origin of the information on the website: the source is a community-based hospital
	Origin of the information on the website: the source is a non-profit website, such as Wikipedia
	Origin of the information on the website: the source is a news site
	Origin of the information on the website: the source is blogs/discussion forums of peers
Latest update	Origin of the information on the website: the source is a university medical centre ^a
	The website provides information about the frequency of updates
Design	The website provides the most recent date of update of the website
	Consistent use of colours and logos on the website
	The website has a clear structure ^a
	The website has a logical organisation
Financial disclosure	The website has a professional look and feel
	Transparency on the website about sponsorship
	The website provides the names of non-commercial organisations supporting the website
	The website states clearly that advertising is a source of funding
Advertising	A description of the advertising policy is provided on the website
	The website clearly distinguishes between editorial and advertising content ^a
	The amount of information found on the website ^a
	It is easy to find the required information on the website ^a
Usability	The type of information which can be found on the website ^a
	The website contains an internal search engine
	Any claims on the website relating to the benefits of treatments, commercial products or services are supported by evidence ^a
	The website provides this evidence about these benefits of a specific treatment, commercial product or service ^{a,b}
Readability	No use of complex words on the website ^a
	No use of too many words per sentence on the website
	No use of medical terms on the website ^{a,b}



Reliability	A statement is included on the website whenever medical/health advice is offered by medical professionals ^a Provision of contact information of the author/editor of the website The website identifies who produced the website The website identifies the background of the author
Complementary	A statement is included on the website that the information provided, is only meant to complement and not replace any doctor-patient encounter ^a
Attribution	Sources of information are clearly labeled on the website ^{a,b} The website cites the source and dates of medical information, where possible specific HTML links ^{a,b}
Accessibility	The website is easily accessible ^a The website mentions contact information The information is accessible without the need to download software
Interactivity	The website provides the opportunity to leave comments The website has a forum
Privacy	The website displays a statement that the producers adhere to privacy legislation ^a The website describes the privacy policy The website informs visitors whether or not their data will be stored in a database The website informs who can access the database containing logging information of visitors

- a. Items selected in phase II.
- b. Items scored significantly different in phase IV.

Phase II

In this phase of the study, 25 patients, 27 parents, and nine professionals participated, with participation rates of 76%, 84%, and 90%, respectively.

Consensus between the three groups was reached on 31 out of the 42 quality criteria; all three groups prioritized 16 items as being important for the quality of online information (Table 3 and Fig. 2). The five quality items with the highest overall summary scores were: (1) sources of information are clearly labelled on the website; (2) the website is easily accessible; (3) origin of the information on the website: the source is a university medical centre; (4) it is easy to find the required information on the website; and (5) any claims on the website relating to the benefits of treatments, commercial products, or services are supported by evidence.

Prioritization of the quality items by the patients, parents, and professionals showed distinct differences for 11 quality items. For instance, patients found it important that a website has an internal search function, whereas parents and professionals did not. Parents and professionals did not agree with the patients about the presence of a forum. Having access to information without the need to download additional software was only important to patients. This also applied to information on whether data about website visitors are stored in a database.

The description of a privacy policy was important to both patients and parents, but not to professionals. Professionals placed importance on a professional look and feel of a website, as well as to the identification of the authors and their backgrounds. Patients and parents did not.

Phase III

Four patients and nine parents participated in this phase, in which websites on CL/P were selected. The participants found a total of 22 different Dutch websites. Seven of these websites were visited more than once. Two of the authors selected the four most frequently visited websites to be judged on quality in the final phase of the study. These websites included the patient website of a professional cleft association and those of a patient association, an academic cleft centre, and a non-academic cleft centre.

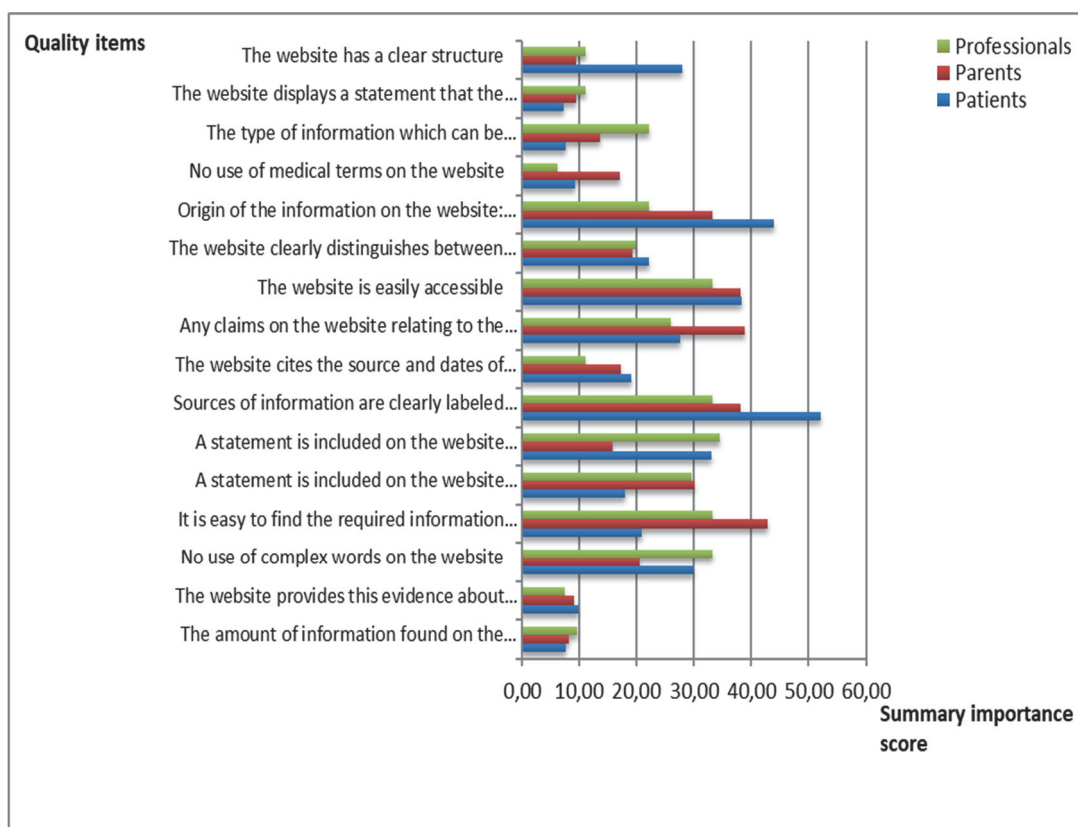


Figure 2 Phase II: Items on which patients, parents, and professionals agreed in the selection of important quality items.

Phase IV

A total of 36 patients, 39 parents, and 22 professionals were invited to participate in phase IV of the study. The assessment of the selected websites was performed by 10 patients, 23 parents, and 13 professionals (participation rates of 28%, 59%, and 59% respectively). Websites 1 and 4 underwent a website update during the study; respondents who participated after the update were excluded from the analysis for these websites only.

Website 2 had the highest score, ranging from 62% agreement among professionals to 81% agreement among patients. Website 3 had the lowest score of agreement with the quality items, ranging between 42% and 66% agreement (Fig. 3). Professionals agreed to the least extent that the websites met the quality criteria compared to the other two groups. However, a consistent pattern emerged across the four websites: professionals had the

lowest overall agreement scores, followed by the parents; the patients agreed the most, with the exception of website 4 for which the parents agreed most. The results by quality item by website per group differ significantly in six items, with a P -value $<0,01$ (Table 4). In these six items, professionals disagreed most to the websites meeting the quality items. Two of these six quality items differed significantly between the three groups for more than one website: (1) no use of medical terms (website 2 and 3); (2) the website provides this evidence about these benefits of a specific treatment, commercial product or service (website 2 and 3).

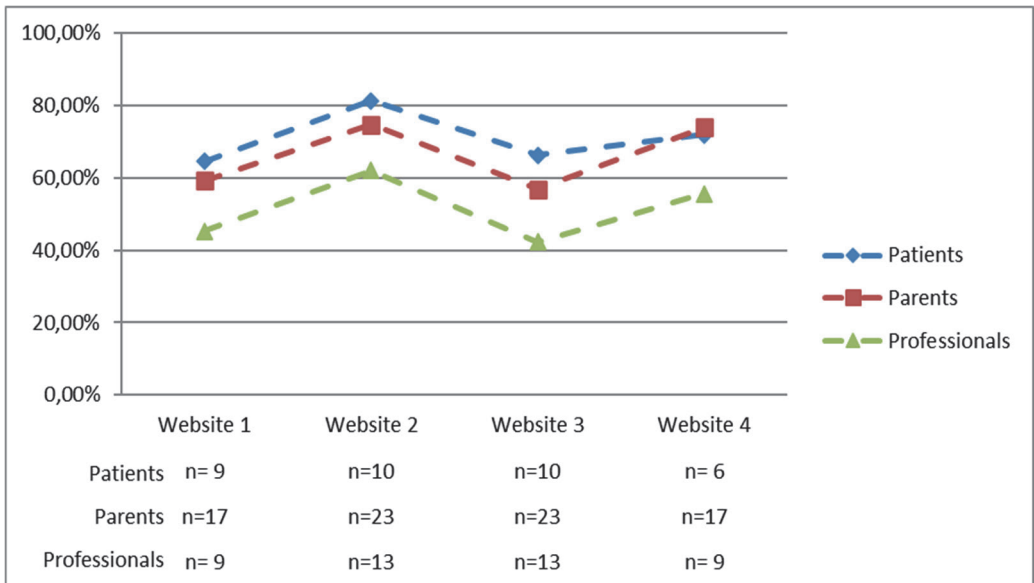


Figure 3 Phase IV: Extent of agreement with all 16 quality items for the four websites and the three groups of participants. Respondents by website varied, since websites 1 and 4 were updated during the study. Only respondents who assessed the website prior to the update were included in the data analysis.

Table 4 Phase IV: Quality items that scored significantly differently by group ($P < 0.01$).^a

Website	Quality item				P-value
		Patients n=9	Parents n=17	Professionals n=9	
1	None				
		Patients n=10	Parents n=23	Professionals n=13	
2	No use of medical terms	100%	56,5%	38,5%	0,009
	The website provides this evidence about these benefits of a specific treatment, commercial product or service	80%	60,9%	15,4%	0,004
		Patients n=10	Parents n=23	Professionals n=13	
3	No use of medical terms	90%	56,5%	15,4%	0,002
	The website cites the source and dates of medical information, where possible specific HTML links	90%	78,2%	23,1%	0,001
	The website provides this evidence about these benefits of a specific treatment, commercial product or service	60%	34,8%	0%	0,007
		Patients n=6	Parents n=17	Professionals n=9	
4	Sources of information are clearly labelled on the website	50%	76,5%	11,1%	0,006

a %: percentage of respondents who agreed that the websites met this quality item.

3.4 Discussion

Ninety percent of adults using the internet for health-related information believe this information to be reliable.² The quality of online information is, however, determined by more than just the reliability of the medical content; other quality criteria are also of importance. For instance, readability, design, and accessibility are also conditions related to quality.⁷ To benefit from the great value of online health information, it is of major importance that this information is of high-quality.^{9,20} This study defined quality criteria for online information about CL/P and assessed frequently visited patient websites on CL/P. Compared to the widely used HON, JAMA, and DISCERN instruments for quality of online health information, the quality item set of the present study,

consisting of 16 quality items, adds items on accessibility, usability, design, and readability. The major added value of this instrument is the prioritizing of these items by patients, parents, and professionals. Since patients are the main users of online patient information, it seems inappropriate to consider only the producers' (mostly professionals) perspective. A substantial similarity of the present study quality item set to the eight HON principles was found: six out of eight categories of quality items are represented in our set. This does not come as a surprise, as the HON principles are the most complete of the most used instruments in the literature.

The quality of the four frequently used patient websites on CL/P was found to vary, which is in accordance with the literature on other conditions.^{5-7,11,21} Only for website 2 did all three groups agree in a majority (>60%) that the site met the 16 quality items, hence this website had the highest quality. Of note, the two best scoring websites (2 and 4) were those of a non-academic cleft centre and an academic cleft centre; the websites of the cleft association and the patient organisation scored lower. This confirmed the results of phase II of this study, in which the three different groups agreed that 'Origin of the information on the website: the source is a university medical centre is an important quality item. However, this result from phase II could be biased, since this study was performed in two academic cleft centres.

The three groups of participants showed a consistent pattern in their assessment of the websites. Professionals appeared to be the most critical, as they agreed to the least extent that the four websites met the quality items. Patients were the least critical, as for all four websites more than 60% of the respondents agreed that the sites met all 16 quality items. As health professionals are trained to be critical on the reliability of health information, this might seem obvious. However, it is questionable whether this explains such a distinct difference. As parents agreed less than patients, age might be an explanation. Further research should determine whether age, or for instance education level, socioeconomic status, or other variables, has an influence.

Remarkably, patients differed in their opinion on the item 'No use of medical terms' compared to parents and professionals. Professionals and parents disagreed that two of the websites met this item. Again the professionals' opinion was more distinct than that of the parents. Patients, however, agreed in respectively 100% and 90% that the websites met this item. This raises

questions for composing (internet) information for patients and even speaking with patients in the clinic and online. Do patients understand more medical terms than we think?²² Is this explained by the fact that our population has dealt with medical terms since they were born? Or does familiarity with medical terms not imply patients understand them?²³ Do patients even require us to use more medical terms? The latter is unlikely given the results of previous research.^{20,24} And, since the literature states that patient understanding of commonly used medical terminology is suboptimal and the reading level of online health information is too high, further qualitative analyses are needed to explain this finding.^{25,26}

The finding that professionals were the most critical on labelling the source of information, explicitly citing the source and providing evidence about statements, may be expected because of their expertise and academic training. The fact that patients and parents found these quality items to be of high importance in phase II of this study implies that health professionals need to guide patients and parents more on recognizing these items in online health information. Eysenbach and Kohler described similar findings in 2002 in a group of healthy volunteers.²⁴

There are some limitations to this study that should be considered. The literature search in phase I of the study was conducted in 2012; new quality criteria might have arisen over time based on the dynamic nature of online information.

Recruiting patients to participate in this study was difficult. Parents and professionals were more willing to participate, but a delayed response occurred as participation in phases II, III, and IV was time consuming. This led to small groups; therefore one has to be cautious when generalizing the results for the whole CL/P population. Moreover, updates that included a completely new content and design of websites 1 and 4 during the study led to responses for these websites no longer being comparable. Responses after these updates had to be excluded, resulting in even smaller groups.

Up until now, the perspective of the patient (and parents) has not been taken into account when evaluating the quality of online health information or when developing evaluation tools. There is a small amount of information showing that patients have distinct needs and preferences in relation to online health information.^{8,20,24} This study compared this perspective with that of the

professionals, and showed the importance of patient (and parent) involvement. Patients and parents may draw attention to issues that are considered irrelevant by healthcare professionals.^{27,28} For different conditions, patients might find other quality items relevant. The optimal development process for online patient information should therefore include the patient (and parents if applicable).

Crowd-edited websites (such as Wikipedia) are promising tools to stimulate patient participation in the creation of patient information.^{29,30} Barriers to the use of these are, however, still present.^{14,29,31} Boivin et al. clearly demonstrated that patient involvement does have an impact: in their study, patient participation changed priorities in collective healthcare improvement decisions.²⁷ The present study confirms the conclusions of Boivin et al. for the perspectives on defining what constitutes high-quality of online patient information.

For the reader who might want to use the findings of this study in a practical manner in constructing a website on CL/P, it is advised that attention be paid to the following: clearly label the source of the information, make sure your website is easily accessible, make information easy to find on your website, and support claims relating to benefits of treatment, products, or services with balanced evidence.

Involving patients (and parents) in composing online patient information by exploring mutual needs and discussing content and important quality indicators for this information is necessary to produce high-quality information. Patient involvement will be time-consuming and requires dedicated resources, as appropriate preparation of the patients will be needed for effective patient involvement in deliberations with professionals.²⁷ Nevertheless, a more intensive collaboration with our patients (and parents) to improve health(care) and treating them as equal partners is an essential and inevitable cultural shift in healthcare.



Funding

None

Competing Interest

None

Ethical Approval

The Ethics Committee of Radboud University Medical Centre Nijmegen reviewed the study protocol and approved the study (registration number 2012/451).

Patient Consent

Not required.

Acknowledgements

We would like to thank all of the patients, parents, and professionals from the cleft centres of Erasmus MC Rotterdam and Radboud UMC Nijmegen for their willingness to participate in this study. Furthermore, we are grateful for the participation of all professionals from other cleft centres in the Netherlands.

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4

Patients' Perspective on Artificial Intelligence in Dentistry

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Original title:

Patients' Perspectives on the Use of Artificial Intelligence in Dentistry: a
Regional Survey

Published in:

Head and Face Medicine



Abstract

The use of artificial intelligence (AI) in dentistry is rapidly evolving and could play a major role in a variety of dental fields. This study assessed patients' perceptions and expectations regarding AI use in dentistry. An 18-item questionnaire survey focused on demographics, expectancy, accountability, trust, interaction, advantages and disadvantages was responded to by 330 patients; 265 completed questionnaires were included in this study. Frequencies and differences between age groups were analysed using a two-sided chi-squared or Fisher's exact tests with Monte Carlo approximation. Patients' perceived top three disadvantages of AI use in dentistry were (1) the impact on workforce needs (37.7%), (2) new challenges on doctor–patient relationships (36.2%) and (3) increased dental care costs (31.7%). Major expected advantages were improved diagnostic confidence (60.8%), time reduction (48.3%) and more personalized and evidence-based disease management (43.0%). Most patients expected AI to be part of the dental workflow in 1–5 (42.3%) or 5–10 (46.8%) years. Older patients (>35 years) expected higher AI performance standards than younger patients (18–35 years) ($P < 0.05$). Overall, patients showed a positive attitude towards AI in dentistry. Understanding patients' perceptions may allow professionals to shape AI-driven dentistry in the future.

4.1 Introduction

Recent advances in artificial intelligence (AI) have led to tremendous changes and challenges in the field of dentistry.¹ AI describes the theorization and development of computer systems (e.g., neural networks) aiming to imitate the human intellect.² These networks are composed of many layers that transform input data (e.g., images) into outputs (e.g., disease presence/absence), allowing a wide range of possible applications from automated treatment planning to improved diagnostics.³ In the near future, AI could play a major role in nearly every part of dentistry, including oral and maxillofacial surgery, cariology and endodontics, periodontics, paediatric dentistry, orthodontics and prosthodontics.² The image analysis of dental X-rays could be considered as the most important possible function of AI in dentistry. The frequent use of intraoral and panoramic images underlines the importance of the imaging sector in dentistry. Recently, AI has shown promising results in the analysis of dental X-rays in various studies.^{4–7} The first Food and Drug Administration (FDA) approved/Conformité Européenne (CE) marked AI solutions are currently entering the market and the clinical arena.⁸

Nevertheless, a range of challenges still require solutions. The technical complexity of modelling patient data to tailor medical decisions increases exponentially with the confronted uncertainties and erroneous data used in clinical decision-making.⁹ The limited availability of data, poor methodological reproducibility and the narrow usability of current AI systems are the three main reasons why AI has not yet become a major assistive technological system in dentistry.¹⁰ Moreover, ethical and legal challenges remain; debates around data privacy, safety and effectiveness or liability are still ongoing. Open public and political discussions are needed to rethink the current regulatory frameworks and ensure they can be adapted to the healthcare system.¹¹ However, the extent to which AI solutions are adopted in dentistry will mainly depend upon the attitudes of clinicians and patients.¹²

Few studies have investigated dentists' and dental students' attitudes and perceptions towards AI.^{13–15} These studies shared optimistic views, with a positive impact on dental care. One recent controlled study assessed patients' perspectives towards AI for radiographic caries detection and the impact of AI-



based diagnosis on patients' trust.¹⁶ Compared to Kosan et al., the current work addressed patients' perspectives on AI in general.

Another study assessed patients' perceptions of the use of AI in radiology and identified six key domains of patients' perspectives: (1) proof of technology, (2) procedural knowledge, (3) competence, (4) efficiency, (5) personal interaction and (6) accountability.¹⁷

The purpose of the present study was to assess patients' knowledge and perceptions of AI in dentistry. This study was purely explorative, without formal hypothesis testing. Understanding patients' perceptions may allow dentists to shape AI-driven dentistry in the future.

4.2 Materials and Methods

A modified 18-item questionnaire in the German language (Table 1) was used based on the survey design by Scheetz et al.¹² The survey questions focused on demographics, self-perceived dental health, expectancy, accountability, trust, interaction, advantages and disadvantages. The survey questions were validated through a literature review and pilot testing. Disagreements regarding any questions were resolved by consensus (NA, LB, MH). To avoid any potential discrimination, questions regarding gender or education were omitted. The inclusion criteria were a minimum age of 18 and fluent proficiency in German. Approval for this survey was granted by the Ethics Committee of the Westphalia-Lippe Medical Association, Westfälische-Wilhelms University Münster (IRB approval no. 2021–616-f-5). This study was conducted in accordance with the code of ethics of the World Medical Association (Declaration of Helsinki).

Sample Size

Sample size estimation and power calculations were waived by the Institute of Biostatistics and Clinical Research of Westfälische-Wilhelms University Münster. This study was purely explorative and observational, using convenience sampling without concrete hypothesis testing.

Study Design

The cross-sectional questionnaire was distributed to patients who visited the outpatient clinic at the Department of Cranio-Maxillofacial Surgery, University Hospital Münster, and a private dental clinic in Münster, Germany, between November 2021 and March 2022. These two clinics cover a broad range of clinical areas, such as implantology, oral surgery, reconstructive dentistry, prosthodontics, orthognathic surgery and periodontics. Participation was voluntary, and no incentives were provided. Written informed consent was obtained from each participant prior to commencement of the survey.

All participating patients received an ethically approved information sheet with a written explanation of the anticipated use of AI in dentistry (e.g., intraoral scan segmentation and digital implant position design). For further clarity, the first AI application receiving CE marking in dentistry (dentalXrai Pro, dentalXrai GmbH, Berlin) was provided as an example.

Descriptive statistical analysis was conducted using SPSS Statistics Version 28.0 (IBM, Armonk, NY, USA). Depending on the frequency, group differences were calculated using two-sided chi-squared or two-sided Fisher's exact tests. An asymptotic approximation using the Monte Carlo method was used in cases with invalid computational times. The level of significance was set at $P < 0.05$.

Table 1 Questionnaire

How old are you?	☐ 18–25	☐ 26–35	☐ 36–50	☐ 51–60	☐ 61–80
How often do you visit the dentist per year?	☐ semiannual	☐ annual	☐ biennial	☐ emergency	
How important is your oral health to you?	☐ not at all	☐ low	☐ normal	☐ high	
Which dental treatments had you in the past? (Multiple choice possible)	☐ Fillings	☐ Root canal treatment	☐ Bleaching	☐ Tooth extraction	☐ None
	☐ Prosthetics (crown, bridge, prosthesis etc.)	☐ Apicectomy	☐ Other:		
Have you had panoramic radiographs/ radiographs taken in the past?	☐ yes	☐ no			
How would you assess your knowledge about the digital world?	☐ nothing	☐ below average	☐ average	☐ above average	
How would you assess your knowledge about artificial intelligence?	☐ nothing	☐ below average	☐ average	☐ above average	
Do you have concerns about the use of artificial intelligence in dentistry? If yes, which? (Multiple choice possible)	☐ No concerns	☐ Impact on workforce needs	☐ Data security	☐ Lack of accuracy of "electronic" diagnoses	
	☐ New challenges for the doctor-patient-relationship	☐ Costs	☐ The influence of technology giants	☐ Other concerns:	
From your point of view, what is the greatest advantage of using artificial intelligence in dentistry? (Multiple choice possible)	☐ Time savings	☐ Improved health comprehension	☐ Better doctor-patient-relationship	☐ More safety in diagnoses	
	☐ More uniformity among dentists	☐ Other:			
Would the use of artificial intelligence be able to compensate mistakes from the dentists?	☐ no	☐ yes	☐ unsure		
Do you think that the use of artificial intelligence would lead to shorter treatment time?	☐ no	☐ yes	☐ unsure		
Does the use of artificial intelligence improve the overall oral health?	☐ no improvement	☐ less improvement	☐ yes		
Do you think that the use of artificial intelligence would lead to an increase the treatment quality?	☐ no improvement	☐ less improvement	☐ yes	☐ major improvement	☐ no opinion
Does the use of artificial intelligence improve the doctor-patient-relationship?	☐ no improvement	☐ less improvement	☐ yes	☐ major improvement	☐ no opinion

Table 1 (continued)

What level of error is tolerable for artificial intelligence-based diagnostic systems?

- ☐ Equivalent to the worst performing dentist
- ☐ Superior to the average performing dentist
- ☐ Equivalent to the best performing dentist
- ☐ Superior to the best performing dentist

Would you endorse the following procedure? Dental X-rays will be analyzed by an artificial intelligence and the findings will be assessed by the dentist afterwards

- ☐ yes
- ☐ no
- ☐ unsure

To what extent would you agree to the following statement? Dentistry will benefit from the use of artificial intelligence

- ☐ yes
- ☐ no
- ☐ unsure

When would artificial intelligence be fully implemented in the daily dental work?

- ☐ within one year
- ☐ in 1 to 5 years
- ☐ in 5 to 10 years
- ☐ in over 10 years
- ☐ never

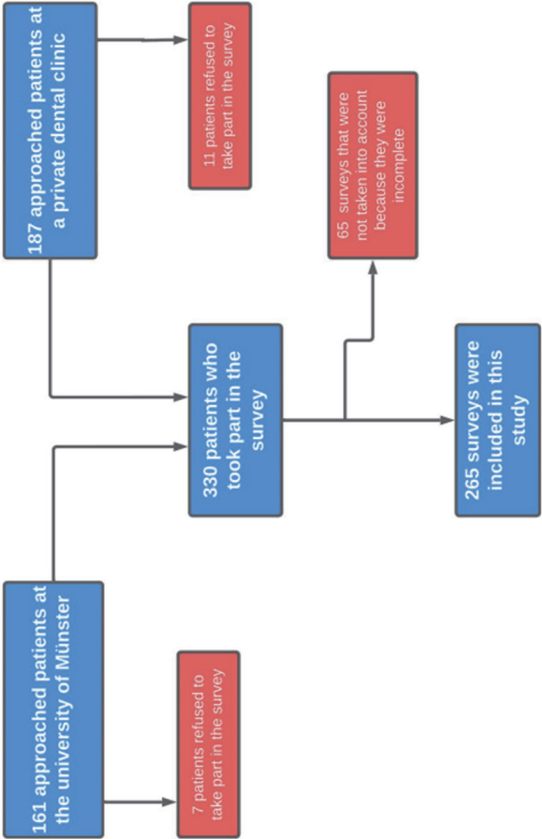


Figure 1 Flowchart showing the survey distribution procedure



4.3 Results

Of the 348 participants to whom the questionnaire was distributed, 18 (5.2%) refused to answer, and 265 answered the questionnaire completely. Sixty-five incomplete surveys were excluded from further analysis based on the exclusion criteria. The flowchart showing the survey distribution procedure is shown in Fig. 1. The demographics and self-perceived dental health of the 265 patients are outlined in Table 2.

Self-perceived Knowledge of Artificial Intelligence

The majority of the patients (n=248, 93.6%) assessed their knowledge of digital technology as 'average' or 'above average'. In comparison, only half of the participants (n=139, 52.5%) rated their knowledge of AI as 'average' or 'above average'. In total, 47.5% (n=126) rated their knowledge of AI as 'nothing' or 'below average'.

Disadvantages of Using AI in Dentistry

The top three disadvantages cited by patients regarding the use of AI in dentistry were (1) the impact on workforce needs (37.7%), (2) new challenges to the fiduciary relationship between dentist and patient (36.2%) and (3) increased dental care costs (31.7%) (Fig. 2). Additional expressed disadvantages were liability, neglect of education, limited applicability for older dentists and lack of empathy. Only 12.8% of the cases were perceived as having a data privacy disadvantage.

Major Advantages of AI in Dentistry

The top three advantages respondents perceived regarding the use of AI in dentistry were 'improved diagnostic confidence' (60.8%), followed by 'time reduction' (48.3%) and 'more personalized and evidence-based disease management' (43.0%) (Fig. 3). Another stated advantage was the dual-control principle. The dual-control principle is a theory that requires for certain activities (i.e. decision-making in diagnosing or treatment) at least two operators/systems in order to increase accuracy and transparency. In addition, the impact on the fiduciary relationship between the dentist and patient was considered an advantage by only 9.1% of respondents.

Table 2 Demographics and self-perceived dental health

		n (%)
Age	18-25	28.7
	26-35	23.0
	36-50	16.6
	51-60	17.0
	61-80	14.7
	Semi-annual	54.0
Regular Dental Check-Up	Annual	34.7
	Biennial	4.5
	Emergency	6.8
Importance of oral health	Low	0.8
	Normal	33.2
	High	66.0
Types of treatment	Filling	81.5
	Prosthetics	44.5
	Extraction	42.6
	Root canal treatment	38.9
	Bleaching	8.3
	Apicectomy	22.3
	Other	17.0
	None	3.8

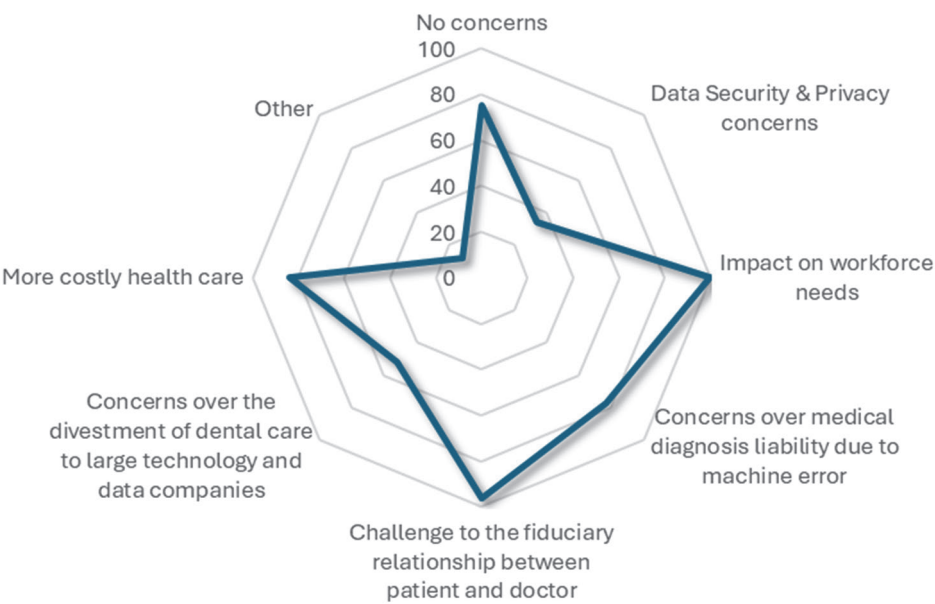


Figure 2 Cited disadvantages of using AI in dentistry

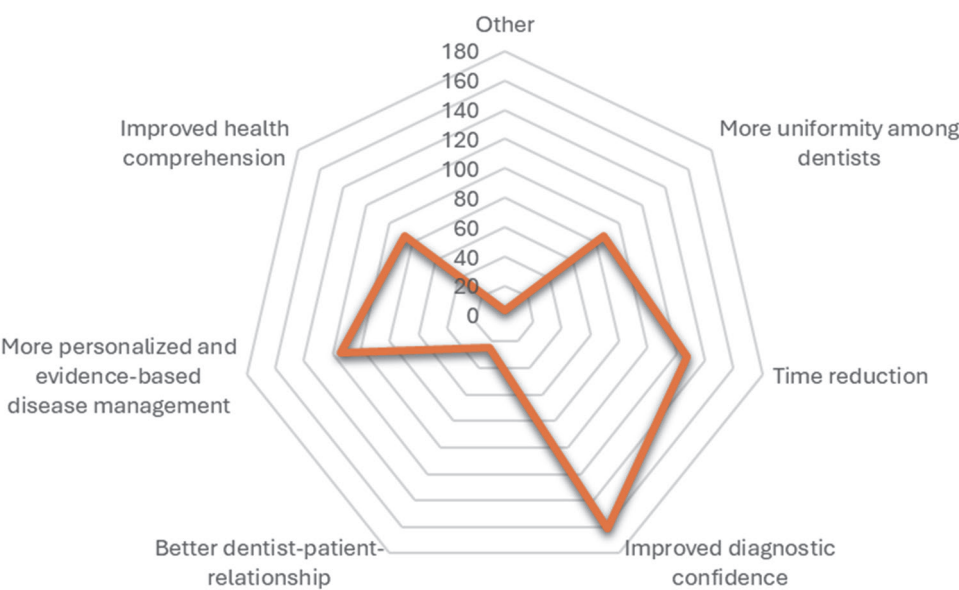


Figure 3 Cited advantages of using AI in Dentistry

Improvement in Public Oral Health

Regarding whether the implementation of AI would lead to better public oral health, the majority (n=137, 51.7%) responded that they were unsure. About one quarter of the volunteers (n=73, 27.5%) believed that public oral health would experience a major improvement due to the use of AI.

Hypothetical Workflow for Diagnosing Dental X-rays

One possible future way of diagnosing intra- and extra-oral dental images could be as follows: Dental images will be analysed by an AI first and the findings will be assessed by the dentist afterwards. Of the respondents, 84.9% (n=225) agreed with this proposed procedure, while a minority (4.9%, n=13) disagreed.

Acceptable AI Performance Standards and Clinical Workflows

Around half of the patients (n=125, 47.2%) stated that AI should perform better than an average-performing dentist, while 29.1% (n=77) expected AI to be as good as the best dentist. Only a minority (7.5%, n=20) demanded that AI should be better than the best performing dentist. Significant differences were seen between younger (18–35 years) and older (> 35 years) patients in terms of acceptable AI performance standards ($P < 0.05$). Older patients expected higher AI performance standards. Around half of the respondents assumed that the use of AI could prevent mistakes made by dentists (n=129, 48.7%).

Expected Time until AI will be Part of Dental Workflows

Most patients expected that AI would be part of the dental workflows either in 1–5 (n=112, 42.3%) or 5–10 years (n=124, 46.8%). Only a tenth (n=21, 7.9%) expected AI integration 10 years or later. Furthermore, the majority (n=195, 73.6%) agreed with the following statement: 'Dentistry will benefit from the use of artificial intelligence'.

4.4 Discussion

The use of AI in dentistry is rapidly evolving and could play a major role in the dental office in the near future. As Chen et al. pointed out, AI systems can be categorised into pre-, inter- and post-appointment AI systems.¹⁸ The idea of a comprehensive AI dental care system predicts that AI could play a role in patient management (pre-appointment) to analyse patients' needs and risks, in diagnosis and treatment planning/decision and in outcome prediction (inter-appointment), as well as in labour work (e.g., design for prosthodontics) and treatment evaluation (post-appointment). This model emphasizes the variety of tasks that AI could take part in. Nevertheless, the inter-appointment AI systems would be most visible to patients, as these systems would intervene in diagnosis, treatment decisions and planning.

The present survey assessed patients' perceptions and attitudes towards AI in dentistry. Our findings are in line with previous surveys. The introduction of new technologies will lead to a shift in skill and expertise requirements. A consensus has arisen that education and training programs need to be adjusted to labour market requirements.¹⁹ Furthermore, surveys have highlighted disadvantages regarding employment prospects.^{20, 21} However, as other studies have pointed out, AI will rather work synergistically with clinicians than replace clinicians completely by overtaking clinical work.²² The conclusion of other surveys that investigated the attitudes of dental students towards AI was that implementing AI in further dental training curricula is important.^{15, 23}

AI-based communication often lacks intentionality and therefore constitutes a significant obstacle at the communication level. In line with these findings, previous studies have shown a preference for clinician-based diagnostic decisions over AI-based diagnostic decisions.^{17, 24–26} Handing over parts of the communication to AI-driven systems as part of the diagnosis and treatment procedure can be crucial to the well-being of the patients and therefore the relationship between dentists and patients. Compared with the findings of this study, about a third of the participants stated that the use of AI in the dental field could give rise to new challenges to the fiduciary relationship between dentist and patient (36.2%). However, assistive AI systems should provide support to the dentist, which would enhance their ability to attend to higher

valued tasks, such as more professional interactions with patients, integrating patients into the diagnosis and treatment process and being more visible to the clinical team and patients.²⁷ The dentist is constantly asked to nonverbally assess the patient's feelings and adapt their further actions based on their evaluation.²⁸ Moreover, due to the fact that 330 patients took part in the survey and only eighteen patients have declined to do so, an considerable interest in AI in dentistry among dental patients is observable. This underlines the importance of such surveys in order to demonstrate the possibilities of AI implementation in the dental field for patients.

Lastly, AI-based dental care will raise new questions about cost-effectiveness and ever rising healthcare costs. About a third of the patients who participated in our survey were concerned about a possible increase in costs. However, Rossi et al. analysed cost-effectiveness using health economic modelling via Markov models and concluded that the current evidence supporting AI as a decision support mechanism is limited.^{29, 30} Further research is needed.

Previous studies have referred to AI as a facilitator of faster, more precise and more personalized and evidence-based disease management. These studies have reported on par or even higher diagnostic accuracies than average dentists.^{8, 10, 31}

To be more precise, AI is mainly used in lesion segmentation in the fields of cariology and endodontics. Identifying tooth surface loss, root caries, periapical lesions or root fractures is crucial in further treatment decision-making. Depending on the diagnosis, the affected tooth may undergo tooth preserving/restorative treatment or, in the worst case, extraction. The treatment decision will have a major impact on further treatment requirements. Accurate and precise detection of lesions is important in the implementation of suitable treatments.³² In terms of caries detection, numerous studies have reported that trained and validated AI systems have significantly higher accuracy and sensitivity than clinicians.^{8,29,32,33} As the present study assessed the acceptable performance of AI, about half of the participants stated AI systems should be better than an average dentist and could prevent mistakes made by the dentist. Compared with the studies that investigated the actual performance of AI, current AI systems could live up the participants' expectations. The detection of periapical lesions in endodontic treatment is essential for further treatment planning and the prediction of treatment success.



Setzer et al. reported excellent results in identifying periapical lesions on Cone Beam Computer Tomography (CBCT) using a deep learning system based on an encoder-decoder architecture (U-NET).³⁴ The application of such systems could lead to more reliability in diagnosis, with accuracy levels on par or even higher than experienced specialists.³⁵

Furthermore, the development of AI systems in the fields of Oral and Maxillofacial surgery is promising. AI systems may help in diagnosing the pathologies of various types of diseases and assist in treatment planning. Neural networks may be used to diagnose pathologies in the bone and mucosa, guiding orthognathic surgery, implantology and complication management.³⁶ For example, with an accuracy of 94%, a support vector machine (SVM) classifier system was able to differentiate between periapical cysts and keratocystic odontogenic tumours in CBCT scans.³⁷ In addition, diagnosing tumorous lesions at an early stage has a significant impact on disease treatment and outcomes. AI systems may have the ability to help professionals and mitigate healthcare delays.³⁸ In terms of orthognathic surgery, AI could play a major role from treatment planning to treatment follow-up. With the ability to visualize the treatment beforehand, confusion and misunderstanding by the patient may be limited.³⁹

In orthodontic treatment planning, the analysis of cephalometric radiographs is vital to successful treatments. The automated detection of landmarks by a knowledge-based algorithm showed no significant difference from manual detection.^{40,41} Another study showed that a web-based deep learning application analysing 23 landmarks on cephalograms showed a classification success rate of 88.43%.⁴² Camci et al. showed that a deep learning system that evaluated the tooth size of unerupted teeth had higher accuracy than the use of a Moyer's table.⁴³ A scoping review stated the possibility of improving diagnostic accuracy in orthodontics using AI.⁴⁴

AI can also be used in paediatric dentistry. Numbering deciduous teeth in paediatric panoramic radiographs is crucial to identifying congenital or non-congenital issues. Recently, a convolutional neural network (CNN)-based system was able to detect deciduous teeth in panoramic radiographs with a sensitivity of 0.98.⁴⁵

As the majority of the patients have stated that AI could lead to an improved diagnostic confidence, the opinion of most participants comes in line with the

studies that observed promising results regarding AI performance in the dental field. When it comes to an improved public oral health by using AI in dentistry, only about a quarter of the participants expect a major improvement. The authors conclude that more studies are needed to create awareness for AI systems among patients.

Nevertheless, these models need to undergo a more transparent validation process using external data to verify their generalizability and reliability.⁴⁶ Due to the rapid development process, AI systems may be considered black-box systems by critical users and consumers. Developers may need to stress the principles of these models in a more transparent manner to keep clinicians and patients engaged and to avoid trust issues.⁴⁷ As about half of the respondents (47.5%, n=126) rated their knowledge of AI as 'nothing' or 'below average', integrating patients in the development process and creating greater insight into the medical AI world may lead to enhanced AI knowledge. Transparency in the development process could lead to more trustworthiness among patients.

Furthermore, AI models have proven to be extremely time-efficient for certain tasks, such as image segmentation.⁶ Yasa et al. used a CNN-based system to identify teeth in bitewing radiographs, which yielded promising results in terms of accuracy and time efficiency.⁴⁸ Improving the dental workflow and increasing diagnostic accuracy may lead to more efficient, personalized dentistry. Time efficiency has also been stated to be a major advantage of using AI in dentistry by the participants of the study.

The present study has a range of strengths and limitations. First, it is one of the few studies that focused on the attitudes and expectations of patients towards AI in dental and maxillofacial fields. The representativeness of this explorative study should be regarded with caution for several reasons. Even though the sample size was reasonable, larger sample sizes are needed for in-depth subgroup analysis next to validated instruments. Furthermore, Germany is a high-income country and therefore higher oral care awareness can be expected. Future studies can then be tested with a concrete hypothesis in reference to this study.



Conclusion

Overall, patients showed a positive attitude towards the use of AI in dentistry. Major advantages were the increase in diagnostic confidence, time efficiency and more personalized disease management. To achieve an increase in knowledge about AI, the development of AI should be more transparent and visible to patients.

Acknowledgements

We kindly thank Dr. Dr. Walid Ayad and his personnel for helping to recruit patients for this study.

Authors' Contributions

Conceptualization, N.A. and S.V.; methodology, M.H.; validation, N.A., L.B. and F.S.; formal analysis, N.A.; investigation, N.A., S.V.; resources, F.S, S.vB, S.B., M.H., J.K.; data curation, N.A., S.V., L.B.; writing—original draft preparation, N.A., S.V., L.B.; writing—review and editing, M.H., F.S., S.B., S.vB., J.K.; visualisation, N.A., L.B.; supervision, M.H., F.S., J.K., S. B., S.vB.; project administration, M.H., F.S., J.K., S.B., S.vB.; funding acquisition, M.H. All authors have read and agreed to the published version of the manuscript.

Funding

Open Access funding enabled and organized by Projekt DEAL. This research received no external funding.

Availability of Data and Materials

The data used in this study can be made available from the corresponding author within the regulatory boundaries for data protection.

Declarations

Ethics approval and consent to participate

Approval for this survey was granted by the Ethics Committee of the Westphalia-Lippe Medical Association, Westfälische-Wilhelms University Münster (IRB approval no. 2021–616-f-S). This study was conducted in accordance with the code of ethics of the World Medical Association (Declaration of Helsinki).

Consent for Publication

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of the authors. All authors have read and agreed to the published version of the manuscript.

Competing Interests

F.S. and J.K. are co-founders of the dentalXrai GmbH, a startup. dentalXrai GmbH did not have any role in conceiving, conducting, or reporting this study.



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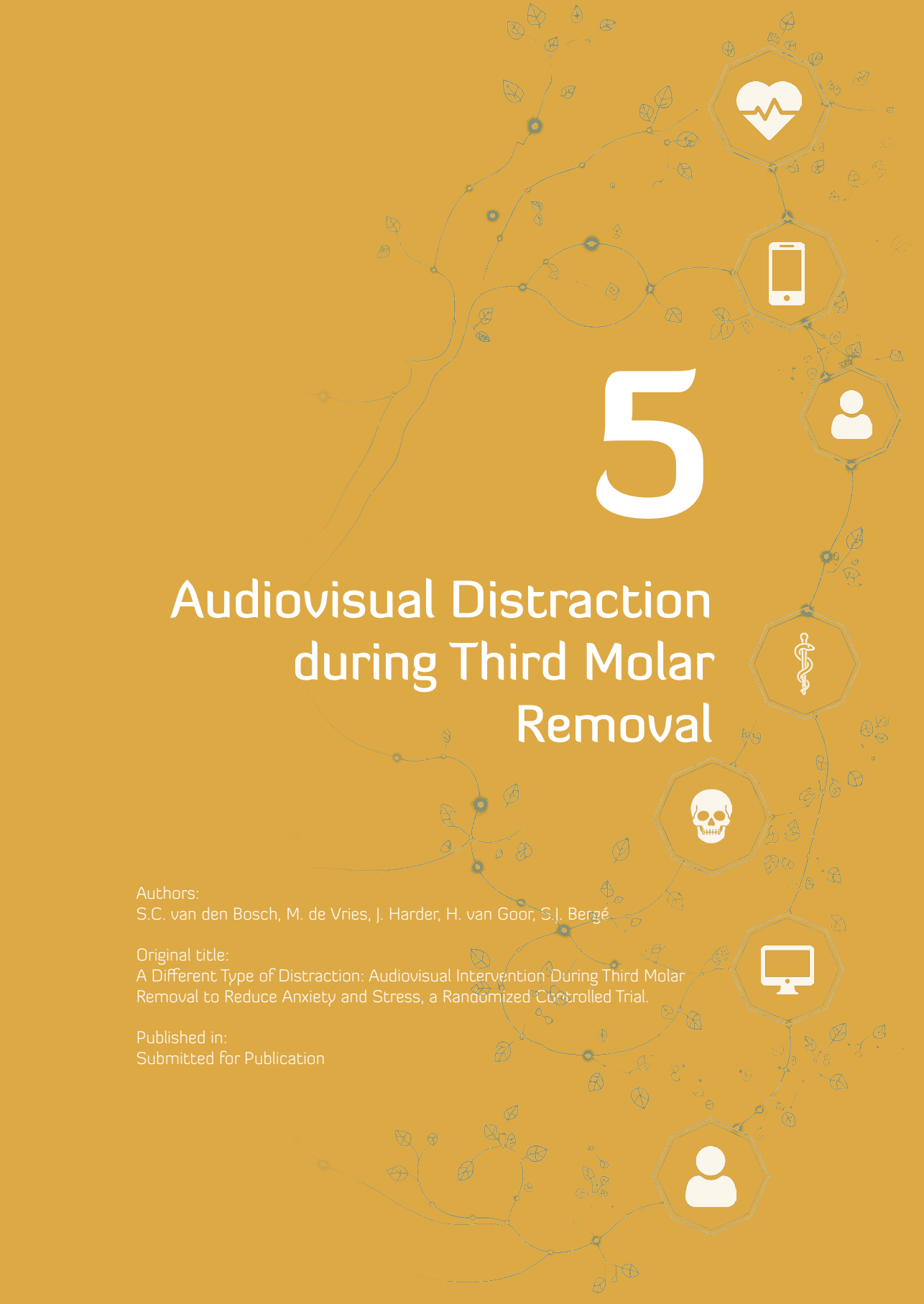
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II Evaluation in Clinical Practice



The background is a solid orange color. A stylized, light-colored tree branch with small leaves and circular nodes winds across the page. Several white icons are enclosed in hexagonal frames, connected by thin lines. The icons include a heart with an ECG line, a smartphone, a person silhouette, a caduceus, a skull, a computer monitor, and another person silhouette.

5

Audiovisual Distraction during Third Molar Removal

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Original title:

A Different Type of Distraction: Audiovisual Intervention During Third Molar Removal to Reduce Anxiety and Stress, a Randomized Controlled Trial.

Published in:

Submitted for Publication

Abstract

Third molar removal is a procedure that patients often find fearful and stressful. Anxiety has a negative effect on operation time, wound healing and post-operative recovery. The aim of this study is to assess the impact of audiovisual eyeglasses on anxiety and stress during third molar removal in local anaesthesia. In a split-mouth trial, patients served as their own controls, undergoing the procedure with (1) audiovisual support or (2) standard care. Randomization took place for type of video: a relaxing or thrilling video. Baseline anxiety was measured using the short Dental Anxiety Inventory. Anxiety was assessed post-surgery using the State Trait Anxiety Inventory and a visual analogue scale. Heart rate (HR) and respiratory rate (RR) were recorded pre-, peri-, and post-operatively. Post-operative use of analgesia was monitored for three days. Out of 42 included patients, 35 completed the study. Overall, the audiovisual intervention had no significant effect on anxiety, irrespective of the video type. However, HR was consistently lower in the video arm, while RR was higher. Specifically, a relaxing video decreased HR compared to the control, a thrilling video increased RR.

In conclusion, while the audiovisual intervention did not impact anxiety, the choice of video influenced physiological stress parameters during third molar removal.

5.1 Introduction

Third molar removal is a frequently performed procedure; in the United States, 3.5 million inferior third molars are removed annually.¹ This procedure is found to be the most stressful and fearful treatment for patients undergoing oral surgery in local anaesthesia.^{2,3} Up to 97% of patients are described to be anxious for this procedure.⁴

Anxiety and stress alter endocrine and metabolic functions, activate the sympathetic nervous system and have a profound negative effect on immune response, wound healing and post-operative recovery.^{5,6} In oral surgery, increased levels of anxiety are correlated with longer operation time and higher difficulty of third molar removal.⁷ Reducing anxiety and stress is therefore not only of importance for the patient's peri-operative well-being, but might benefit workflow and lead to uneventful recovery.

Pharmaceutical ways of reducing pre-operative anxiety are subject to unwanted side effects, e.g., somnolence, lack of coordination, disorientation, respiratory depression and decreased saturation.^{8,9} Innovative distraction techniques offer a non-invasive and personalized alternative in an attempt to reduce anxiety and stress. Listening to music pre- and intra-operatively has already shown to decrease anxiety levels during third molar removal¹⁰⁻¹³, and is frequently applied in daily practice. Removal of third molars under hypnosis had no significant effect on anxiety, but did reduce post-operative pain and the use of analgesia.¹⁴ The pre- and intra-operative use of virtual reality is an upcoming innovation, which still has to prove its effect during third molar removal.¹⁵⁻¹⁷

In this study, we used novel audiovisual eyeglasses that distract patients during third molar removal. We aimed to investigate the efficacy, safety and tolerability of this audiovisual intervention during third molar removal for anxiety reduction. The effect of the audiovisual intervention on stress was assessed before, during and at the end of the operation, also taking into account type of video that was shown. In addition, the effect of the audiovisual intervention on post-operative pain perception and use of analgesia was determined.

5.2 Materials and Methods

A within-subject split-mouth design was used to explore efficacy and tolerability of an audiovisual intervention during third molar removal. The study population concerned patients scheduled for elective bilateral upper and lower third molar removal at the department of Oral and Maxillofacial (OMF) surgery, Radboud university medical centre Nijmegen, the Netherlands. All participants, enrolled from August 1st 2016 to April 26th 2017, gave written informed consent. The trial was approved by the institutional ethical review board (reference: 2016-2589, NL58019.091.16) and was conducted in accordance with the Declaration of Helsinki (2013). For this publication we followed the CONSORT guidelines.

Participants

Adult patients scheduled for bilateral third molar removal, at an interval period of at least 3 weeks, with an American Society of Anaesthesiologists (ASA) physical status classification of 1, were eligible for inclusion. The impaction classification of the third molars did not need to be similar on both sides to be included in the study. Exclusion criteria were: (1) contra-indications for outpatient oral surgery under local anaesthesia, (2) self-reported loss of sight or hearing, or other conditions otherwise impairing the use of the video equipment according to the investigator's judgement.

Procedures

Patients were randomly assigned (1:1) to the sequence of both arms using a randomized block design with random block sizes. One group received conventional third molar removal first (care as usual) and third molar removal while wearing audiovisual eyeglasses second (video arm). The second group was scheduled the other way around. After randomization, even numbers were allocated to a relaxing video, uneven numbers to a thrilling video. Patients were informed about the two types of treatment, but did not know whether they would have the care as usual or the audiovisual intervention first. Audiovisual eyeglasses (HappyMed®, Vienna, Austria) were used as distracting audiovisual intervention. In this system, video glasses and headphones are integrated, creating a two-dimensional cinema experience (Fig. 2). The desired video can be selected using an operating control panel.

For this study, two videos were selected: a soothing, relaxing video (i.e., a wildlife documentary) and a thrilling video (i.e., Formula 1 documentary). The audiovisual eyeglasses were worn from administering local anaesthesia until the end of the surgical procedure.

In the control situation usual care was given by covering the patient's eyes by a sterile drape. All procedures were performed by a senior OMF surgeon (SJB) in similar settings and by starting with removal of the inferior third molar, followed by the superior third molar. Local anaesthesia was administered with articaine/epinephrine 40 mg/10 µg in cartridges of 1.7 mL.

Efficacy Outcome

Efficacy was primarily based on anxiety and secondarily on heart and respiratory rates, post-operative pain and analgesia use.

Anxiety

Pre-operative dental anxiety was measured using the Dutch version of the Short Dental Anxiety Inventory (S-DAI). The S-DAI is a validated questionnaire to measure dental anxiety.^{18, 19} Participants filled out this form once, during intake at the outpatient clinic.

The level of anxiety during surgery was measured by the validated Dutch 6-item short form of the Spielberger State Trait Anxiety Inventory (STAI Y-6)²⁰ and an anxiety related visual analogue scale (VAS anxiety).²¹ The STAI Y-6 items are scored on a 4-point Likert scale. The calculation of the STAI score (ranging from 20 to 80) followed protocol, wherein the scoring of positive items was reversed, and the sum of all six scores was then multiplied by 20/6.²⁰

The VAS anxiety was defined as a line of 100 mm on which participants could mark their level of anxiety during the procedure, ranging from “not at all anxious” to “extremely anxious”.

Both STAI Y-6 and the VAS anxiety questionnaires were taken directly after both procedures.

Stress

Participants' heart rate (HR) and respiratory rate (RR) were measured, as a proxy for stress, using a Vitalconnect HealthPatch® (Vital Connect, San Jose, USA). This is a flexible self-adhesive patch containing two ECG electrodes and a battery (Fig. 3). The patch is validated to measure 7 items: single-lead ECG, HR, RR, skin temperature, body posture, activity and steps. Patch data are streamed to a smartphone via Bluetooth, from where they are transmitted to a secured online cloud for storage. Data can be downloaded from individual accounts for analysis. The patch was placed to the participants' chests, left midclavicular over the second intercostal space, vertically over the sternum or left midclavicular over the sixth intercostal space. Participants wore the patch during both procedures during the total length of stay at the outpatient clinic. It was applied in a separate quiet room, where first measurements were taken directly after application (pre-operative), 5 minutes before treatment. Subsequent measurements were recorded repeatedly in real time during surgery by one of the authors (JH): at injection of local anaesthesia, at time of incision, at the start of luxation of the lower third molar, and at the start of removal of the upper molar. Post-operative measurements were performed in the surgical chair, in upright position, 5 minutes after the procedure was finished.

Post-operative Follow-up: Pain and Analgesia use

Three days post-operatively, participants were asked to fill out a daily digital questionnaire containing a VAS pain and questions concerning the use of analgesia (type of analgesia taken and number of tablets per day).

Safety and Tolerability

Safety and tolerability were evaluated using spontaneously reported adverse events, recorded throughout the study until follow-up.

Statistical Analyses

No sample size calculation was performed for this pilot RCT due to lack of data for this novel audiovisual eyeglasses. We expected 40 subjects with 80 procedures to be sufficient to provide initial efficacy, safety and tolerability data. Primary outcome measure was difference in anxiety between the care as usual

arm versus the video arm using an analysis of covariance (ANCOVA). Treatment sequence (care as usual first, video first) was the between-subjects variable, and treatment condition (care as usual, video) the within-subjects variable. S-DAI was taken into account as covariate. Post-operative difference in STAI Y-6 and VAS anxiety between the type of video (relaxing versus thrilling) were statistically analysed using an analysis of variance (ANOVA).

Difference in HR and RR between the type of procedure at the 4 peri-operative time points were statistically analysed using a linear mixed model analysis with five fixed effects (type of procedure and 4 peri-operative time points) and a random subject effect (random intercept). The S-DAI, pre-operative HR and RR and the type of video were taken into account as covariates.

Difference in HR and RR between the type of video (relaxing versus thrilling) were statistically analysed using a linear mixed model analysis with five fixed effects (type of procedure and 4 peri-operative time points) and a random subject effect (random intercept).

Statistical analyses were performed using IBM SPSS Statistics version 25. All statistical tests were performed as two-tailed tests, and the limit for statistical significance was set at $P < 0.05$.

5.3 Results

Participants

Forty-six patients were screened, of whom four were excluded. Seven patients were lost to follow-up after the first allocated treatment. Thirty-five patients completed the study protocol and were included in the analysis (Fig.1).

Patient demographics and clinical characteristics are shown in Table 1. A non-significant increase in mean operation time of 97 seconds was observed in the video arm.

Anxiety

STAI Y-6 and VAS anxiety scores according to treatment sequence are shown in Figure 4. Although both STAI Y-6 and VAS anxiety scores decreased in the second procedure in the group that watched the video during the first procedure, no significant treatment effect of audiovisual intervention was found on the STAI Y-6 ($F(1, 32) = 0.15$, $P = 0.70$) and VAS anxiety ($F(1, 32) = 0.03$, $P = 0.86$).

The covariate S-DAI was significantly related to the STAI Y-6 in both control ($P < 0.01$, $r = 0.54$) and video arm ($P < 0.01$, $r = 0.51$). This was also seen for correlation of S-DAI with VAS anxiety in the control ($P < 0.01$, $r = 0.47$) and video arm ($P < 0.01$, $r = 0.56$). Both correlation coefficients are moderate, meaning that a higher baseline anxiety on the S-DAI tends to result in higher anxiety scores on both STAI Y-6 and VAS anxiety in both arms. No significant sequence effect was observed.

No significant effect was found in both STAI Y-6 and VAS anxiety score after watching the relaxing video compared to the thrilling video (respectively $F(1, 33) = 0.23$, $P = 0.63$ and $F(1, 33) = 0.74$, $P = 0.40$).

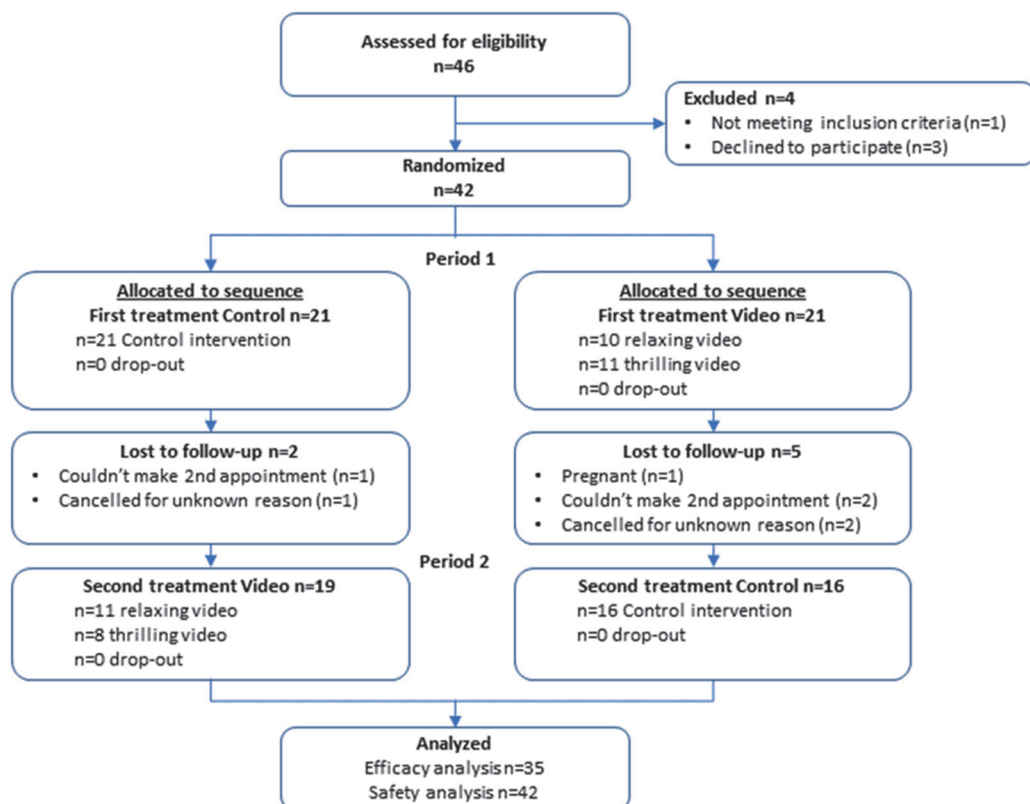


Figure 1 CONSORT flow-chart with study participants



Figure 2 The audiovisual eyeglasses (HappyMed®, Vienna, Austria)



Figure 3 The Vitalconnect HealthPatch®

Table 1 Patient demographics and clinical characteristics

	Conventional (n=35)	Video (n=35)	Total (n=35)	<i>P</i>
Sex				
Female			20 (57.1)	
Male			15 (42.9)	
Age (yr)				
Mean $\pm$ SD			23.1 $\pm$ 2.9	
Range			18-30	
S-DAI score				
Mean $\pm$ SD			23.1 $\pm$ 8.8	
Range			9-44	
Pre-operative medication: n (% yes)				
NSAID	8 (22.9%)	8		
Paracetamol	3 (8.6%)	(22.9%)		
Benzodiazepine	1 (2.9%)	3 (8.6%)		
Anti-depressant	1 (2.9%)	0		
		0		
Local anaesthesia (number of cartridges)				
Mean $\pm$ SD	3.29 $\pm$ 0.75	3.23 $\pm$		0.61 ^a
Range	3-6	0.65		
		3-6		
Operation time (minutes)*				
Mean $\pm$ SD	8.06 $\pm$ 5.01	9.43 $\pm$		0.08 ^a
Range	2.0-25.0	4.72		
		2.0-29.0		

Data presented as n (%) or mean $\pm$ standard deviation (SD).

S-DAI: short version of the Dental Anxiety Inventory

* Time from incision until completion of removal of the upper molar

^a Wilcoxon signed rank test

Stress

Mean HR over time is shown in Figure 5. Linear mixed model analysis showed a significantly lower HR in the video arm compared with the control arm (mean difference HR control – video 3.6, 95% CI of the difference 1.7, 5.5, $P < 0.001$). No significant interaction was found between the intervention and HR on the 4 peri-operative time points ($P = 0.18$). No significant sequence effect was observed ($P = 0.81$).

A significant decrease in HR was seen in the relaxing video versus the control group (mean difference HR control – relaxing video 5.0, 95% CI of the difference 2.4, 7.7, $P < 0.001$) (Figure 6a.)

Figure 7 shows mean RR over time. A significant increase was found of the audiovisual intervention on the RR (mean difference RR control – video -1.4, 95% CI of the difference -2.3, -0.4, $P = 0.01$). A significant interaction between the intervention and the RR over the 4 peri-operative time points was shown ($P = 0.02$). The sequence of the intervention, control versus video arm first, showed no significant effect on the RR ($P = 0.22$).

A significant increase in RR was seen in the thrilling video compared to the control group (mean difference RR control – thrilling video -1.64, 95% CI of the difference -2.89, -0.39, $P = 0.01$) (Figure 8b.)

Post-operative Follow-up: Pain and Analgesia Use

Thirty patients completed the post-operative questionnaire on pain and the use of analgesic medication after the care as usual, 29 of them completed the questionnaire after the audiovisual intervention. No significant effect was found in the mean VAS pain scores and the use of analgesics between the control and video group (Table 2 and 3).

Table 2 Post-operative VAS* pain scores

	Control (n=30)	Video (n=29)	P^{**}
Day 0	32.1 ±15.3	39.2 ±23.7	0.21
Day 1	27.2 ±16.2	26.3 ±21.1	0.96
Day 2	24.4 ±18.8	29.7 ±25.4	0.25
Day 3	19.90 ±16.7	23.8 ±24.3	0.61

Data presented as mean ± standard deviation.

* VAS pain: 0 no pain, 100 extreme pain

**Wilcoxon signed ranks test

Table 3 Use of post-operative analgesic medication in daily number of tablets.

	Control (n=30)	Video (n=29)	P*
Paracetamol			
Day 0	2.6 ±2.9	2.4 ±2.9	0.73
Day 1	2.7 ±3.0	2.1 ±2.6	0.44
Day 2	2.4 ±2.8	2.5 ±2.9	0.68
Day 3	2.7 ±2.8	2.2 ±2.8	0.76
Ibuprofen			
Day 0	2.2 ±1.1	2.2 ±1.1	0.90
Day 1	2.3 ±1.2	2.4 ±0.9	0.56
Day 2	2.4 ±1.4	2.3 ±1.1	0.97
Day 3	2.1 ±1.7	1.9 ±1.1	0.83

Data presented as mean ± standard deviation.

*Wilcoxon signed ranks test

Safety and Tolerability

No serious adverse events or possibly intervention related adverse events were reported.

Eight patients dropped out of the study; 7 were lost to follow-up after the first allocated treatment. One patient was pregnant and further third molar removal was rescheduled after giving birth, 3 patients did not give a reason for cancellation, 3 patient were not able to make a second appointment within the study period. One patient prematurely took off the audiovisual eyeglasses, because he wanted to be able to hear the surgeon. This patient did receive both conditions.

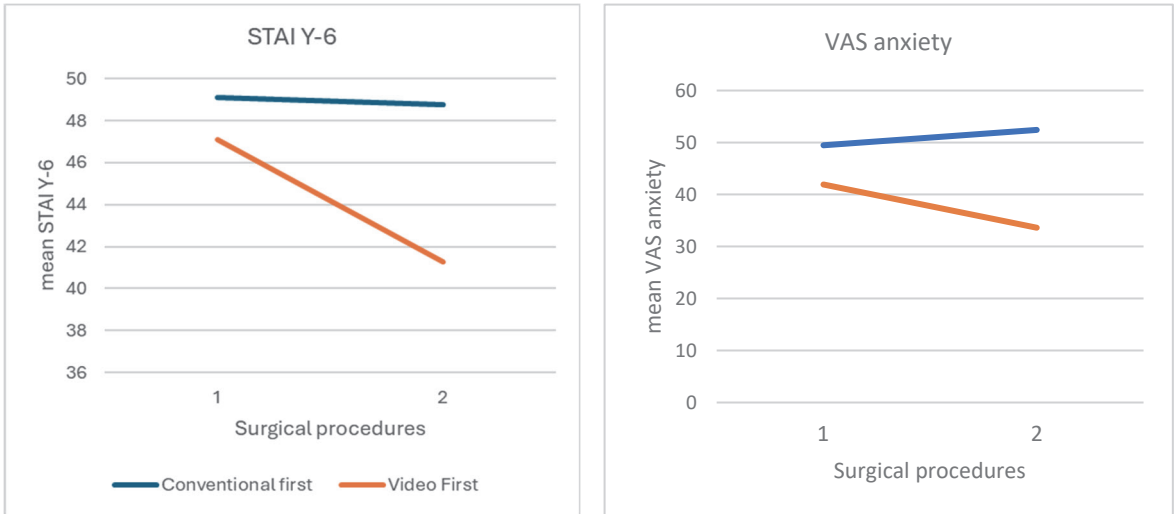


Figure 4 STAI Y-6* and VAS anxiety** score between control and video group according to sequence of treatment.

A decrease in both STAI Y-6 and VAS anxiety scores is shown in the second procedure in the group that watched the video during the first procedure; however, this decrease was not found to be significant.

*STAI Y-6: range 20-80, with a low score meaning a low level of anxiety, a "normal" score is 34-36.

** VAS anxiety: 0 not at all anxious, 100 extremely anxious

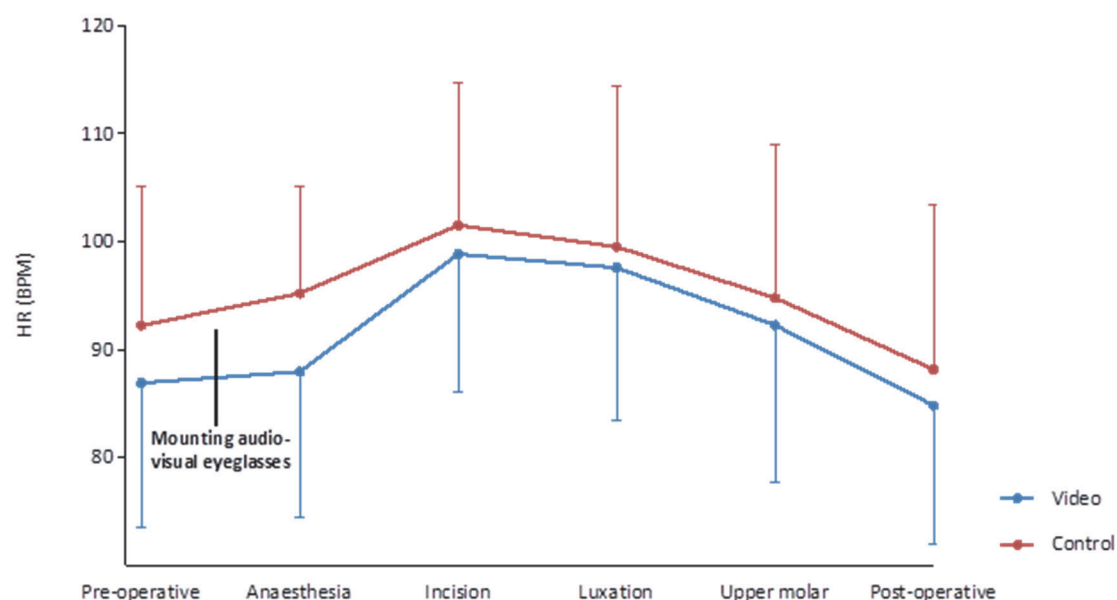


Figure 5 Mean heart rate (HR) per stage of the procedure. A lower mean HR was observed at all recorded measurements in the video group. Error bars indicate standard deviation.

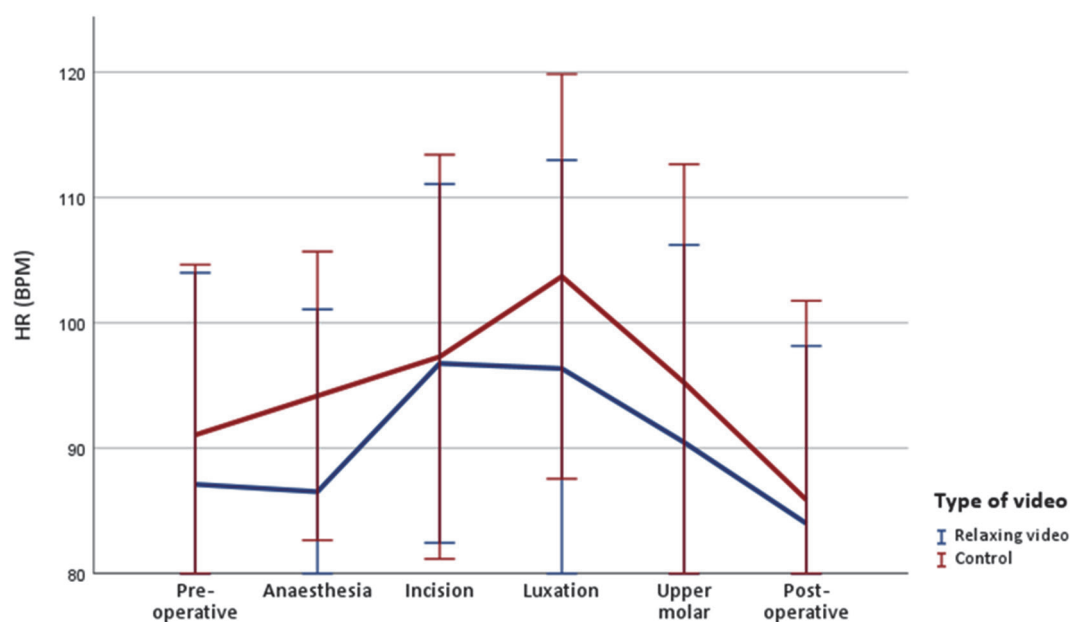


Figure 6a Mean heart rate (HR) per stage of the procedure for the group that viewed the relaxing video. Error bars indicate standard deviation.

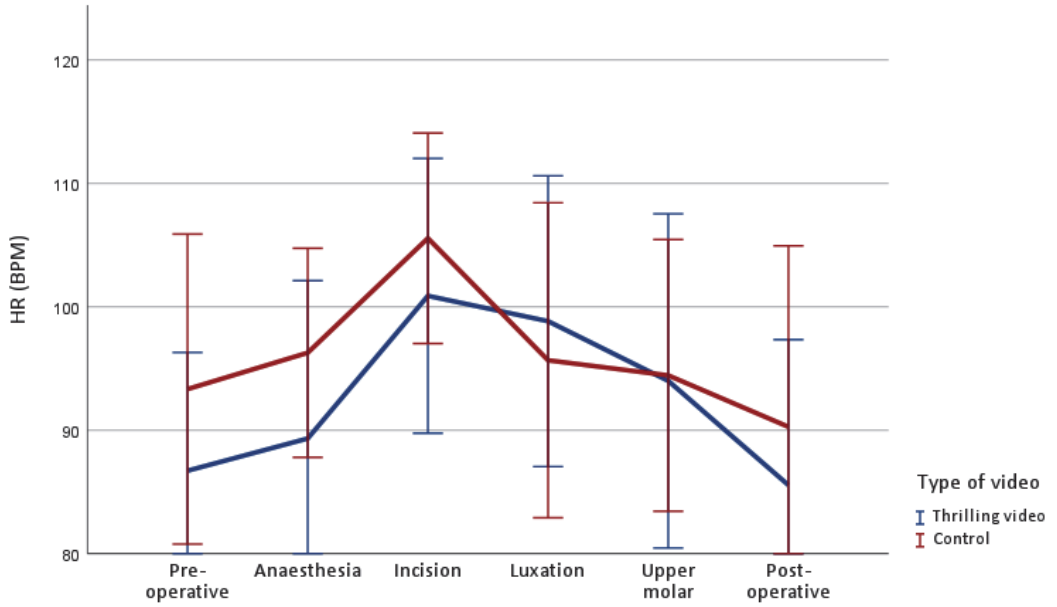


Figure 6b Mean heart rate (HR) per stage of the procedure for the group that viewed the thrilling video. Error bars indicate standard deviation.

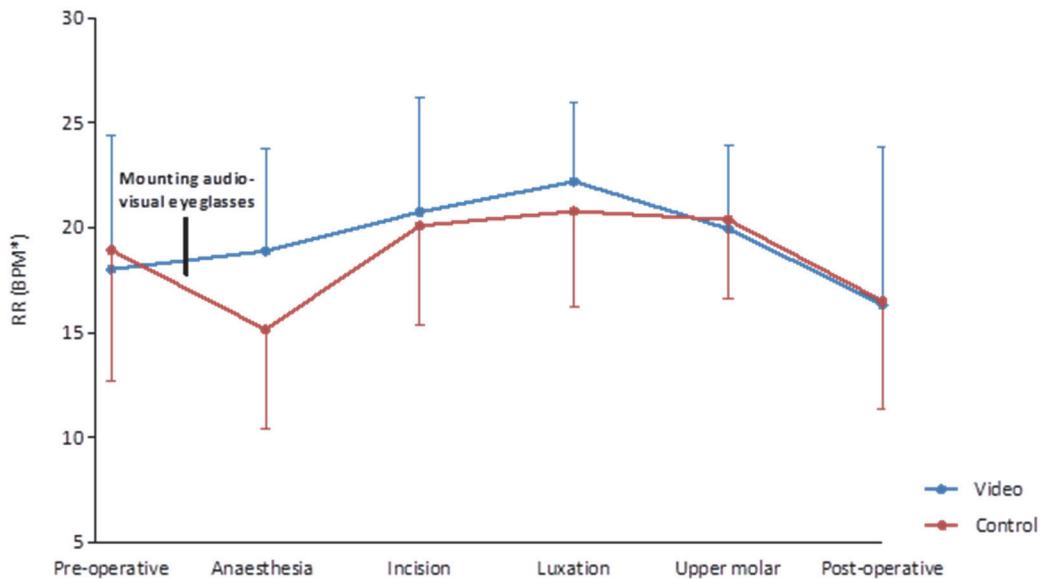


Figure 7 Mean respiratory rate (RR) per stage of the procedure. Error bars indicate standard deviation

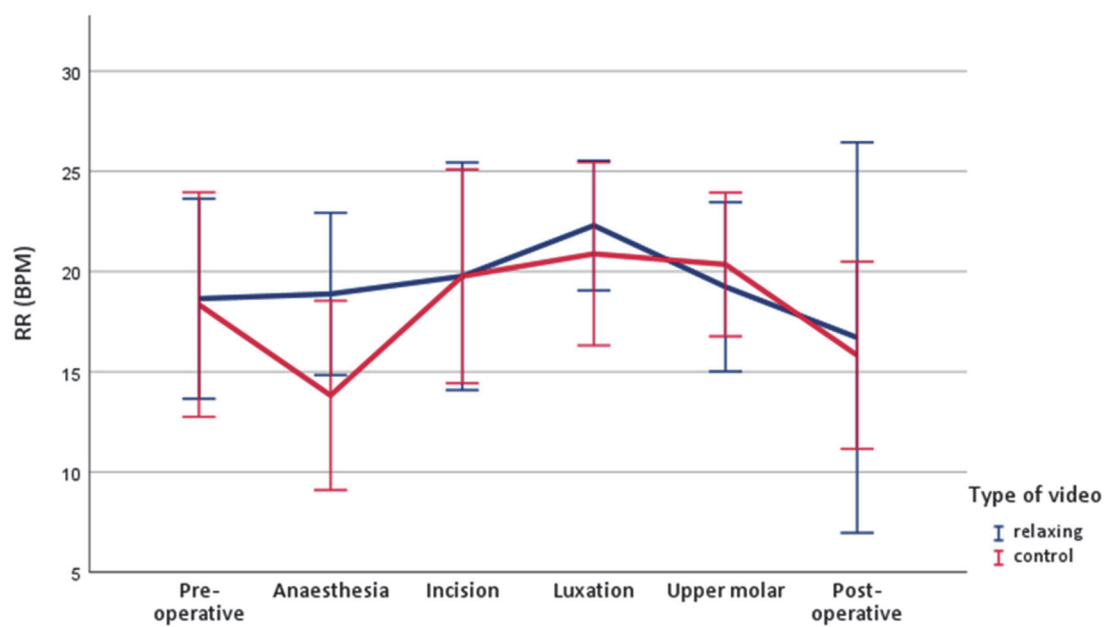


Figure 8a Mean respiratory rate (RR) per stage of the procedure for the group that watched the relaxing video. Error bars indicate standard deviation.

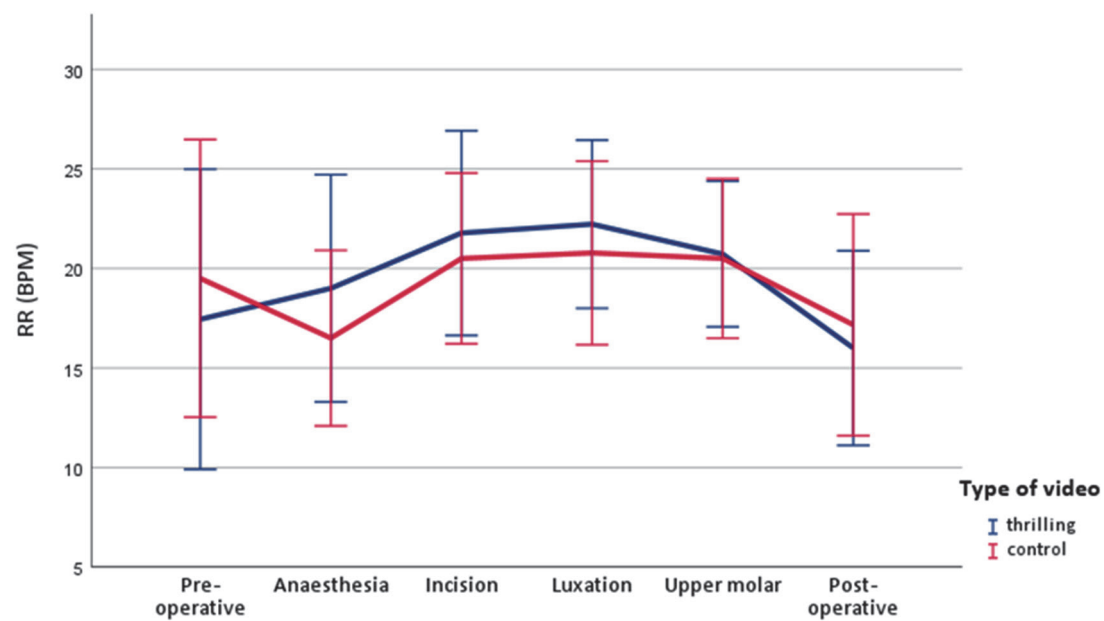


Figure 8b Mean respiratory rate (RR) per stage of the procedure for the group that watched the thrilling video. Error bars indicate standard deviation.

5.4 Discussion

Pre-operative anxiety is known to have a negative influence on post-operative swelling and trismus after third molar removal.²² Considering the large number of third molar removals that is performed worldwide and the large number of people facing anxiety associated with this^{1, 3, 4}, reducing this anxiety is not just to increase comfort for patients but also of significant economic and social importance. This study analysed the effect of an audiovisual intervention on anxiety and stress (HR and RR) during third molar removal in local anaesthesia. The effect of the type of video (relaxing or thrilling) was also taken into account. We demonstrated in this study that the audiovisual intervention had no effect on experienced anxiety assessed by the STAI Y-6 and VAS anxiety in healthy young adults. This might be explained by the fact that our population showed a mild baseline dental anxiety with a mean S-DAI score of 23.09 (on a scale of 9-45). A score of ≥ 28 indicates severe anxiety and justifies referral to an anxiety specialized dental clinic. It is known that anxiety for third molar removal is influenced by numerous factors.²³ Previous pain experience is a reliable factor determining anxiety in a subsequent tooth extraction procedure.²³ All participants in this study did not have any experience with tooth extractions. Since patient anxiety is usually higher before the procedure than after the procedure²³, this might explain the relatively low post-operative anxiety scores in our population. Luque-Ribas et al. did also not find an effect of audiovisual eyeglasses on anxiety during third molar removal with the State-Trait Anxiety Inventory (STAI-T and STAI-S) and the Corah Modified Dental Anxiety Scale (MDAS), which were completed pre- and post-operatively.²⁴ In several dental settings positive effects on anxiety of distraction with an audiovisual intervention were found. In dental hygiene treatment a positive effect of an audiovisual intervention was found on anxiety measured with the Dental Fear Survey.²⁵ In dental treatment of children (aged 4-7 and 7-10) a significant decrease in anxiety, measured by the Modified Child Dental Anxiety Scale, was found after the use of audiovisual distraction.^{26, 27}

HR is found to be significantly lower when patients wore the audiovisual intervention, particularly when they watched a relaxing video. A higher RR is seen in patients watching a video compared to care as usual, which was enhanced watching a thrilling video. The available literature shows inconsistent

findings on this matter; no significant effect is found on HR during third molar removal while wearing an audiovisual intervention.²⁴ A decrease in HR was seen in dental treatment of children wearing audiovisual eyeglasses.²⁸ A Cochrane review on the effects of listening to music before surgery also demonstrated inconsistent findings on HR and diastolic blood pressure.¹⁰

Listening to music has a beneficial effect on pre-operative anxiety.^{10, 13} More specifically, pre- and intra-operative music interventions have also shown to be able to lower patients per- and post-operative anxiety levels during third molar removal.^{11, 12, 29, 30} A randomized controlled trial in which fearful patients listened to music before third molar removal, showed a significant decrease of VAS anxiety scores and HR variability.³⁰ Per-operative listening to classical music during third molar removal was found to significantly decrease post-operative anxiety levels compared to Turkish music, soft rock music and a control group without music.²⁹ Music selected by the patients themselves significantly lowers per-operative anxiety levels.¹¹ There are a number of factors influencing the patients' response to per-operative use of music. Bradt et al. therefore state that in a dental setting, patients should be able to select the music themselves, have control over the volume of the music and should be given the option to listen through headphones or free field.³¹ Thereby, recommendations for sorts of sedative music are made, the music listening should be started before dental treatment and the patient should be instructed to actively focus on the music rather than passively listening to the music.³¹ A similar effect was seen on pain perception with the use of active virtual reality (VR). Whereas passive VR had no analgesic effect following painful electrical stimuli, active VR significantly decreases pain scores.³² A review of literature on the use of VR in oral surgery found that it reduces anxiety.¹⁵ The use of (passive) VR during third molar removal demonstrated a significant reduction of pain during administering anaesthesia and third molar removal, furthermore a significant decrease in HR was found before and during the procedure.³³

This study has some limitations. First, the use of a split mouth design might not be the most suitable design for this study, as the period effect and carry-over effect might have influenced the results.^{34, 35} Although not significant, for both STAI Y-6 and VAS anxiety a decrease was seen in the second procedure, except for the VAS anxiety in the group that underwent the conventional procedure first. Added to this, impaction classification was not similar on both sides in all patients, which could result in varying levels of anxiety, as the second procedure might have been either easier or more difficult.

Secondly, blinding was not feasible in the study, as the surgeon could immediately distinguish the group assignment of the participants. This may have introduced bias into the study's outcomes.

Third, the selection of our population might have caused a lack of treatment effect, since the baseline anxiety (S-DAI score) was mild. It can be considered to focus on solely possible relaxing interventions in patients with a high pre-operative level of anxiety. In daily practice, it seems obvious to let a patient decide whether such an intervention is desirable.

Fourth, the short operation duration of the procedures in this study might explain the absence of a distinct effect. Duration and surgical difficulty both influence the stress levels experienced by a patient.³⁶

Patient anxiety itself also influences the operation duration and difficulty.⁷ Again, a selection could be considered to study such an intervention only in cases that are foreseen to take more time. Surgeon experience, surgical difficulty and cooperation of the patient should also be taken into account, as these are factors that influence the operation duration.

Finally, to be able to truly interpret the patients' experience with a possible relaxing intervention, mixed methods of qualitative and quantitative outcomes are required to optimize the indication, application and outcome measurements in order to determine the value of audiovisual distraction. Since the perceived patients' experience with a relaxing intervention might be good, quantitative measures might not show this.

The used anxiety scales were after all not specifically developed for third molar removal.²³ Although HR is routinely used for assessment of stress response, it is also known that HR and RR are influenced by more factors than anxiety and stress alone.^{37, 38} Semi-structured interviews give more insight in the patient's experience. Combining this with quantitative measures might identify patient characteristics for which the relaxing intervention is more suitable, leading to actual personalized healthcare. Letting the patient actively select the type of video to be watched, might also contribute to the patients' experience and thereby the observed effect.

In conclusion, this study shows no effect of the use of an audiovisual intervention on anxiety experienced by patients during third molar removal. Choice of video type may affect physiological stress levels.

Ethical Considerations

The Radboud university medical centre Nijmegen ethics committee reviewed the study protocol and approved the study to proceed (registration number 2016-2589). All participants provided written informed consent before the first study procedure started.

Abbreviations

BPM	Beats per minute
BPM*	Breaths per minute
HR	Heart rate
OMF	Oral and Maxillofacial
RR	Respiratory rate
SDAI	Short Dental Anxiety Inventory
STAI Y-6	6 -item short form of the State Trait Anxiety Inventory
VAS	Visual analogue scale

Funding

None

Competing Interest

None

Trial Protocol and Data Availability

The trial protocol and data used in this research will be made available by the authors upon reasonable request.

Acknowledgements

We would like to thank all the patients for their willingness to participate in this study.



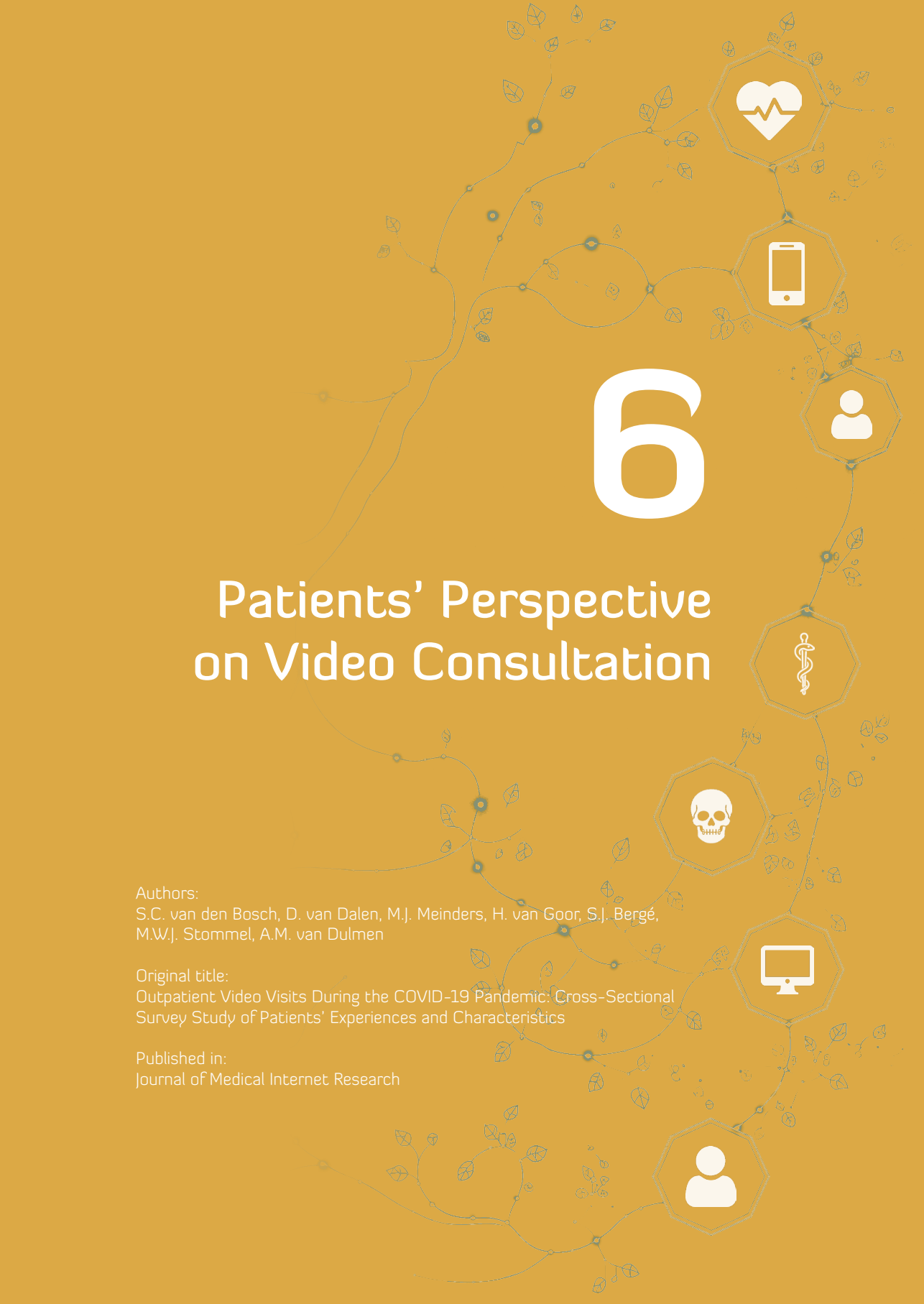
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6

Patients' Perspective on Video Consultation

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Original title:

Outpatient Video Visits During the COVID-19 Pandemic: Cross-Sectional
Survey Study of Patients' Experiences and Characteristics

Published in:

Journal of Medical Internet Research

Abstract

During the first lockdown of the COVID-19 pandemic, an exponential increase in video consultations replacing in-person outpatient visits was observed in hospitals. Insight into patients' experiences with this type of consultation is helpful for a broad, sustainable, and patient-centred implementation of video consultation.

This study aims to examine patients' experiences with video consultation during the COVID-19 pandemic and identify discriminative patient and consultation characteristics to determine when video consultation is most feasible.

A cross-sectional survey study was conducted. Patients aged ≥ 18 years and scheduled for a video consultation at the outpatient clinic of a Dutch university medical centre from August 2020 to December 2020 for all medical specialties were eligible. Patients' experiences were explored through a study-specific survey using descriptive quantitative statistics. Open-ended questions were qualitatively analysed and thematically categorised into appreciated aspects and aspects for improvement. Discriminative patient and consultation characteristics were identified using 3 distinctive survey items. Characteristics of patients who scored and those who did not score all 3 items positively were analysed using binary logistic regression.

A total of 1054 patients were included in the analysis. Most patients (964/1054, 91.46%) were satisfied with their video consultation, with a mean overall grade of 8.6 (SD 1.3) of 10. In the qualitative analyses, 70.02% (738/1054) of the patients cited aspects they appreciated and 44.97% (474/1054) mentioned aspects for improvement during their consultation. Patients with better self-rated health reported a positive evaluation significantly more often ($P=.001$), which also held true for other medical specialties (vs surgical and nonsurgical specialties; $P<.001$).

Video consultation was perceived as highly satisfactory by patients during the COVID-19 pandemic, with the best experience reported by healthy participants and those undergoing their first consultation. Appreciated aspects are mainly at the individual professional level, organisational level, and innovation level itself. The aspects that were mentioned for improvement can be changed for the better.

6.1 Introduction

In the Netherlands, the COVID-19 pandemic led to the first lockdown from March 2020 to June 2020 and the second lockdown from mid-December 2020 to April 2021. Throughout these periods, in-person visits were minimized to reduce the risk of potential virus transmission. As a substitute for in-person visits, the use of video visits significantly increased across many medical specialties. Video visits were already in practice on a limited scale in a wide range of contexts: for speech evaluation in patients with cleft palate¹, genetic counselling², follow-up after facial plastic surgery³, and post-operative wound assessment.⁴ Video visits were found to be satisfactory for patients⁵ and enabled empathetic patient-professional relationships remotely.^{1,6,7} However, large-scale implementation in daily practice was found to be challenging owing to the multilevel complexity of implementation, where people, organisations, and technology continuously interconnect and develop.⁸⁻¹¹ For example, attitudes and beliefs of individual professionals have been shown to act as both facilitators and barriers in the implementation of eHealth applications.⁸ Furthermore, video visits appeared to be particularly successful in follow-up appointments, when a preexisting relationship of trust is established between the patient and clinician.¹⁰ For instance, video visits were more easily adopted in follow-up care after cancer surgery compared with a multidisciplinary context of antenatal diabetes care.¹⁰ Owing to the pandemic-driven, accelerated application of video visits, many clinicians gained experience with this mode of healthcare delivery. This way of providing care offers several advantages, including saving travel time and costs for both patients and their companions and the efficient use of healthcare resources, such as outpatient clinic space and support.¹²⁻¹⁴ As we move into the post-COVID-19 era, video visits are expected to persist as a routine practice, but large-scale use has seemed to stagnate, presumably owing to a lack of guidance, vision, and attention to patients' needs, as observed in the United States.^{15,16} The use and implementation of video visits are expected to be most successful when tailored to the needs of patients, clinicians, and healthcare organisations.^{17,18} Therefore, it is crucial to understand patients' perspectives and experiences with video visits and identify specific patient groups that show a greater or lesser degree of appreciation for and suitability to video visits.¹⁹ Large studies with diverse patient populations

covering all medical specialties need to be conducted to learn more about patients' perspectives.^{16,18} However, we are concerned that only a limited number of studies have been published that evaluated video visits for patients within large, diverse populations. Consequently, this study contributes significantly to the existing body of knowledge in this area.²⁰⁻²²

The primary aim of this study was to examine patients' evaluations of video visits in the context of the COVID-19 pandemic. The secondary aim was to identify patient groups for whom video visits are relatively more suitable, given their positive experiences. With these results, the first step toward patient-tailored choices for type of visit can be made.

6.2 Methods

Study Design and Population

A cross-sectional study was conducted from August 2020 to December 2020 at the Radboud University Medical Centre (Radboudumc). Zaurus was used as the video visit app, which is compatible with all smartphones and tablets. Patients were invited via email to register and download the app. Patients scheduled for a video visit were automatically selected based on the registered mode of visit. Links to the questionnaire were sent by an independent research firm (Expoints) on behalf of the Radboudumc. Selected patients received the survey within eight days after their visit via email to evaluate the visit and collect their sociodemographic details. The survey had to be completed within two weeks, and a reminder was sent one week after the initial invitation. An incomplete survey could be saved to be completed later (within two weeks). No reminder for completion was sent.

All patients aged ≥ 18 years who received a video visit at an outpatient clinic at Radboudumc were eligible for inclusion. When a patient had multiple video visits in the selected period, the most recent video visit was selected.

Patients were excluded if they had cognitive impairment; had difficulties with reading and understanding Dutch owing to a hindering language barrier; were deceased at the time of selection; completed a survey regarding video visits in the 180 days before the start of our study; completed a survey regarding their admission experience or experience with an in-person visit 30 days before the start of our study; or were admitted to the hospital, as priority was given to the

patient experience survey regarding admission. In addition, when the video visit was a follow-up visit after giving birth or when the video visit was replaced with another visit modality, the patient was excluded.

Ethical Considerations

All patients participated voluntarily and anonymously in the survey and gave informed consent to use their data in accordance with the General Data Protection Regulation. Ethics approval was requested and waived by the local Medical Research Ethics Committee of Radboudumc (CMO [committee on research involving human subjects] Oost-Nederland; registration number 2021-8415).

Survey

A combined survey was used, which consisted of the Patient Experience Monitor (PEM) for adult outpatient experience²³, developed by the Dutch Federation of University Medical Centres, and the patient satisfaction survey for video visits created by Hanna et al.⁷ This combined survey was constructed after extensive deliberation by an expert panel. In this process, a literature review of surveys specifically about video visits was performed. The experts found the survey by Hanna et al.⁷ to be the most suitable for the aim of our study.

The PEM survey was constructed by adapting a validated Picker Institute survey following a comprehensive theory-driven approach of item selection by an expert panel, cognitive interviews with patients, analysis of psychometric properties, and member checking. This survey of 14 items represents eight key domains of person-centred care: (1) fast access to reliable healthcare advice; (2) effective treatment delivered by trusted professionals; (3) continuity of care and smooth transitions; (4) involvement and support for family and caregivers; (5) clear information, communication, and support for self-care; (6) involvement in making decisions and respect for preferences; (7) emotional support, empathy, and respect; and (8) attention to physical and environmental needs.²⁴ The Picker Institute surveys are measures for evaluating patients' experiences in outpatient and inpatient clinical care and have been validated and extensively used in university medical centres in the Netherlands since 2019.²⁵ The PEM survey was adapted to the videoconferencing setting by rephrasing the questions.

Overall, 2 items were open-ended questions (Multimedia Appendix 1). Quantitative analyses of the PEM survey were based on individual survey items, whereas open-ended questions were analysed using qualitative methods.

The 13-item survey by Hanna et al.⁷ is designed according to the principles of survey development for telemedicine to evaluate patients' experiences with video visits in pain clinics.²⁶ This survey was translated into Dutch, and 1 item was removed, as it was already covered by the PEM survey (Multimedia Appendix 1, items 16-27). In total, 4 items were rephrased based on the advice of the patient communication experts. Analysis of the survey by Hanna et al.⁷ is based on an overall sum score, where a higher overall sum score represents greater satisfaction. For correct analysis and to calculate an overall sum score, the 3 negatively phrased questions (items 17, 21, and 23) were reversed (e.g., "No, definitely not" was converted to "Yes, definitely"), according to the protocol.

Finally, a question was added to assess the visit by assigning a score on a scale ranging from 1 to 10 (with 10 being most positive). The survey was conducted according to CHERRIES (Checklist for Reporting Results of Internet-Based e-Surveys; Multimedia Appendix 2).²⁷

Statistical Analysis

Quantitative Analysis

Descriptive statistics were used for the closed-ended items (Multimedia Appendix 1, items 1-11 and 16-27). To identify patient and visit characteristics associated with positive evaluation of video visits, 4 authors found consensus upon the 3 key items from the survey by Hanna et al.⁷ that stood out the most (item 18: "the care I received by a video visit was just as good as with an in-person appointment"; item 22: "I was comfortable talking by video to the healthcare professional"; item 27: "I would recommend the video visit option to other patients"). Throughout the paper, these 3 items have been referred to as "crucial" components of the survey by Hanna et al.⁷, as they best displayed a positive experience.

Patient and visit characteristics were determined for the group answering the 3 crucial items positively. In this analysis, the following characteristics were included: sex, age category, level of education, self-rated health, type of visit (first vs follow-up), and medical specialty (surgical, nonsurgical, or other). High self-rated health was defined as a score that indicates “very well” or “excellent.” Statistical analysis was performed using SPSS Statistics (version 25; IBM Corp). Binary logistic regression analysis was used to calculate differences in patient and visit characteristics between the patient subgroup that scored positively on all crucial items and the patient subgroup that did not score positively, as the dependent variable was not normally distributed.

Qualitative Analysis

Qualitative analysis was performed on the open-ended questions (items 13 and 14) to identify appreciated aspects and aspects for improvement for video visits. Overall, 2 authors (SCvdB and DD) independently categorised all the answers into six categories of factors that influence the implementation of innovations: (1) the innovation itself, (2) the individual professional, (3) the patient, (4) social context, (5) organisational context, and (6) economic and political context.²⁸ In case of conflicts in the categorization, consensus was reached through discussion between the authors. Responses including multiple levels within a single response were counted as individual items. Examples of answers for both aspects in each category have been cited in the Results section.

6.3 Results

Quantitative Results

From August 2020 to December 2020, a total of 1244 surveys were completed, with a response rate of 28.32% (1244/4392). After excluding 15.27% (190/1244) of the patients who reported that the visit was either a telephone consultation or replaced by telephone after technical difficulties, 84.73% (1054/1244) of the surveys were used in the analysis.

Table 1 shows the patients' demographics. An equal distribution across age categories was observed. Clinical Genetics, Neurology, and Medical Oncology accounted for 65.84% (694/1054) of the total number of evaluated video visits, whereas the distribution across the other medical specialties varied widely.

The numbers of first and follow-up visits were equal, with most follow-up visits (480/1054, 45.54%) performed by a known clinician. After a video visit, 36.91% (389/1054) of the patients had to make an appointment for an additional in-person visit or medical examination. A follow-up visit via video was planned in 40.32% (425/1054) of the evaluated video visits. Clinicians from Medical Oncology and Neurology more frequently scheduled an in-person follow-up visit for their patients—18.6% (40/215) and 23.3% (50/215), respectively. Moreover, in 39.7% (69/174) and 14.4% (25/174) of cases, the visits provided by Clinical Genetics and Neurology respectively, were followed by a consecutive visit for additional (diagnostic) testing.

The overall grading for the video visit had a mean of 8.6 (SD 1.3; median 9) of 10. For 5 PEM items, >80% of the patients answered positively, that is, patients waited no longer than 5 minutes, clinicians had read their medical records well, patients received understandable answers, patients trusted the clinician, and patients had enough time to discuss their problems with the clinician. Refer to Table 2 for details about the responses of patients.

For the remaining 6 items, more than 21% stated that the item was either “not applicable” or answered positively. For instance, 80.25% (829/1033) indicated not receiving any new medication for the question about whether the professional explained the adverse effects of new medication. Analysis of the items in the survey by Hanna et al.⁷ showed that 91.46% (964/1054) of the patients were satisfied with their video visit, 66.98% (706/1054) found it to be just as good as an in-person visit, and 68.69% (724/1054) would recommend video visits to other patients, as shown in Table 3.

Of 1054 patients, 574 (54.46%) answered all 3 crucial items on the survey by Hanna et al.⁷ positively, 234 (22.2%) answered 2 of 3 positively, 138 (13.09%) answered only 1 item positively, 72 (6.83%) patients answered “not applicable” or responded negatively, and 36 (3.42%) responses were missing. Patient and visit characteristics of patients who positively answered all 3 crucial Hanna⁷ items versus the group who did not are shown in Multimedia Appendix 3.

Results of the binary logistic regression are shown in Table 4. Negative association was found between the positive evaluation of a visit and the surgical and “other” medical specialties ($B=-0.64$; $P<.001$).

Positive evaluation was also associated with the patient category who described their health as “very well” ($B=1.12$; $P=.01$). Sex, age, and educational level had no influence on whether a patient rated the visit positively. In addition, the reason for the visit was not found to have any influence on the positive evaluation of a video visit.

Table 1 Demographic characteristics.

Characteristic		n (%)
		Total n = 1054
Sex	Male	448 (42.5)
	Female	606 (57.5)
Age	18-34	131 (12.4)
	35-54	333 (31.6)
	55-64	272 (25.8)
	65-79	304 (28.8)
	80-99	14 (1.3)
Educational level	None	5 (0.5)
	Primary	105 (9.9)
	Secondary	378 (35.9)
	Higher/university	468 (44.4)
	Different	29 (2.8)
	Missing	69 (6.5)
Self-rated health	Excellent	95 (9.0)
	Very well	167 (15.8)
	Good	466 (44.2)
	Not so well	255 (24.2)
	Bad	49 (4.6)
	Missing	22 (2.1)
Specialty	Non-surgical medical specialties	498 (47)
	Cardiology	33 (3.1)
	Dermatology	3 (0.3)
	Gastro-enterology	16 (1.5)
	Haematology	40 (3.8)
	Internal medicine	66 (6.3)
	Medical Oncology	121 (11.5)
	Nephrology	14 (1.3)
	Neurology	153 (14.5)
	Pulmonary medicine	25 (2.4)
	Reproductive medicine	25 (2.4)
	Rheumatology	2 (0.2)
	Surgical specialties	101 (9.6)
	ENT	6 (0.6)
	General Surgery ^a	36 (3.4)

	Gynaecology	9 (0.9)
	Neurosurgery	13 (1.2)
	Obstetrics	1 (0.1)
	OMF surgery	1 (0.1)
	Orthopaedic surgery	3 (0.3)
	Plastic surgery	8 (0.8)
	Urology	24 (2.3)
	Other medical specialties	455 (43.2)
	Clinical Genetics	420 (39.8)
	Psychiatry	29 (2.8)
	Radiology	2 (0.2)
	Radiotherapy	4 (0.4)
Type of visit	first visit, referred by primary care	195 (18.5)
	first visit different healthcare professional	270 (25.6)
	first visit, 2nd opinion	15 (1.4)
	Follow-up known healthcare professional	480 (45.5)
	Follow-up new healthcare professional	71 (6.7)
	Missing	23 (2.2)
Follow-up after video consultation	Follow-up visit at the outpatient clinic	215 (20.4)
	Follow-up video visit	425 (40.3)
	Additional medical examination	174 (16.5)
	Referred to the referring physician	41 (3.9)
	There is no follow-up needed	126 (12.0)
	I don't know	61 (5.8)
	Missing	12 (1.1)

- a *This includes trauma surgery, visceral surgery, surgical oncology and vascular surgery.*

Table 2 Responses of patients on Patient Experience Monitor (PEM) items.^a

PEM item and response options	Responses (n=1054) n (%)
Did you have to wait for the video visit?	
The professional was on time	719 (68.2%)
I waited < 5 minutes	143 (13.6%)
I waited > 5 minutes	62 (5.9%)
I waited > 10 minutes	42 (4.0%)
I waited > 15 minutes	63 (6.0%)
I don't know	22 (2.0%)
Did the professional read your health record?	
Yes	991 (94.0%)
Not thoroughly	25 (2.4%)
No	2 (0.2%)
I don't know	21 (2%)
Did you get answers you could understand?	
Yes	985 (93.5%)
Most answers were understandable	26 (2.5%)
No	2 (0.2%)
No opportunity to ask questions	0
I didn't have any questions	26 (2.5%)
Did you trust the professional?	
Yes	1021 (96.9%)
Less than I wanted	17 (1.6%)
No	4 (0.4%)
Was there enough time to talk to the professional about your disease/problem?	
Yes	1015 (96.3%)
I needed more time	14 (1.3%)
No	1 (0.1%)
I don't know	3 (0.3%)
Could you participate in the decision-making process?	
Yes	732 (69.5%)
Less possible than I wanted	18 (1.7%)
No	10 (0.9%)
No need	272 (25.8%)
I don't know	7 (0.7%)

Could a relative participate in the conversation?

Yes	499 (47.3%)
More possible than I wanted	8 (0.8%)
Less possible than I wanted	4 (0.4%)
No	8 (0.8%)
There were no relatives present	241 (2.3%)
No need	277 (26.3%)
I don't know	4 (0.4%)

Did the professional explain the advantages/disadvantages of treatment or diagnostic process?

Yes	743 (70.5%)
Some aspects weren't clearly explained	20 (1.9%)
No	4 (0.4%)
There was no explanation	2 (0.2%)
No need	268 (25.4%)

Did the professional explain the adverse effects of the new medication?

Yes	170 (16.1%)
There wasn't enough explanation	23 (2.2%)
No	11 (1.0%)
I didn't receive new medication	829 (78.7%)

Did the professional tell you what to do after the visit?

Yes	784 (74.4%)
Not enough	14 (1.3%)
No	7 (0.7%)
No need	228 (21.6%)
I don't know	9 (0.9%)

Could you speak to anyone of the hospital about your worries/anxieties?

Yes	235 (22.3%)
Sometimes	24 (2.3%)
No	25 (2.4%)
No need	758 (71.9%)

- a *Where the total responses do not add up to 100%, it concerns missing responses.*

Table 3 Responses of patients on the Hanna⁷ items.

Hanna item	Yes, definitely	Yes, I think so	Maybe yes, maybe no	I don't think so	No, definitely not	Not applicable	Missing
<i>I am satisfied with my video visit</i>	671 (63.7%)	293 (27.8%)	46 (4.4%)	17 (1.6%)	10 (0.9%)		17 (1.6%)
<i>I worried about my privacy</i>	13 (1.2%)	18 (1.7%)	97 (9.2%)	366 (34.7%)	549 (52.1%)		11 (1.0%)
<i>The care I received by video visit was just as good as with an in-person appointment.</i>	321 (30.5%)	385 (36.5%)	162 (15.4%)	102 (9.7%)	23 (2.2%)	44 (4.2%)	17 (1.6%)
<i>It is important to me that the video visit saved me travel time.</i>	428 (40.6%)	280 (26.6%)	191 (18.1%)	107 (10.2%)	32 (3.0%)		16 (1.5%)
<i>It is important to me that the video visit saved me money.</i>	169 (16.0%)	179 (17.0%)	276 (26.2%)	140 (13.3%)	106 (10.1%)	165 (15.7%)	19 (1.8%)
<i>I experienced technical problems during the video visit which caused a disturbance of the visit.</i>	33 (3.1%)	74 (7.0%)	92 (8.7%)	265 (25.1%)	575 (54.6%)		15 (1.4%)
<i>I was comfortable talking by video to the healthcare professional.</i>	580 (55.0%)	359 (34.1%)	71 (6.7%)	25 (2.4%)	8 (0.8%)		11 (1.0%)
<i>I would rather travel to have my next visit in-person than use video visit.</i>	100 (9.5%)	142 (13.5%)	272 (25.8%)	257 (24.4%)	211 (20.0%)	56 (5.3%)	16 (1.5%)
<i>I was able to develop a friendly relationship with my healthcare professional.</i>	305 (28.9)	477 (45.3%)	209 (19.8%)	43 (4.1%)	4 (0.4%)		16 (1.5%)



<i>I was able to explain my problems clearly to my healthcare professional during the video visit.</i>	482 (45.7%)	472 (44.8%)	65 (6.2%)	11 (1.0%)	3 (0.3%)	21 (2.0%)
<i>The video visit was convenient.</i>	389 (36.9%)	474 (45.0%)	141 (13.4%)	32 (3.0%)	8 (0.8%)	10 (0.9%)
<i>I would recommend the video visit option to other patients.</i>	329 (31.2%)	395 (37.5%)	254 (24.1%)	42 (4.0%)	12 (1.1%)	22 (2.1%)

Table 4 Binary logistic regression model results.^a

Variable		B (95% CI)	P value
Sex			
	Male	0.03 (0.78-1.37)	0.83
Age category			
	18-34	reference	N/A ^b
	35-54	0.17 (0.76-1.86)	0.45
	55-64	0.14 (0.72-1.85)	0.55
	65-79	0.06 (0.65-1.73)	0.81
	80-99	-0.17 (0.20-3.54)	0.82
Educational level			
	None	reference	N/A
	Primary	0.05 (0.16-7.07)	0.96
	Secondary	0.05 (0.16-6.89)	0.95
	Higher/university	-0.04 (0.15-6.22)	0.96
	Different	-0.16 (0.11-6.43)	0.88
Self-rated health			
	Excellent	reference	N/A
	Very well	1.12 (1.39-6.72)	0.01
	Good	0.52 (0.85-3.35)	0.13
	Not so well	0.14 (0.61-2.15)	0.66
	Bad	0.27 (0.69-2.50)	0.41
Specialty			
	Non-surgical	reference	N/A
	Surgical	-0.64 (0.37-0.75)	<.001
	'Other'	-0.45 (0.38-1.06)	0.08
Type of visit			
	First visit	reference	N/A
	Follow-up visit	0.17 (0.86-1.65)	0.30

a Nagelkerke $R^2=0.08$

b N/A : not applicable



Qualitative Results

Overview

Table 5 displays the frequencies of appreciated aspects and aspects for improvement. Most patients (738/1054, 70.02%) cited appreciated aspects of the use of video visits in the open-ended questions. The most frequently cited appreciated aspects were expressed at the individual professional level, followed by the organisational context level and the innovation level. Few aspects were mentioned at the patient level, economic and political context level, and social context level. Approximately half of the patients (474/1054, 44.97%) cited aspects for improvement. Most were cited at the innovation, organisational context, and patient levels. In contrast, no improvable aspects were reported at the economic and political context level.

Innovation

The perceived ease of use and audiovisual quality were frequently mentioned as appreciated aspects. The intuitive character of the app was seen as valuable, as not all patients were familiar with using web-based apps. Patients appreciated the audiovisual quality, allowing the video visit to be a good alternative for an in-person visit. However, not all the patients experienced the same ease of use, as the most reported aspect for improvement was poor audio and video quality, sometimes clearly caused by an unstable internet connection. Although Zaurus is compatible with all electronic devices, users have reported issues with video size specifically on smartphones (Textbox 1).

Textbox 1 Responses related to innovation.

Appreciated Aspect:

“The application is straightforward and easy to understand. The conversation went well, the doctor even asked me if I could hear her well.” (Female, aged 18 – 34, Clinical Genetics)

Aspect of Improvement:

“The video connection was really bad. Almost immediately the app crashed, and the audio stuttered, so I could not understand what the doctor was saying. After two attempts, we continued the visit by telephone.” (Female, aged 65 – 79, excluded for further analysis, Clinical Genetics)

Individual Professional

Patients often mentioned what they valued in the clinician's professional behaviour, such as their attitude, and communicative style. In contrast, a lack of adequate or visible body language and lack of knowledge about someone's medical history were mentioned as aspects for improvement (Textbox 2).

Textbox 2 Responses related to the individual professional.

Appreciated Aspect:

"There is still a kind of personal touch in the contact, which is nice for the perception as well. The doctor radiated tranquillity and was understanding, and she had read my personal record well. That gives me confidence." (Female, aged 55 – 64, Clinical Genetics)

Aspect of Improvement:

"The doctor did not look at us during the video visit. Both my daughter, who was also present, and I had noticed. That felt a little awkward. He was mainly looking down (I guess at a file or something like that, which was in front of him)." (Female, aged 80 – 99, Clinical Genetics)

Patient

The possibility to have face-to-face interactions remotely was often mentioned as valuable, as patients were able to watch the clinicians' nonverbal reactions. It made video visits a safe alternative for patients with a weak immune system, for example, during the pandemic. Personal lack of experience with video visits was a hindering factor, as not all patients were familiar with the use of videoconferencing apps. Some of them preferred an in-person visit, as they felt uncomfortable owing to inexperience (Textbox 3).

Textbox 3 Responses related to the patient.

Appreciated Aspect:

"It is nice to see the doctor, but for a first meeting, it is something I need to get used to. However, this feels safer regarding the coronavirus and a vulnerable immune status." (Female, aged 35 – 54, Neurology)

Aspect of Improvement:

"I'd rather have the first visit in person. Maybe I'm old fashioned, but I prefer physical contact, even during this COVID pandemic. Feelings and emotions might be more difficult to pick up on screen." (Male, aged 55 – 64, Neurology)

Social Context

The possibility of the involvement of others, such as next of kin or other family members, was one of the mentioned appreciated aspects. Creating a culture in which a patient can share their preference or opt for a certain visit modality could stimulate the use of video visits. Patients expressed that they would like to have a say in choosing which visit modality they like, especially when the nature of the visit is sensitive (Textbox 4).

Textbox 4 Responses related to the social context.

Appreciated aspect:

"On time, pleasant conversation, space for questions, clear explanation. It was nice that my partner could join with his phone." (Female, aged 18-34, Reproductive Medicine)

Aspect of improvement:

"It was a shame they communicated the results by a video visit. I was shocked and found they acted a bit indignant about my reaction. I was not capable anymore to follow the conversation." (Female, aged 18 – 34, Clinical Genetics)

Organisational Context

Internet-based assistance, clear instructions, and time management by the clinician during the visit were often mentioned as appreciated aspects at this level. Many patients were called in advance of the visit to check for technical problems. However, patients were not always informed correctly if the visit would start later than scheduled, and in some cases, patients received the link

for the video visit just before the visit started, which was an aspect for improvement (Textbox 5).

Textbox 5 Responses related to the organisational context.

Appreciated aspect:

"The support was really good, as I am not so technical and there was enough explanation. Great." (Female, aged 55 – 64, Clinical Genetics)

Aspect of improvement:

"I would like to receive a notification when the doctor is held up, especially when it's a first visit. Also, I would like to receive a heads-up when I get another doctor than the one the appointment was originally scheduled with." (Male, aged 55 – 64, Medical Oncology)

Economic and Political Context

Time and financial savings were identified as valuable aspects at the economic and political context level. Patients often cited less travel time and costs as beneficial. There were no improvable aspects reported at the economic and political context level (Textbox 6).

Textbox 6 Responses related to the economic and political context.

Appreciated aspect:

"It is pleasant that there is no need for traveling to the hospital (regarding travel time and travel distance) and still have 'personal' contact with the doctor through a video connection." (Male, aged 35 – 54, Neurology)



Table 5 Aspects of appreciation and improvement of patients’ experiences with video visits, extracted from answers on open-ended questions.

Level	Appreciated Aspects Frequency (n=) ^a	Aspects of Improvement Frequency (n=) ^b
Innovation	185	138
Individual Professional	399	46
Patient	82	91
Social Context	11	17
Organisational Context	204	96
Economic and Political Context	45	0
Total	926 ^c	388 ^c

- a A total of n=738 (out of 1054, 70%) patients cited appreciated aspects
- b A total of n=474 (out of 1054, 45%) patients cited aspects of improvement
- c Responses including multiple levels within one single response, were counted as individual items.

6.4 Discussion

Principal Findings

In this study, we comprehensively analysed evaluations of visits via video to a tertiary clinic made by a large, diverse patient population, including appreciated aspects and aspects for improvement. Most patients (964/1054, 91.46%) evaluated the video visits positively, with significantly more positive evaluations when the visits were provided by a clinician from “other” medical specialties, as compared to surgical and nonsurgical specialties, or when the patient rated their health status as “very well.” The appreciated aspects were mostly at the individual professional level, whereas aspects for improvement were reported at the innovation level itself.

Comparison with Previous Studies

Our finding that high self-rated health of patients is an influencing patient characteristic for suitability of video visits echoes the finding that patients with less complex, more straightforward clinical needs are more suitable candidates for video visits than those with complex, high-risk diseases.^{10,29}

Similar findings were identified in an oncological study wherein telemedicine was received favourably for low-acuity cancer care.¹⁶ In contrast to findings that video visits appear to be more appropriate when the clinician knows the patient beforehand and when it is a follow-up visit¹⁰, we found that the reason for the visit did not have any influence on whether patients rated the video visit positively. Remarkably, the medical specialty providing the visit was found to be a significant associated factor. Nonsurgical visits were found to be most suitable for telemedicine. One can imagine that these visits are less dependent on physical examination, such as internal medicine or dermatology, for instance, as these specialties can easily review laboratory abnormalities or skin disorders on screen.³⁰ In addition to specific aspects of the visit that may depend on the medical specialty, other dimensions or elements during the visit could affect the patient experience, such as the communication strategy used by the clinician.³¹ Nonetheless, more studies are needed to get a clear overview about whether medical specialty is a truly discriminative characteristic or whether it is more dependent on the attitude of certain clinicians and patient groups.

Qualitative analysis of the open-ended questions revealed both facilitating and hindering factors for broad implementation and upscaling of video visits. Following Groel and Wensing²⁸, these factors were categorised into innovation, professional, patient, social context, organisational context, and economic and political context levels. Appreciation was mostly centred on the professionals' skill in adapting communication to the video setup; however, there was scope for improvement among some individuals, as they might benefit from investing additional effort in making visual contact. The way in which the video visits were organized was also highly valued, especially for the provision of technical support to patients as and when needed.

The attitude of the clinician during the video visit was one of the most frequently mentioned aspects for improvement. The bedside manner, which may be better described as the "webside" manner, of a clinician refers to how the clinician behaves, approaches the patient, and communicates during the visit. Clinicians sometimes seem to lack awareness of how their nonverbal behaviour looks on screen, as was also shown by a study that analysed a large data set of >5000 patients.³² Patients prefer increased expression of nonverbal empathy from

clinicians when they show signs of distress. Inadequate nonverbal communication and body language are often reported as barriers for telemedicine adoption.^{3,33,34} Despite expert recommendations dating back several years to raise awareness for nonverbal and paraverbal communication, our study also indicates that there is still considerable scope for improvement and training at the clinician level.^{31,35}

In accordance with several survey studies conducted during the pandemic, our response rate was low. This might be explained by the questionnaire fatigue that was frequently observed during the COVID-19 pandemic, as patients received multiple questionnaires and messages from the outpatient clinic, apart from research.³⁶

Regarding future perspectives, clinicians should seek guidelines to assess the suitability of a video visit, and the following recommendations might be useful. The Dutch Centre of Expertise on Health Disparities recommends checking the patients' digital skills beforehand, providing digital support, and evaluating whether the information is correctly understood through techniques such as "teach back" at the end of the visit.³⁷ Video consulting guidelines advise considering several factors while deciding whether video visits may be suitable, such as whether there is an established relationship with the patient, whether it entails nonurgent care, whether there is a need for physical examination, and whether there are factors in favour of the patient staying at home.³⁸

Limitations

The findings of this study must be considered in the light of some limitations. First, our study might have been exposed to selection and sampling biases for several reasons. It was an "open" survey, where patients could decide voluntarily whether they would participate in the survey, which might have led to a sample of patients that is not representative of the entire population of the hospital. In addition, owing to the exclusion criteria, not all video visits were evaluated.

Second, the validity of the combined survey was not tested. As the analysis of our data was reported at the item level, calculating the internal consistency using Cronbach α was not applicable. PEM is known to be a validated survey; however, the psychometric properties of the survey by Hanna et al.⁷ are not known and should be determined. As the PEM items were rephrased to the videoconferencing setting, reliability of this new PEM survey will have to be reassessed.

The educational status of patients attending a university medical centre is, in general, often higher than the mean educational status of the general population. In our study population, 44.4% (468/1054) of the patients were highly educated, compared with 30% in the Dutch population in 2018.³⁹ As teaching hospitals and referring hospitals might serve different populations, the generalizability of our results might be limited, and further studies including different types of hospitals are recommended.

A total of 139 patients reported a failed video visit and noted that the visit was replaced by telephone. However, the exact number of times this occurred is not known, as not all patients might have reported this failure, which also may have resulted in selection bias.

In this evaluation, we deliberately focused on the patient evaluation of video visits. As it is known that patients and clinicians have different views about quality of information and visits⁴⁰⁻⁴², the clinicians' point of view should also be explored for a comprehensive evaluation of the use of video visits. Healthcare providers, such as clinicians, might experience different barriers and facilitators compared with patients, thus influencing the successful implementation of video visits. Key barriers to successful implementation such as the lack of training and motivation to offer video visits need to be addressed.^{3, 8, 43, 44}

Conclusions

Video visits were perceived as highly satisfactory by patients during the COVID-19 pandemic, with the best experiences reported by healthy participants and participants who scheduled a visit with a clinician outside the realms of surgical and nonsurgical medical specialties, such as Clinical Genetics or Radiotherapy. Appreciated aspects were mainly at the individual professional level, organisational level, and at the level of the innovation itself. The mentioned aspects for improvement can be changed for the better.

The findings cannot be directly generalized as they were collected in a university medical centre with a specific patient population, but they provide additional results for understanding the suitability of video visits in a broad patient population. To be able to truly tailor the use of video visits to patients' needs, a patient-centred perspective involving both patients and healthcare professionals is needed.

Data Availability

The data used in this study will be made available by the authors upon reasonable request.

Authors' Contributions

SCvdB, MM, MS, and SvD contributed to the study's conception and design. SCvdB and DD performed the statistical analyses. SCvdB managed the project administration and data curation. SCvdB, DD, MS, and SvD drafted the manuscript. HvG, SB, MS, and SvD supervised the research project. SCvdB and DD contributed equally to this work and share first authorship. MS and SvD contributed equally to this work and share senior authorship. All authors interpreted the data, critically revised the paper, and approved the final version of the paper.

Conflicts of Interest

None declared

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III Emerging Technology





7

Artificial Intelligence in Oral Maxillofacial surgery

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Original title:

Artificial Intelligence in Cranio-Maxillofacial Surgery

Published in:

Book Chapter in Atlas of Virtual Surgical Planning and 3D Printing for
Cranio-Maxillofacial Surgery

7.1 Evolution of Medical Imaging

Medical imaging has transformed the landscape of healthcare, offering non-invasive methods to visualize the internal structures of the body. The evolution of this field can be traced back to the late nineteenth century, when Wilhelm Röntgen discovered X-rays in 1895, revolutionizing medical diagnostics.¹ This marked the birth of medical imaging, which rapidly developed over the years with the invention of new technologies like ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI).² These modalities have progressively advanced, giving healthcare providers more precise diagnostic tools.

The major boom in medical imaging occurred during the 1980s, driven by the development of digital imaging technologies and the widespread use of MRI and CT scans. In this period, remarkable improvements in the speed, quality, and accessibility of imaging technologies developed. The transition from analog to digital systems allowed faster image processing, easier storage, and broader distribution of images among healthcare professionals, which significantly improved diagnostics.³ Radiologists could now assess intricate details of tissues and organs, enabling earlier disease detection and more effective treatment planning.

Since the 1980s, medical imaging has continued to evolve rapidly. Innovations such as 3D and 4D imaging have further enhanced diagnostic capabilities, allowing for better visualisation of complex anatomical structures.⁴ Real-time imaging technologies now play a crucial role in guiding surgeries and other medical procedures, making healthcare safer and more efficient.⁴

In the context of cranio-maxillofacial (CMF) imaging, the evolution of medical imaging has been particularly impactful. Early imaging techniques like X-rays provided basic views of the CMF region, but advancements in CT and MRI revolutionized the ability to visualize complex structures in this area. The development of cone beam computed tomography (CBCT) in the twenty-first century has further refined imaging in the CMF field, offering high-resolution, 3D images with lower radiation doses and lower costs compared to conventional CT. These advancements have improved pre-operative (3D) planning, post-operative assessments, and overall outcomes in CMF surgery, contributing to more precise and less invasive interventions.⁵

7.2 Evolution of Artificial Intelligence

Artificial intelligence (AI) has experienced a transformative journey, much like medical imaging. The term “artificial intelligence” was introduced by John McCarthy in 1956 during the Dartmouth Conference.⁶ Early AI research focused on symbolic reasoning and problem-solving, but progress was limited due to technological constraints. However, in the 1980s, a significant boom was seen in AI research, with the introduction of machine learning and neural networks, allowing computers to learn from data and improve over time.⁶

One of the key milestones in AI development was the creation of deep learning algorithms in the early 2000s. These algorithms mimicked the structure of the human brain through artificial neural networks, enabling computers to recognize patterns in large datasets with unprecedented accuracy and marking a turning point in AI’s evolution.⁷ More recently, the development of large language models (LLMs), such as GPT-3 and GPT-4, has revolutionized AI and natural language processing (NLP). These models have demonstrated remarkable capabilities, including understanding and generating human-like text, translating languages, writing code, and passing professional exams.⁸ In the following sections, the basics of deep learning and the higher-level concepts of AI will be explained.

7.3 Neural Networks

Neural networks (NNs) are computational models inspired by the structure and function of the human brain.⁷ NNs consist of interconnected nodes called neurons organized in layers. Each neuron receives inputs, performs a mathematical operation on them, and produces an output.⁹

In mathematical terms, let x_i denote the input vector to a neuron, w_i represent the weights associated with each input, and b represent the bias. The output of the neuron, denoted y , is calculated using an activation function, typically denoted as f , applied to the weighted sum of inputs plus the bias (Fig. 1).



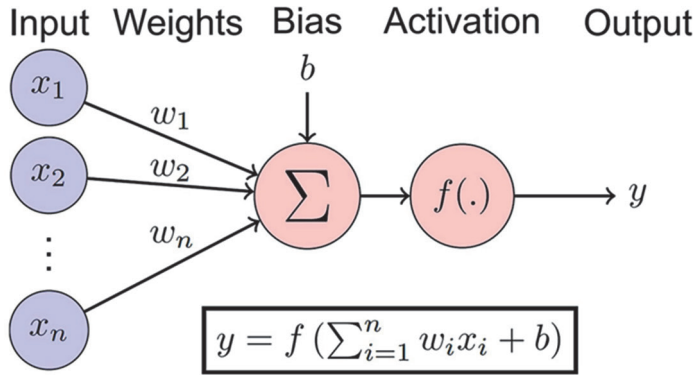


Figure 1 Artificial neuron: to determine the output value of an artificial neuron, the neuron activation is computed as a weighted sum given the input values and connection weights. The artificial neuron applies a nonlinear activation function to determine the final output.

Common activation functions include the sigmoid function, hyperbolic tangent (tanh) function, and rectified linear unit (ReLU) function.⁶ These functions introduce nonlinearity into the neural network, allowing it to learn complex patterns in the data.⁹

Neural networks learn by adjusting the weights and biases during a process called training. This is typically done using optimization algorithms like gradient descent, which minimizes a loss function that measures the difference between the predicted outputs and the true outputs.^{9,10}

7.4 Convolutional Neural Network

Convolutional neural networks (CNNs) are deep learning models specifically designed for processing grid-like data, such as images. They consist of multiple layers, including convolutional layers, pooling layers, and fully connected layers.⁹ The convolutional layer is the core building block of a CNN. It applies filters to input images, extracting features such as edges, textures, and shapes.¹¹ Mathematically, the convolution operation in a CNN layer is represented as:

$$Z^{[l]} = W^{[l]} * A^{[l-1]} + b^{[l]},$$

where $Z^{[l]}$ is the output of the l th layer, $W^{[l]}$ and $b^{[l]}$ are the weights and bias of the layer, $A^{[l-1]}$ is the activation of the previous layer, and $*$ denotes the convolution operation.^{7,9}

Pooling layers are used to reduce the spatial dimensions of feature maps while retaining the most important information. They downsample feature maps by applying operations such as max-pooling or average-pooling.⁹(Fig. 2)

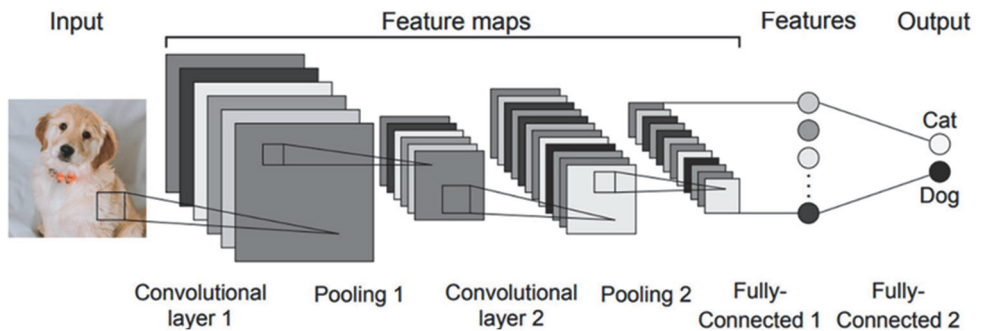


Figure 2 Convolutional neural network: an input image is processed by computing a feature value for each image patch to create a feature map. These feature maps are processed by additional convolutional and pooling layers to learn increasingly more complex features while reducing the spatial resolution. The final feature maps are converted to a vector of features and two fully connected layers determine the final output: classifying whether the input image contains a cat or dog.

Finally, fully connected layers integrate the extracted features and perform classification or regression tasks. Through the combination of these layers, CNNs can automatically learn hierarchical representations of input data, making them effective for tasks such as image classification, object detection, and image segmentation.⁹

7.5 Classification

Classification is a machine learning task where the goal is to categorize data points into predefined classes or categories based on their features. Mathematically, this can be represented as follows:

Let X be the input features, Y be the output class labels, and $f(X)$ be the mapping function that predicts the class label for each input data point X . The classification task involves learning this mapping function $f(X)$ from labeled training data. Formally, the goal is to learn a classifier $h(X)$ that maps input features to class labels. In binary classification, where there are only two classes, the classifier can be represented as:

$$h(X) = \begin{cases} 1, & \text{if } P(Y = 1|X) \geq 0.5 \\ 0, & \text{if } P(Y = 1|X) < 0.5 \end{cases}$$

where $P(Y = 1 | X)$ represents the probability that the output class Y is equal to 1 given the input features X .¹²

For multi-class classification, the classifier $h(X)$ can be represented using the softmax function:

$$P(Y = k|X) = \frac{e^{f_k(X)}}{\sum_{j=1}^K e^{f_j(X)}}$$

where $f_k(X)$ represents the score or output of the classifier for class k , and K is the total number of classes.¹² The class with the highest probability is predicted as the output class label (Fig. 3).

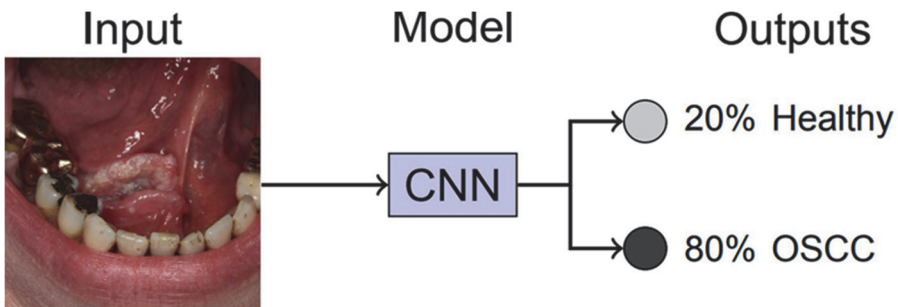


Figure 3 Classification task. Classification categorizes an input image as one class from a pre-defined set of classes. The model's uncertainty about its prediction is provided as a score between 0 and 100.

7.6 Object Detection

Object detection is a computer vision task that involves identifying and localizing objects within images or videos. Unlike image classification, which assigns a single label to an entire image, object detection aims to detect multiple objects of interest and precisely locate them within the image by drawing bounding boxes around them (Fig. 4).

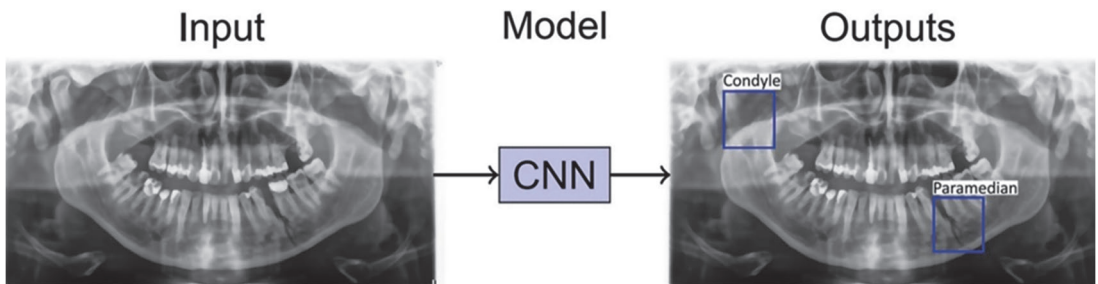


Figure 4 Object detection task: object detection processes an input image to predict the location and category of objects of interest with bounding boxes and classes, respectively. This illustrative example shows fracture detection on an orthopantomogram (OPG) with the subregion of each fracture predicted as category.

Object detection typically involves several steps. Firstly, the image is processed to extract features using CNNs or other feature extraction methods.¹³ Then, a detection algorithm identifies regions of interest (ROI) likely to contain objects using techniques like selective search or region proposal networks (RPNs).¹³ These regions are further refined and classified to determine the presence of objects and assign class labels using classification models. Finally, the detected objects' bounding boxes are adjusted to accurately localize them within the image.¹³

7.7 Segmentation

Segmentation is the process of partitioning an image into multiple segments or regions to simplify its representation and facilitate analysis. It aims to identify and delineate objects or regions of interest within an image (Fig. 5). In medical image analysis, segmentation is particularly valuable for identifying structures

like organs, tissues, or abnormalities.¹⁴ Common techniques include thresholding, region-based methods, and CNNs. These methods use mathematical functions to assign each pixel in the image to a specific class or label, enabling accurate and precise delineation of structures for further analysis or diagnosis.

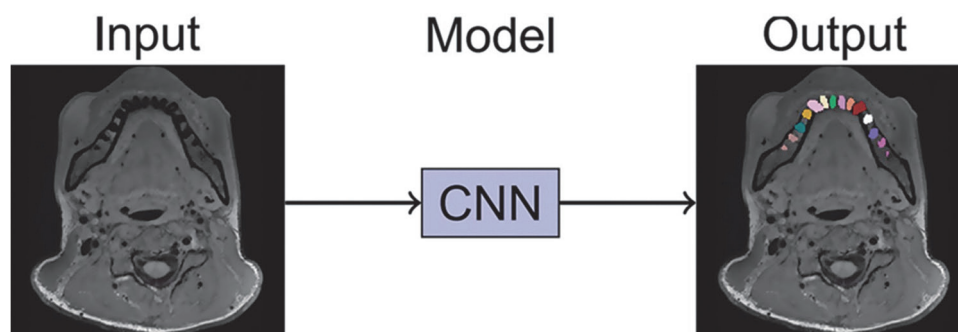


Figure 5 Segmentation task: segmentation processes an input image to predict a class for each pixel of the image. The illustrative example shows a slice from an MRI scan with the model predicting pixel-level segmentations of the individual mandibular teeth.

7.8 The Role of AI in Cranio-Maxillofacial Surgery

The integration of advanced imaging technologies and artificial intelligence (AI) will revolutionize the field of Oral and Cranio-Maxillofacial (CMF) surgery, which involves highly complex procedures aimed at treating conditions such as congenital deformities, trauma, and head and neck oncology affecting the facial skeleton and soft tissues.¹⁵ Precise pre-operative planning and real-time intraoperative guidance are critical to the success of these surgeries, and the combination of medical imaging and AI plays a pivotal role in improving these processes.¹⁶

Moreover, AI-driven simulations are increasingly used to model various surgical scenarios, allowing surgeons to anticipate potential challenges, such as the soft tissue simulation in orthognathic surgery. These simulations offer insights into how a patient's anatomy may respond to different interventions, enabling surgeries to be tailored to the patient's unique physiological features.

This approach not only improves surgical outcomes but also reduces the likelihood of complications, leading to faster recovery times and overall better patient care.⁹

Building on the profound impact that AI has had in Cranio-Maxillofacial surgery, its applications extend across multiple subspecialties within the field. The integration of AI into surgical workflows is enhancing precision, improving outcomes, and transforming pre-operative planning in several key areas:

- Dentoalveolar surgery
- Implantology
- Traumatology
- Oncology
- Craniofacial surgery
- Orthognathic and feminization surgery

7.8.1 Dentoalveolar Surgery

One of the intriguing challenges in dentistry and oral surgery is to determine whether a wisdom tooth should be removed or not. In cases of diseased wisdom teeth, where pain or pathology is obvious, there is a general consensus that surgical removal is indicated. However, most of the removed wisdom teeth are asymptomatic.¹⁷ In the Netherlands, more than 200,000 wisdom teeth are removed annually¹⁸, which is associated with a large societal and financial burden (over €40,000,000/per year). Nevertheless, it is a well-hidden public secret that millions of unnecessary wisdom teeth surgeries are performed worldwide per annum.¹⁷ A 25% to 50% reduction of unnecessary wisdom teeth removals would result in a cost reduction of up to € 20,000,000 annually in the Netherlands only.

Nowadays, the decision flowchart for wisdom tooth removal is based on the experience of the surgeon as well as on considerations of a wide range of risk versus benefit factors, including the anatomy, general health, age, dental status (pericoronitis, unrestorable caries, odontogenic infection, periapical pathology, periodontitis, root resorption, food trapping, or other oral pathology (cysts, tumors, etc.), drug history, and other specific patient-, surgeon-, and financial-related factors.¹⁹



The decision about whether to remove a wisdom tooth or not can only be made by combining all this clinical data with necessary radiological information. Therefore, removal of wisdom teeth necessitates a high-quality pre-operative orthopantomogram (OPG) radiograph. In certain circumstances, radiological abnormalities detected on an OPG may require further investigation with a cone beam computed tomography (CBCT). The proximity of the inferior alveolar nerve (IAN) to the roots of lower wisdom teeth is a risk factor for the occurrence of nerve damage and subsequent sensory disturbances of the lower lip and chin following the removal of wisdom teeth.^{18,20} CBCT supports the decision-making process by imaging this proximity so that the patient can be appropriately and accurately counseled regarding the potential risks and associated complications during the consent process for this procedure.

Taking the numerous interactions between all those clinical and radiological factors into account, it is very challenging to make the correct decision. It is hypothesized that an AI-based decision flowchart for wisdom teeth removal may have a huge potential to aid patients and surgeons in making the right choice, thereby inducing health improvement to patients, whose wisdom teeth will pose a significant health risk to them, while protecting those who will not benefit from surgery.

Recent studies have explored the application of AI in diagnosing, predicting, and managing third molar impactions.²¹ AI's role in predicting third molar eruption has also been investigated, with mixed results. While AI models show promise in predicting molar uprighting, studies like Chopra et al.'s suggest challenges in accurately predicting eruption.²²

In assessing the relationship between third molars and the inferior alveolar nerve, AI models help identify positional relationships, aiding safer surgeries (Fig. 6). Furthermore, AI tools have been developed to predict removal difficulties and potential complications, enhancing pre-operative preparation and decision-making, although more comprehensive databases are needed to improve accuracy and reliability.

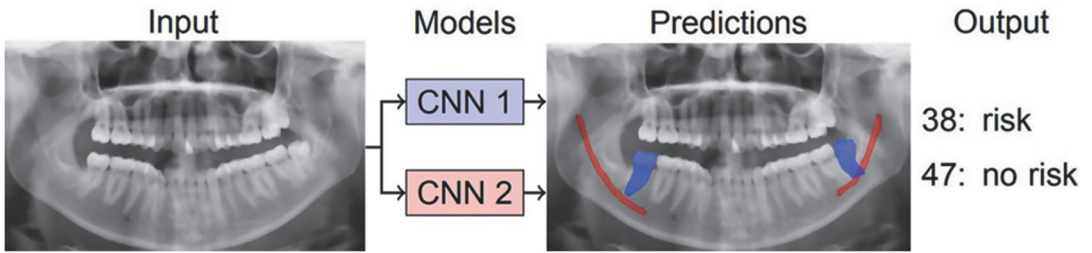


Figure 6 Automated assessment of tooth extraction risk. One application of AI for dentoalveolar surgery is the automated assessment of risk to damage the inferior alveolar nerve during tooth extraction. Deep learning models are used to predict segmentations of teeth and the mandibular canal, which are used to determine the overlap between the teeth and the nerve.

7.8.2 Implantology

Dental implantology is a continuously growing working area for dental surgeons. Implants are an often used treatment modality for single tooth replacement, but also in traumatology and oncology, implants have an important role. Many dental surgeons are still working without implant guides from computer-assisted implant planning (CAI). This software enables the accurate planning of the implant structure, combining functional and esthetic planning of the suprastructure for the future prostheses. Also critical anatomical structures, like the inferior alveolar nerve and the maxillary sinus, are visualized. During surgery, the planned implant positions are accurately transferred to the surgical site using guided or navigated systems. However, despite its advanced capabilities, the diagnostic and planning phases in CAI are still more time-consuming and expensive than traditional workflows.²³ The integration of AI is set to revolutionize CAI, where speed and cost-efficiency will be greatly improved. AI has the potential to streamline these stages, thus reducing costs and improving efficiency, ultimately making CAI more accessible for widespread clinical use.²⁴

7.8.2.1 Treatment Planning: Toward Automation

In the current implant planning systems, the user has to assess the intended implant site. This is usually the technical physician. The implant type and system are given by the performing surgeon, which is a maxillofacial surgeon or a specialized dentist. The anatomical structures near the implant site are evaluated by the technician and risk of damage needs to be estimated. If the risk



is considered to be low, the location, angulation, and depth are determined, while considering the function and esthetic of the coming suprastructure.

Recent studies have shown the potential of AI in analyzing CBCT scans for detailed implant planning. Bayrakdar et al. applied deep learning to dental implant planning with CBCT images but found limited success, suggesting more training is needed for accurate bone height and width measurements.²⁵ Moufti et al. compared AI-based segmentation with human evaluations for edentulous areas, showing that AI offers acceptable accuracy and significantly reduces time and cost in implant planning.²⁶

While AI's performance in measuring bone height and width for implant placement has been moderate, it has proven valuable in detecting anatomical landmarks. Studies by Kwak et al. and Oliveira-Santos et al. demonstrated AI's accuracy in identifying the mandibular canal and its variations, which are critical for implant planning.^{27,28} AI models have also shown consistency in segmenting the maxillary sinus, aiding 3D model creation for diagnosis and treatment planning.²⁹

AI-powered surgical navigation systems are being increasingly used to guide clinicians in implant placement. These systems provide real-time guidance based on pre-surgical planning. These systems visualize the position of the implant within the anatomy of the patient using augmented reality (AR). By doing so, surgeons will be able to place the implants with higher precision, reducing the risk of errors such as perforation of vital structures or misalignment of the implant. A case report by Mangano et al. showcased how this combination enhances surgical efficiency and accuracy.³⁰

Furthermore, AI can enhance robotic systems for implant placement with the ability to make automated adjustments intraoperatively. This automation improves accuracy and consistency, therefore improving outcomes with less manual intervention. For instance, AI-based robotic systems can adapt in real time to optimize implant placement based on the patient's unique anatomy.

7.8.2.2 Predicting Treatment Outcomes

Dental implants are the preferred treatment for tooth replacement, but complications and implant failures are rising, leading to increased costs and additional procedures for patients and clinicians. Predicting implant loss or complications is challenging due to various risk factors, including patient

characteristics, bone quality, implant type, and surgical plan. Currently, implant failure predictions rely on clinicians' expertise, but AI shows promise in improving treatment outcome predictions.²⁴ Machine learning algorithms can analyse patient data, such as medical history, bone condition, and previous dental procedures, to predict outcomes and recommend personalized implant placement strategies. For example, AI can help in identifying potential complications, such as insufficient bone volume or proximity to vital structures like the inferior alveolar nerve, thus allowing clinicians to adjust their approach in advance.

Research in this field is limited, with few studies and no comprehensive systematic reviews. Lyakhov et al. developed a neural network model that predicted single implant survival with 94.48% accuracy based on patient case histories but concluded that AI should assist, not replace, clinical decision-making.³¹ Oh et al. demonstrated AI's potential in predicting osseointegration using radiographs, and Cha et al. applied AI to measure peri-implant bone loss, finding no significant difference between AI and clinician measurements.^{32,33} Huang et al. introduced AI models to predict implant loss over 5 years, suggesting AI could help identify high-risk patients and adjust treatment plans.³⁴

7.8.2.3 Post-surgical Monitoring and Predictive Analytics

AI is also of great value in the post-surgical phase by monitoring the healing process and detecting potential complications. AI systems can analyse post-operative images, such as dental single-tooth X-rays, OPGs or CBCTs, to identify signs of infection, implant failure, or bone loss around the implant. The ability of machine learning models to predict the complication rate allows for early intervention if necessary. A large dataset is, however, needed to build such a prediction model.

Moreover, AI can assist in predicting long-term outcomes by analyzing the patient's response to the implant over time. These predictive models can help clinicians adjust treatment plans, whether through early interventions, additional procedures, or customized follow-up schedules, to ensure the long-term success of implants.



7.8.2.4 Implant Type Detection

With the increasing number of dental implant brands and prosthetic components on the market, identifying the correct implant system can be challenging, particularly when complications arise or when treatment was performed at another clinic. AI can automate the identification and classification of different dental implant systems (DIS) based on radiographic images.³⁵ This reduces time and complexity involved in manual identification, providing clinicians with a more efficient way to determine the correct implant system.

Recent literature supports AI's potential in dental implant system (DIS) detection, with studies showing high accuracy (93.8–98%) in AI models using 2D radiographs, like periapical or panoramic images. However, CBCT has not yet been widely used for AI model training due to lower resolution concerns. Larger and more diverse datasets are needed to improve AI accuracy and global applicability.³⁵

7.8.2.5 Challenges and Future Directions

Despite the numerous advantages, there are a variety of challenges that exist in integrating AI into implantology. The first limitation involves large and high-quality data for the training of AI algorithms. Ensuring that AI systems are accurate across a diverse range of patients and anatomical variations is crucial. In addition, clinicians must have confidence in the recommendations made by AI, which requires transparent and explainable AI models that provide clear justifications for their decisions.

Future development of AI in implantology will be the further integration of CBCT with MRI and other diagnostic tools to create more comprehensive treatment plans. AI-driven technologies may evolve further to take into consideration patient-specific factors in real time, that might alter the proposed treatment during surgery for an even more optimized outcome. In conclusion, AI will revolutionize implantology by improving the accuracy, efficiency, and predictability of dental implant procedures. Further evolution of AI holds great promise for better patient outcomes, smoother clinical workflows, and more personalized care in dental implantology.

7.9 Traumatology

7.9.1. Fracture Detection

AI is increasingly being integrated into craniofacial traumatology, offering significant advancements in the diagnosis, treatment planning, and management of facial injuries. One of the primary applications of AI in this field is in the detection and classification of facial fractures, which are often complex and challenging to diagnose manually due to their intricate patterns and the overlapping structures in craniofacial imaging.

AI algorithms, particularly deep learning models, have shown great promise in automating the detection of various craniofacial fractures, such as those in the zygoma, mandible, and nasal bones. Convolutional neural networks (CNNs) have been employed to analyse CT and CBCT scans, significantly reducing diagnostic time while maintaining high accuracy levels. These AI models can identify fractures that may be missed by human observers, especially in cases involving subtle or complex fracture patterns, such as those with both horizontal and vertical components. This automation not only improves diagnostic efficiency but also allows clinicians to focus on more complex aspects of patient care, such as treatment planning and surgical intervention (Fig. 7).

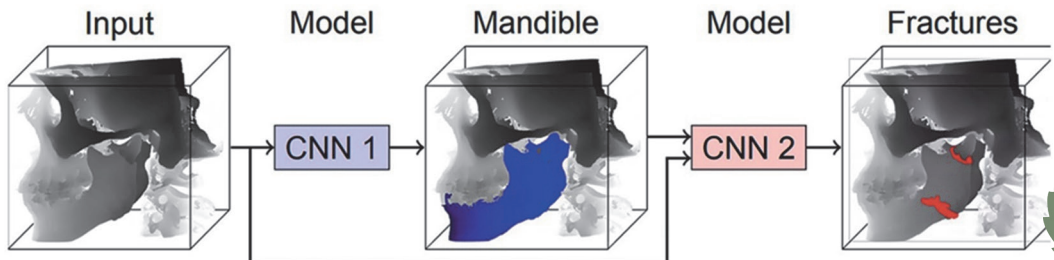


Figure 7 Automated detection of mandibular fractures. AI has been applied to automatically detect fractures of the mandible in CBCT scans. The method uses an intermediate segmentation of the mandible to improve the robustness of fracture segmentation.

For example, Tong et al. developed a CNN algorithm that automatically detects zygomatic fractures using CT imaging, demonstrating comparable performance to manual diagnosis and highlighting its potential for clinical use.³⁶

Similarly, other studies have implemented CNN-based models to detect mandibular fractures in panoramic radiographs, achieving success rates that surpass expert-level human performance, with AUC values exceeding 90%.^{37,38} AI has also proven to be a reliable tool in diagnosing orbital blow-out, mandibular, and nasal bone fractures from (CB)CT scans, enhancing both accuracy and efficiency in facial trauma diagnosis.^{39,40,41} These advancements hold promise for improving patient care, expediting clinical workflows, and contributing to resident training.

7.9.2. Prognosis Prediction

In addition to fracture detection, AI has the potential to assist in predicting the severity and prognosis of craniofacial trauma. By analyzing large datasets of patient images, clinical information, and outcomes, AI models can help predict the likelihood of complications, recovery times, and the best course of treatment. These predictive capabilities could be especially valuable in determining whether non-surgical management is appropriate or if surgical intervention is necessary.

7.9.3. Image Quality

AI is also helping to optimize image quality in craniofacial imaging. Advanced deep learning algorithms, such as those used in low-dose CT imaging, improve the quality of scans while reducing radiation exposure, which is a significant benefit for patients, especially in pediatric and trauma cases. By enhancing image resolution and clarity, AI aids in more accurate detection and better visualisation of fractures and soft tissue injuries.

Rozema et al. demonstrated the effectiveness of advanced modeled iterative reconstruction (ADMIRE) and the PixelShine DL algorithms in low-dose CT protocols for midfacial trauma. These algorithms significantly improved image quality while reducing radiation exposure by 61.7%.⁴²

7.9.4. Further Prospects

Despite these advancements, challenges remain in the implementation of AI in craniofacial traumatology. One major hurdle is the variability in image quality, especially in emergency situations where imaging may be suboptimal due to the

patient's condition or limited access to advanced imaging technology. Additionally, AI models must be able to handle the complexity of the craniofacial anatomy, where fractures can sometimes be hidden by overlapping structures or may be missed due to the presence of artifacts.

Looking ahead, future directions in AI for craniofacial traumatology include the development of multimodal AI systems that can integrate different imaging modalities (such as CT, MRI, and X-rays) to provide a more comprehensive view of the injury. These systems could offer enhanced accuracy in fracture detection, soft tissue injury assessment, and treatment planning. Furthermore, AI could be used to assist in personalized treatment strategies by combining imaging data with clinical factors, allowing for more tailored care and better outcomes.

7.10 Head and Neck Oncology

7.10.1. Histology Whole-Slide Imaging

AI is transforming the field of histology, mainly in whole slide imaging (WSI). This process involves digitizing histological slides to generate high-resolution images that can be analysed by pathologists and researchers without losing the rich morphology of the slides. The shift from traditional microscopy to digital platforms enhances the capacity to store, share, and analyse pathological data without the need for a microscope, making it a valuable resource for both research and clinical diagnostics.⁴³

Deep learning models are increasingly being applied to WSI to assist in the interpretation of histological images. These algorithms are shown to be successful in tasks like the identification and classification of various tissue types and pathological features, significantly speeding up the diagnostic process. The models can detect malignant cells, quantify tumor characteristics, and even predict patient outcomes based on histological patterns. This automation not only improves accuracy but also reduces the workload on pathologists, allowing them to focus their labor on more complex cases that require expert analysis.⁹ Furthermore, the integration of AI into WSI facilitates standardization and objective assessments. Traditional histological evaluations are prone to subjective interpretations, whereas AI models trained on large datasets give more consistent results, making the results more reproducible. Also, the capability to analyse large volumes of imaging data can reveal patterns and



insights that might be missed in manual reviews, potentially leading to new understandings of disease mechanisms and the development of personalized treatment strategies.⁴⁴

Despite these advantages, the implementation of AI in digital histology does come with challenges. The necessity for a high amount of high-quality annotated datasets to train AI models is a hurdle to overcome, especially the need for computing power to train and employ such a model.⁴⁴ It is also important to ensure that AI serves to complement the expertise of pathologists to maintain diagnostic quality, rather than replacing the latter. As this technology continues to evolve, collaboration between AI developers and histopathologists will be essential in harnessing the potential of AI in WSI, ultimately improving patient care and advancing the field of pathology.⁴⁴

7.10.2. Radiological Imaging

Radiological imaging plays a crucial role in the diagnosis, treatment planning, and monitoring of head and neck oncology. Techniques such as ultrasound, CT, MRI, and positron emission tomography (PET) provide detailed insights into the anatomy and pathology of tumors in this complex region. These imaging modalities help clinicians identify the extent of disease, evaluate lymph node involvement, and assess potential treatment responses, ultimately guiding therapeutic decisions.

The integration of AI into radiological imaging will be transforming the approach of head and neck oncology. Deep learning AI algorithms can analyse large volumes of imaging data with remarkable speed and accuracy. These technologies have been shown to assist radiologists in detecting tumors, characterizing lesions, and predicting treatment outcomes by recognizing patterns that may be hard to notice for human observers. For instance, AI can enhance the detection of early-stage cancers, allowing for timely intervention and improved patient prognosis.⁴⁵

Also, AI-driven tools will facilitate the standardization of imaging interpretations, reducing variability among radiologists. This is particularly important in head and neck oncology, where the complex anatomy and overlapping structures can complicate assessments. By providing consistent and objective analyses, AI algorithms help to ensure that patients receive

appropriate and effective treatment plans based on imaging data. Additionally, machine learning models can be trained to integrate clinical information with imaging findings, offering more comprehensive insights into patient management.

7.10.3. Clinical Imaging

In head and neck oncology, physical examination plays the most important role, where radiological imaging only adds to the clinical view. The golden standard for diagnosing head and neck cancers remains clinical examination and biopsy. When diagnosed in early stages, less invasive treatment is necessary for these tumors. Here, the diagnostic challenge arises since not every mucosal lesion is (potentially) malignant and not every mucosal lesion requires biopsy. It is also shown before that primary healthcare workers have good, but not perfect detection rates for oral potentially malignant disorder (OPMD) and oral cancer, with sensitivities ranging from 0.59 to 0.99 and specificities ranging from 0.64 to 0.99.⁴⁶ It has been reported that an AI model using a visual transformer gives a sensitivity and specificity of 0.99 in detecting head and neck cancers in digital clinical photographs (Fig. 8). When used in conjunction with the visual inspection of a primary healthcare worker, a near-perfect accuracy is to be expected. This will result in less doctors delaying and diagnosing in early stages, meaning less invasive treatment and higher survival rates.



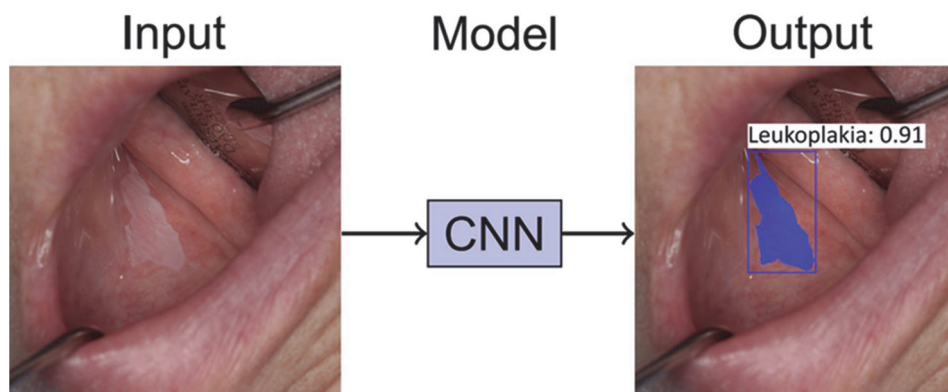


Figure 8 Automated detection and segmentation of potentially malignant oral disorders. The model implemented the instance segmentation task, which includes bounding box detection, classification, and segmentation. The score above the bounding box represents the confidence of the model.

Another clinical imaging modality where AI models are applied is in nasal endoscopic images. A real-time augmentation during the endoscopy can be applied, for example.⁴⁷ The accuracy of the AI model is comparable to trained otolaryngologists for certain diagnosis, such as sinonasal inverted papilloma.⁴⁸ Research on AI models predicting the HPV state and assessing prognosis of tumors is to be expected sooner rather than later.

Despite these advancements, challenges remain in the implementation of AI in clinical practice. The quality and quantity of data needed to train AI models can be limiting, especially for rare cancers. Furthermore, the interpretability of AI outputs is crucial; clinicians must understand the rationale behind AI recommendations to make accurate informed decisions.

7.11 Craniofacial Surgery

Craniofacial surgery, which encompasses the diagnosis, treatment, and surgical management of congenital and acquired deformities of the skull, face, and jaw, can benefit greatly from AI-driven advancements. From pre-operative planning to post-surgical care, AI promises to enhance precision, improve patient outcomes, and streamline complex workflows in craniofacial procedures.

7.11.1 Detection of Craniofacial Abnormalities

AI algorithms have demonstrated the ability to detect subtle craniofacial patterns that may elude even experienced clinicians.⁴⁹ Han et al. developed a deep learning model using U-Net to segment and evaluate the masseter muscle in patients with hemifacial microsomia, achieving high efficiency compared to manual segmentation by radiologists.⁵⁰ Geisler et al. achieved a 90.6% accuracy rate using a pre-trained AI model to screen, detect, and classify non-syndromic craniosynostosis from 2D clinical photographs.⁵¹ Similarly, Mizutani et al. developed an AI system using skull X-rays, which reached 100% accuracy, sensitivity, and specificity for non-syndromic craniosynostosis compared to CT scans⁵² (Fig. 9).

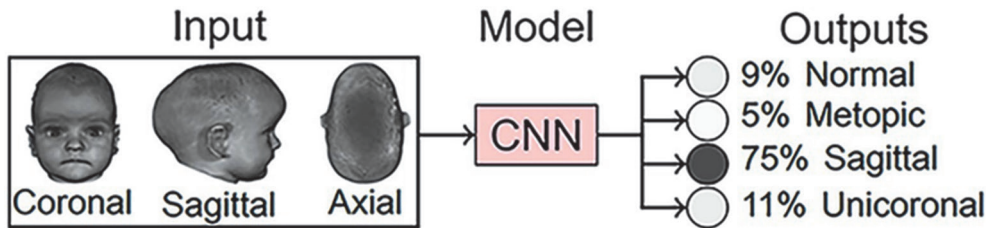


Figure 9 Automated classification of craniosynostosis. A three-dimensional stereophotogrammetry scan of a baby's head is used to automatically classify the type of skull deformity.

Further advancements include Blum et al.'s machine learning algorithm for rating the severity of metopic synostosis in CT images.⁵³ Xu et al. developed a 3D point cloud graph CNN for predicting and locating landmarks in patients with cleft lip and palate, achieving results comparable to expert annotations.⁵⁴ Arjmand et al. utilized a modified 3D U-Net to predict facial shape from CT images, improving understanding of the link between craniofacial deformities and bone structure.⁵⁵

However, limitations remain. AI models have struggled to classify rare craniofacial conditions, such as lambdoid craniosynostosis, and to distinguish between different causes of craniofacial abnormalities, including trauma, genetics, and muscle-related deformities.⁴⁹

7.11.2 Pre-operative Planning

Pre-operative planning is critical in open craniofacial surgery, where even small errors can lead to significant functional and aesthetic challenges. An AI system can help surgeons by analyzing patient data, including 3D photographic imaging and CT scans, to create highly detailed, personalized surgical plans. AI can automatically segment different structures, such as bones, soft tissues, and blood vessels, from these images, helping surgeons visualize critical anatomical features in greater detail.

AI-powered virtual surgery platforms allow surgeons to “practice” complex procedures virtually. These systems can simulate tissue movement, bone cutting, and the placement of implants, ensuring that the surgical team is well-prepared for the actual operation. Surgeons can explore these 3D models interactively, adjusting angles, observing potential risks, and determining the best surgical approaches before performing any incisions.

7.11.3 Further Considerations

In the future, a role is reserved for AI to assist in forecasting long-term outcomes, such as the potential for facial growth in pediatric patients or the durability of skull implants in adult patients. By predicting how a patient’s face will evolve over time, AI helps in planning not only the immediate surgical intervention but also future corrective surgeries if necessary. Some studies on cephalometric measurements in healthy adolescent patients have been conducted, showing promising results.

The integration of AI into clinical practice requires careful training for healthcare professionals. Surgeons and medical staff must be adequately prepared to work with AI tools, interpreting the insights provided by AI while maintaining clinical judgment. AI should be seen as a tool that enhances human expertise, not as a replacement for it.

7.12 Orthognathic and Feminization Surgery

Orthognathic surgery, which corrects jaw and facial bone irregularities, is often required to address functional issues such as bite problems, malocclusion, and facial asymmetry. Virtual surgical planning (VSP), particularly three-dimensional (3D) pre-operative treatment planning and surgical outcome simulation, has

become the gold standard in orthognathic surgery. A key step in successful VSP is the accurate segmentation of skeletal structures from CT or CBCT scans. However, manual segmentation is time-consuming, often requiring several hours of effort. Once 3D models are generated, cephalometric landmarks must also be identified manually, further adding to the time burden. AI is revolutionizing orthognathic surgery by improving precision, streamlining planning processes, and enhancing surgical outcomes. With the integration of AI technologies, the field is experiencing significant advancements that improve both the efficiency and effectiveness of these complex procedures.

7.12.1 Segmentation

Recent advances in AI have significantly improved the segmentation of skeletal structures and the identification of cephalometric landmarks in CT and CBCT images. Studies over the past 3 years have increasingly focused on training CNNs for these tasks, with accuracy comparable to that of trained clinicians.⁴⁹ AI-driven tools provide a substantial time-saving advantage, with some CNN-based processes completing tasks up to 100 times faster than manual approaches. Even when manual touch-ups are necessary, AI significantly reduces overall processing time.⁵⁶

For example, Menezes et al. demonstrated that AI models could accurately detect cephalometric landmarks under varying conditions of brightness and contrast, illustrating continuous improvements in AI-based image analysis.⁵⁷ Choi et al. developed an AI model with a 96% success rate in determining whether surgery was required and a 91% accuracy in choosing the appropriate osteotomy or deciding on dental extractions.⁵⁸ AI tools have also been developed to predict post-operative soft tissue profiles and the effects of surgery on facial appearance relative to age (Fig. 10). In one study by Ter Horst et al., a deep learning algorithm was trained using 3D and CBCT images to simulate soft tissue outcomes, which were compared to actual post-operative photographs, showing a clinically acceptable margin of error (mean absolute error of 1.0 ± 0.6 mm).⁵⁹



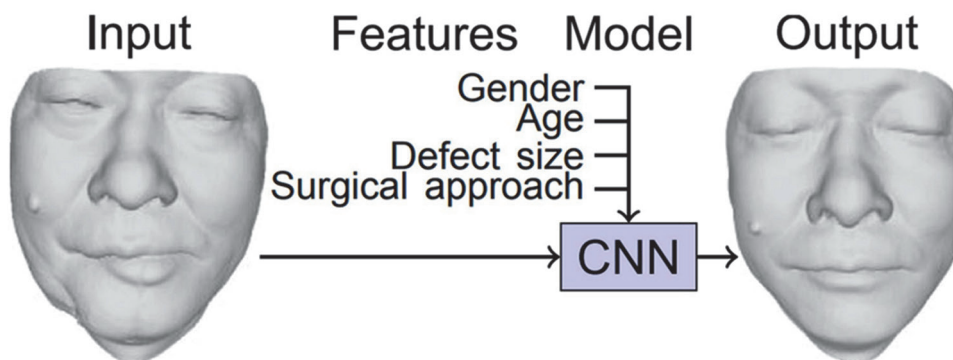


Figure 10 Prediction of soft-tissue changes following orthognathic surgery. Three-dimensional stereophotogrammetry scans are used to predict the post-operative facial profile following orthognathic surgery to correct a mandibular deformity. Clinical features such as gender, age, defect size, and the surgical approach are provided as additional features to the model to evaluate the soft-tissue changes for different surgical plans.

7.12.2 Predictive Analytics and Outcome Modeling

The role for AI in orthognathic surgery extends beyond pre-operative planning into predicting post-operative results. Machine learning models can analyse vast datasets of patient outcomes to identify patterns and predict how specific patients will respond to surgery. By considering factors like age, bone density, and previous treatments, AI can estimate the likelihood of complications or predict recovery times, providing surgeons with invaluable information for personalized treatment plans.

In addition, AI can help optimize the positioning of the jaws, facial bones, and implants during surgery. Algorithms can simulate different surgical approaches and predict how each one will affect the patient's bite, facial symmetry, and long-term outcomes, ensuring that the most appropriate plan is chosen before the procedure begins.

7.12.3 Surgical Assistance and Navigation

During surgery, AI-based technologies, such as robotic systems and augmented reality (AR), provide real-time guidance, improving surgical precision and reducing the risk of errors. AI algorithms integrated into robotic surgical systems

can assist with tasks like bone cutting, aligning the jaw, and securing implants with exceptional accuracy. These systems can also adapt to changes during the surgery, ensuring the procedure is tailored to the patient's real-time anatomy. Additionally, augmented reality (AR) tools can overlay digital images onto the patient's anatomy during surgery, providing the surgeon with visual cues and guiding them in making the right incisions and adjustments. This technology can reduce surgical time and improve the accuracy of the procedure, ultimately leading to better functional and aesthetic outcomes for patients.

AI's potential extends beyond surgical planning. AI accurately predicted peri-operative blood loss in 950 patients undergoing orthognathic surgery, showing a strong correlation between predicted and actual blood loss.⁶⁰

7.12.4 Post-operative Monitoring and Recovery

The role for AI in orthognathic surgery does not end with the procedure itself. Post-operative monitoring is crucial for detecting complications, such as infection, malunion of bones, or issues with the positioning of osteosynthesis material. AI-driven systems can automatically analyse a post-operative CBCT scan to detect early signs of future problems that may require intervention.

Machine learning models can also predict recovery trajectories, enabling clinicians to personalize follow-up care plans. By analyzing historical data, AI can help estimate the patient's healing process and suggest appropriate adjustments to the treatment plan to minimize the risk of complications and enhance recovery.

7.12.5 Patient-Specific Customization

One of the most significant benefits of AI in orthognathic surgery is its ability to facilitate patient-specific customization. AI can help design custom osteosynthesis implants or surgical guides based on the patient's unique anatomy, reducing the risk of plate misplacement and improving the overall fit and function of the surgical outcome. 3D printing, combined with AI, allows for the creation of highly personalized surgical tools and implants that match the patient's bone structure precisely, optimizing both the functional and aesthetic aspects of the surgery.



7.12.6 Challenges and Future Directions

While AI is proving to be a powerful tool in orthognathic surgery, there are still challenges to overcome. One major obstacle is the need for large, high-quality datasets to train AI algorithms effectively. Since each patient's anatomy is unique, AI models must be trained on diverse and comprehensive datasets to ensure accurate predictions and treatment recommendations. Additionally, there is a need for AI systems that can explain their decision-making processes in a way that is understandable to surgeons, ensuring transparency and trust in the technology.

Looking ahead, the future of AI in orthognathic surgery is exciting. As AI models become more sophisticated, they will likely play an even greater role in refining surgical techniques, improving patient outcomes, and reducing recovery times. The integration of AI with other technologies, such as robotic surgery and virtual reality, could further enhance surgical precision and the customization of treatments for individual patients.

In conclusion, AI is transforming orthognathic surgery by improving diagnostic accuracy, refining treatment planning, and enhancing surgical precision. As technology continues to evolve, AI will likely play an even more central role in personalizing care, optimizing outcomes, and advancing the field of craniofacial surgery.

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8

Summary & General Discussion



8. General Discussion

The widespread availability of the internet and IT-tools has redefined the role of the patient, shifting from a passive recipient of care towards an active participant in the management of their own health.

8.1 Introduction

The use of the internet and IT tools, including mobile devices and computers, for care is called eHealth. eHealth is not merely a technological development; it also represents an attitude aimed at improving healthcare through the use of information and communication technology. The 'e' in eHealth does not just stand for electronic but also for efficiency, enhancing quality, evidence-based, equity, empowerment, education, and encouragement.¹ Particularly, the last three terms highlight a shift in mindset, focusing on the roles of both patients and caregivers, where eHealth enables patient-centred care and fosters greater patient involvement in their own healthcare. The patient thus becomes an active partner in the healthcare team.

Although eHealth was initially only marginally integrated into daily practice, the COVID-19 pandemic accelerated the widespread implementation of specific applications, such as video consultations, within healthcare. To date, however, the potential benefits and limitations of patient-centred eHealth applications in Oral and Maxillofacial (OMF) surgery have not been systematically explored. The primary aim of this thesis was therefore to determine the current position of patient-centred eHealth in the field of OMF surgery and to identify both the challenges and opportunities associated with its implementation in routine clinical practice.

To address these objectives, this chapter synthesizes the findings of the studies presented in this thesis. It begins with a concise summary of the individual studies, followed by a discussion of their implications for clinical practice, future research, and education. Finally, recommendations for integrating eHealth interventions into routine care are outlined in the section on future directions.

8.2 Summary of this Thesis

Section I Exploration

The first section of this thesis explored the role of eHealth in OMF surgery.

In **Chapter 2**, a scoping review was conducted to map the existing research (published up to 13 September 2017) on patient-centred eHealth interventions within the field of OMF surgery. The review focused on the detailed composition of these interventions and examined how they were evaluated by both patients and healthcare professionals.

The study mapped 41 papers representing 34 unique patient-centred eHealth interventions in OMF surgery. The majority of these interventions targeted head and neck oncology patients. Most of the identified interventions involved online counselling, with half of these utilizing video consultations. Notably, only 23 out of 41 studies involved patients in the evaluation of the eHealth intervention. As most interventions were still in the feasibility or pilot phase, definitive facilitators and barriers to implementation could not yet be established.

Chapter 3 presents an investigation into the quality of online patient information on cleft lip and/or palate (CL/P). The aims of this study were to (1) define quality criteria for online information on CL/P; (2) assess the quality of online patient information on CL/P and (3) map the potential differences in perspective on the quality of online CL/P information between patients, parents and healthcare professionals.

Quality criteria for online patient information were distilled from the literature and subsequently prioritized by patients with CL/P, parents, and cleft care professionals, resulting in a final list of 16 criteria. Another group of patients and parents was then asked to search for online information on CL/P; the four most frequently visited websites were selected for quality assessment. New groups of patients, parents, and professionals evaluated whether these four websites met the 16 criteria.

This study demonstrated that patients and parents have different needs regarding the quality of online information compared with professionals. For example, patients valued the presence of an internal search function, a discussion forum, and easy access to information without the need to download additional software (e.g., plug-ins), while parents and professionals did not. The description of a privacy policy was considered important by both patients and

parents, but not by professionals. Professionals emphasized the importance of a professional appearance and user experience of a website, as well as the identification of the authors and their qualifications. Patients and parents, however, did not prioritize these aspects.

An exploratory study investigating patients' knowledge and perceptions of Artificial Intelligence (AI) in dentistry was presented in **Chapter 4**. The primary objective of this study was to evaluate patients' awareness and perceptions regarding the use of AI in dental practice. An 18-item questionnaire was administered at both a university dental clinic and a private dental clinic in Germany, yielding 265 complete responses. The findings indicated that approximately half of the participants reported having knowledge of AI, and a substantial majority (73.6%) agreed that dentistry would benefit from its application. Respondents identified both advantages and disadvantages of AI in dentistry.

The three most frequently perceived disadvantages were a potential impact on workforce requirements, new challenges in the doctor–patient relationship, and increased costs of dental care. In contrast, the main anticipated advantages were enhanced diagnostic confidence, improved time efficiency, and more personalized, evidence-based disease management. Furthermore, most patients expected AI to be integrated into the dental workflow within 1–10 years. Interestingly, patients aged 35 years and older expressed higher performance expectations of AI than their younger counterparts.

Section II Evaluation in Clinical Practice

In the second section of this thesis, **Chapters 5 and 6**, two patient-centred eHealth interventions are evaluated in clinical practice: (1) audiovisual eyeglasses during third molar removal and (2) video consultation in the context of the COVID-19 pandemic.

Given that third molar removal is the most frequently performed procedure in oral surgery and that many patients experience high levels of anxiety during this treatment, we aimed to investigate whether eHealth could help make this procedure more tolerable for patients. Hence, we examined whether distraction through audiovisual eyeglasses could provide support in this context. The study in **Chapter 5** aimed to investigate the efficacy, safety, and tolerability of

audiovisual eyeglasses during third molar removal for anxiety and stress reduction. In addition, the effect of the audiovisual intervention on post-operative pain perception and use of analgesia was determined.

We demonstrated in this study that the audiovisual intervention had no effect on measured anxiety assessed by the STAI Y-6 and VAS anxiety. Heart rate was found to be significantly lower when patients wore the audiovisual intervention, particularly when they watched a relaxing video. A higher respiratory rate is seen in patients watching a video compared to care as usual, which was further increased when watching a thrilling video. Due to limited response to post-operative surveys on perceived pain and the use of analgesics, no definitive conclusions could be drawn in this regard.

The second patient-centred eHealth intervention we evaluated concerned video consultation. This was prompted by the sharp increase in the number of video consultations that suddenly had to be implemented as a result of the COVID-19 pandemic. We aimed to investigate how patients experienced this type of consultation for all specialties in our university medical centre, which formed the objective of the study presented in **Chapter 6**. In addition, we aimed to identify patient groups for whom video consultation was particularly suitable due to their positive experiences, thereby enabling more patient-centred choices in the type of consultation offered.

Patients' experiences were assessed using a study-specific survey analysed with descriptive quantitative statistics. In addition, two open-ended questions were qualitatively analysed and thematically categorised into aspects that were appreciated and aspects in need of improvement. A total of 1054 patients were included in the analysis. Most patients (91.46%) reported being satisfied with their video consultation. The qualitative analyses revealed that most appreciated aspects related to three domains: the individual professional level (clinicians' attitudes and communicative style), the organisational level (clear instructions and time management) and the innovation level (ease of use and audiovisual quality). Reported areas for improvement were mainly within the innovation level, organisational and patient level, including poor audio and video quality, insufficient information on appointment delays, late provision of the required consultation link, and lack of personal experience with the technology. Patients who rated their own health as better were significantly more likely to evaluate the consultation positively. This was also observed in

patients treated in “other medical specialties” compared to those in surgical and nonsurgical specialties.

With this study, we were able to gain insight into patients’ experiences with video consultation. The quantitative and qualitative data indicated an overall positive patient experience. However, the qualitative findings also revealed inconsistency at both the innovation and organisational level. While some patients considered the audio and video quality to be very good, others reported poor quality. Similarly, instructions and time management were mentioned both as appreciated aspects and as areas needing improvement. In addition, some patients explicitly expressed a preference for in-person visits due to their limited experience with the technology.

Section III Emerging Technology

The final section of this thesis, **Chapter 7**, provides a glimpse into the near future, focusing on the possible applications of AI in OMF surgery. It provides an overview of the evolution of medical imaging and AI, and how these technologies can be integrated into diagnostics, treatment planning, and surgical execution across different subspecialties of OMF surgery. It can be concluded that across nearly all subspecialties of OMF surgery, AI demonstrates clear benefits for diagnostics, planning, and surgery. The main challenges lie in securing sufficient high-quality data, ensuring transparency and explainability of algorithms, and embedding AI as a supportive tool within clinical decision-making.

8.3 Implications for Clinical Practice

To date, the implementation of eHealth interventions in healthcare in general still seems difficult, and a lot of studies continue to address facilitators and barriers to their successful adoption.² Consistent with the conclusions presented in **Chapter 2**, a review on digital care for head and neck oncology patients reported that 11 out of 17 studies were limited to feasibility or pilot phases.³ Consequently, a widespread uptake of eHealth interventions in routine OMF surgical practice has not yet been observed. Current research in this domain continues to focus predominantly on teleconsultation applications.⁴⁻⁶ Whereas the COVID-19 pandemic initially led to a rapid and widespread adoption of

teleconsultations across medical specialties, a subsequent decline in their use has been observed.^{7,8} This trend is also reflected in our own university medical centre, where the number of video consultations has decreased accordingly (Fig. 1), despite the positive patient experiences demonstrated in **Chapter 6**.

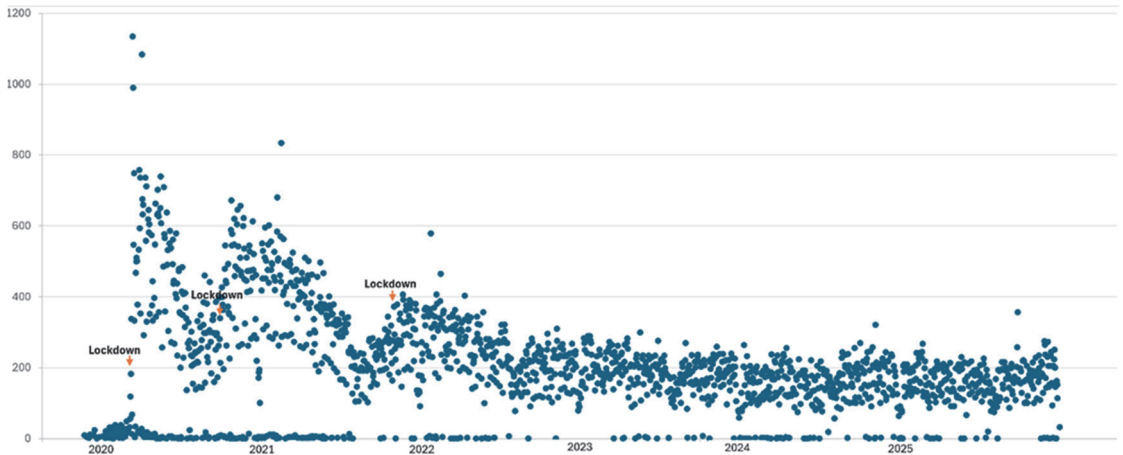


Figure 1 The total number of video consultations at the Radboud University Medical Centre from 2020 to 2025, with each dot representing the total number of video consultations per day.

This decrease in the use of video consultation can be explained by the fact that during the COVID-19 pandemic, there was an urgent need for digital healthcare which caused a rapid uptake of video consultations. As this urgency has since diminished, utilization has declined, although it remains higher than before the COVID-19 pandemic. This underscores the complexity involved in implementing interventions such as video consultations. It also highlights that the implementation of video consultations is shaped not only by structural conditions but also by individual autonomy. This dynamic aligns with broader discussions in the social sciences regarding the structure and agency debate, which examines how individual behaviour is simultaneously enabled and constrained by institutional, technological, and societal structures while still being influenced by personal preferences, professional identities, and individual decisions. This is supported by a comparative viewpoint on the implementation of video consultations in five Northern European countries.⁸ Both the lack of

technological and financial support, as well as professional values and scepticism, influence the uptake of video consultations.⁸

This complexity also accounts for eHealth interventions in general, given the extensive range of facilitators and barriers to the implementation of eHealth interventions identified in the literature.⁹ Legal, ethical, organisational, financial, technological and cultural barriers are interrelated and remain insufficiently addressed in the literature, resulting in knowledge gaps on critical aspects of implementation.^{2, 8} The novelty and dynamic nature of eHealth, combined with the involvement of multiple stakeholders, appear to contribute to the slow progress in overcoming these challenges.²

Data on the uptake of eHealth interventions in the Netherlands over the past five years show distinct trends; while the use of video consultations has declined, telemonitoring has returned to its 2021 level, when a second peak in usage was seen as a result of the COVID-19 pandemic. The use of written digital communication tools (e.g., e-consults and chat) has stabilised since 2021, whereas patient portal usage has continued to increase.⁷ This research also showed that general practitioners adopt telemonitoring and the use of written digital communication more frequently than medical specialists.⁷ These patterns underscore the influence of both structural and individual barriers.

It has therefore been suggested that future efforts should focus not only on the development of new eHealth interventions, but, more importantly, on governance, data strategies, robust evaluation and stakeholder engagement to secure implementation.^{2, 10}

Given the multi-level complexity involved in implementing eHealth interventions and in light of the current shortage of healthcare personnel and already substantial workload, it is not surprising that the large-scale uptake of eHealth remains limited.

With regard to OMF surgery and the adoption of eHealth interventions, the uptake of digital interventions may be slower than in other fields, such as diabetes care, partly because patient numbers are relatively small and most patients do not suffer from chronic conditions. Also, there is relatively little clinical need for telemonitoring within this specialty. Nevertheless, even if only a small proportion of patients benefit - for instance, through improved access to reliable online information - this still represents a meaningful contribution to

the quality of care. Ultimately, this raises the question of who determines the threshold for what constitutes a “successful” intervention, a consideration that must be weighed against the substantial time, effort, and financial resources required for development.

8.4 Involvement of all Stakeholders

All of the research in this dissertation demonstrates the importance of involving all stakeholders, including patients, in the development, implementation and evaluation of patient-centred eHealth interventions; this is equally true for AI-based patient-centred eHealth interventions.

The findings of **Chapter 3** highlight that user perspectives may diverge considerably from what professionals assume, underscoring the importance of incorporating patient and parent input. In some cases, this could even justify the development of distinct website sections on the same subject, such as CL/P, tailored specifically to patients and parents. At the same time, professional input remains indispensable to guarantee the medical accuracy and reliability of the information provided.

The development of online health information should be considered a dynamic process, as the needs and preferences of new generations may shift both in terms of content and format of presentation.^{11,12} For example, preferences may vary with respect to platforms (e.g., websites versus social media) and modes of presentation (e.g., text, animations, or short video formats such as TikTok reels).¹¹ Involving patients and parents in this process ensures that the information is accessible, readable, and user-friendly. Such co-creation may also enhance the likelihood of actual use, thereby increasing the cost-effectiveness of the intervention by aligning with the needs and preferences of end users. However, further research is required to validate this assumption.

Although this dissertation focuses on patient-centred eHealth interventions, it is important to acknowledge that the perspectives of healthcare professionals must also be considered in the development and implementation of these interventions. Since active involvement of healthcare professionals is crucial to implementation, as it promotes ownership, confidence, acceptance and enjoyment.⁹

The importance of involving all stakeholders in the development and evaluation of AI interventions is illustrated by an exploratory study among dentists, orthodontists and OMF surgeons, which contrasts with our own findings on patients' expectations regarding AI. The study with professionals revealed that they primarily anticipated AI to enhance diagnostic processes, promote uniformity in diagnostics and support more individualised and evidence-based care.¹³ The main concerns centred on accountability for AI-induced errors, the transfer of healthcare control to large technology companies, and issues related to privacy and data security.¹³ In contrast to patients' expectations in our study (**Chapter 4**), challenges concerning the patient-doctor relationship and workforce implications were perceived as less critical.¹³ Other studies have similarly highlighted the diverse needs and concerns of different stakeholders regarding AI interventions in OMF surgery.¹⁴

It is important to acknowledge that not all individual needs can be met within a single intervention. While some patients may have a clear preference for digital information, others may not, and it is unrealistic to accommodate every individual need. However, offering patients (and professionals) the choice of how they wish to receive (or provide) care can help accommodate diverse preferences. Delivering care in a hybrid format may contribute to more patient-centred care. Video consultations are particularly suitable in this regard, as the necessary infrastructures are already in place. In OMF surgery, this also applies to the use of audiovisual eyeglasses during wisdom tooth removal (**Chapter 5**). This issue is equally relevant to the adoption of ehealth by healthcare professionals, as not all may feel comfortable with or have an affinity for certain eHealth interventions.

8.5 Methodological Limitations and Implications for Future Research

The primary aim of this thesis was to determine the current position of patient-centred eHealth within OMF surgery and to identify both the challenges and opportunities associated with its implementation in routine clinical practice. These aims have only been partially achieved, largely due to methodological

choices made during the research process – choices that, in retrospect, might have been approached differently.

Regarding the position of patient-centred eHealth in OMF surgery, a reasonably clear impression has been obtained, assuming that the available literature accurately reflects its use in clinical practice. However, identifying challenges and opportunities for implementation has proven to be more complex.

Overall, it can be concluded that qualitative research methods should have played a more prominent role in our studies. In the questionnaire-based studies, such methods could have provided deeper insights into the outcomes, as demonstrated in **Chapter 6**, where two open-ended questions yielded valuable qualitative data. Similarly, the patients' perspective on AI (**Chapter 4**) would have been placed in a clearer context had qualitative methods been employed, revealing a more nuanced understanding of their views.

In **Chapter 5**, our aim was to improve the patient experience during third molar removal. However, we did not obtain an answer to this question, as the study did not directly measure patient experience. A qualitative study design would have been more appropriate to fully capture this experience. Instead, our focus was placed on assessing the feasibility and effectiveness of the audiovisual eyeglasses using quantitative physiological outcome measures such as heart rate, respiratory rate, and anxiety. The interpretation of the observed effects on heart rate and respiratory rate is challenging. We do not know what it means for the effectiveness of the audiovisual eyeglasses that heart rate was lower, while respiratory rate was higher during its use. With the knowledge available now, it can be questioned whether this is of major importance. If patients perceive the treatment as more comfortable with the eyeglasses, even when this is not reflected in the physiological parameters, the patient's subjective experience should not be disregarded. Ultimately, patients benefit most when the treatment is experienced as more comfortable. It would, however, be highly relevant to investigate whether such a positive experience also influences recovery speed, perceived pain, analgesic use, or return to daily activities and work.

Future research on evaluation of patient-centred eHealth interventions should therefore focus on the patient experience and subsequently quantify its effects on outcomes such as recovery speed, return to work and analgesic use. This evidence is essential for informing policymakers and insurers about the added value of the intervention. Patients should then be given the opportunity to make

a well-informed and deliberate choice regarding the use of the eHealth intervention - in this case, audiovisual eyeglasses during treatment.

As this thesis has demonstrated, the large-scale implementation of eHealth interventions requires additional efforts, beyond the demonstration of added value of the intervention. To facilitate the widespread adoption of validated digital and hybrid healthcare processes that demonstrably add value for healthcare professionals, patients, clients, and citizens, Digizo.nu provides targeted support to healthcare organisations within the Dutch healthcare system. This collaborative programme, embedded in the Integrated Care Agreement and supported by the Dutch Ministry of Health, Welfare and Sport, offers such support by selecting and assessing digital health applications, sharing knowledge on this matter and assisting organisations with implementation of digital applications. The initiative promotes a model of healthcare transformation in which broad implementation occurs only after systematic assessment and valuation of an eHealth intervention.

To identify challenges and opportunities for implementing patient-centred eHealth interventions in OMF surgery, these factors must be evaluated for each individual intervention, as the previously mentioned multilevel influences all play a role. Therefore, in my view, an overarching assessment of challenges and opportunities for the entire field of OMF surgery cannot realistically be achieved. Given the multilevel complexity involved in implementing patient-centred eHealth interventions, professionals may be hesitant to develop, implement, and evaluate such solutions. However, this reluctance is not warranted, as valuable lessons can be drawn from data accumulated over the past two decades. Regarding evaluation, different aims and outcome measures may be more appropriate when considering all stakeholders. The success of an intervention should be defined not only by large-scale impact or financial gains, but also by its value for smaller groups of patients and professionals, particularly when it enables more patient-centred care for these groups. This calls for a shift in research perspective—moving beyond a sole focus on quantitative outcomes for large populations toward in-depth qualitative analyses that capture effects at the individual patient (and professional) level.

With regard to the most prominent emerging technology—AI—current applications do not primarily focus on patient-centred interventions, as they are largely aimed at supporting professionals by improving efficiency in processes such as diagnostics and treatment planning.¹⁵ Nevertheless, the ultimate goal of these applications is to enhance healthcare, which indirectly benefits patients as well. AI-based eHealth applications designed for direct patient use will undoubtedly follow. An example can already be seen in dermatological care, where an AI-driven mobile application supports telemedical wound management.¹⁶ As this technology matures, it is essential to involve all stakeholders and to thoroughly evaluate its impact and limitations. More evidence is required, with particular emphasis on patient-relevant outcomes.¹⁷

8.6 Implications for Education

The availability and use of eHealth in daily practice should drive its integration into medical education, as it is imperative to teach and assess healthcare trainees on the skills required to conduct effective virtual consultations.^{18, 19} Furthermore, training future healthcare professionals in the effective use of these technologies may facilitate their broader adoption in clinical practice.^{20,21} Specific competencies for conducting teleconsultations (telephone or video for real-time clinical care) have been outlined by the Association of American Medical Colleges.¹⁸ The defined competency domains are: 1) patient safety and appropriate use of telehealth, 2) access and equity in telehealth, 3) communication via telehealth, 4) data collection and assessment via telehealth, 5) technology for telehealth, 6) ethical practices and legal requirements for telehealth. Since the COVID-19 pandemic, more examples of eHealth integration into medical curricula have emerged; however, overall experience remains limited to date.²¹⁻²⁴

The ability of faculty members to teach and assess these skills highlights the need for new teaching competencies as well. However, to date there are also very limited guidelines addressing the skills required by faculty to effectively deliver this training.^{18, 24}

In addition to teleconsultation, education should also focus on supporting and guiding patients in their use of AI-based eHealth interventions and in the interpretation of AI-derived information. While patients generally expect AI to

improve the quality of care, they also express concerns regarding reliability, safety, privacy, the potential loss of human interaction, and autonomy in decision-making.^{14, 25} As is seen for the use of eHealth in general, also for specific AI interventions demographic characteristics seem to influence patients' attitude towards AI.^{7, 14} Fortunately, integration of AI into medical curricula is increasingly being observed.²⁶⁻²⁸ However, it remains unclear whether such curricula also include teaching on ethical issues related to AI, the assessment of reliability and guidance of patients in these matters.

8.7 Future Directions

At the outset of this PhD project, we were convinced that eHealth could play an important role in making healthcare in OMF surgery more patient-centred. By deploying technology intelligently, more time and space could be created for what truly matters: the meaningful conversation in the consultation room or at the bedside. Technology, after all, could help reduce the administrative burden, thereby freeing professionals from tasks that divert them from direct patient care. It could also enable more personal engagement, for example through video consultations in the patient's own environment. Patients might more easily connect with one another in communities, fostering mutual support. By facilitating this, we could serve the patient more comprehensively.

Providing information tailored to patients' needs—both in terms of content and format—could help patients become better informed and more engaged in their own care. This involves not only written information, but also videos, animations, and images, depending on the patient's preference. Care and reliable information would be available when desired by the patient. In some cases, technology could even make care more enjoyable (e.g., gamification for education or preparation) or reduce stress before or during treatment (e.g., the use of HappyMed®).

However, in OMF surgery this development has not progressed as we had expected. This dissertation offers partial explanations for this lack of uptake. Further research may provide insights into the barriers to implementing patient-centred eHealth applications. In my view, however, it would be more meaningful to devote the limited time, energy, and resources available to adopting new applications that demonstrably address the needs of both patients and

healthcare professionals in daily practice. Evidence-based practice is, of course, essential; evaluation is required to assess whether these needs are indeed met. Still, as this dissertation concludes, no single application will ever meet the needs of an entire patient group. That, however, is precisely the point of patient-centred care. Even when only a small group of patients benefits, such an application can still be of great value. By providing care in ways that fit patients' preferences—and in which caregivers also feel comfortable—a relationship of trust can emerge.

Therefore, we must move away from working solely and rigidly according to protocols, because these by definition are not patient-centred. Protocols and guidelines are derived from scientific studies on large patient populations, not on the individual. Many patients (and professionals) consequently fall between the cracks, leading to unnecessary appointments, diagnostics, and treatments. Protocols and guidelines should serve as tools—as originally intended—not as rigid goals dictating practice. This requires a change in mindset not only from healthcare providers and patients, but also from hospital boards, insurers, and policymakers. Much of everyday practice is currently shaped by reimbursement systems and financial incentives (“production targets”) rather than by patient well-being.

A primary reason many professionals chose a career in healthcare is the desire to help patients. Frustration inevitably arises when this is no longer the main driver due to systemic constraints. Such frustration undermines care delivery, may lead to absenteeism, and even prompts professionals to leave the field altogether. This exacerbates existing staff shortages. It should be evident that the professional well-being of healthcare workers is also of great importance.

When healthcare professionals (as experts in their field) and patients (as experts in their own lives and well-being) can jointly and deliberately deviate from protocols and guidelines, I firmly believe that healthcare can become more cost-effective. Many unnecessary activities (appointments, consultations, diagnostics, treatments) would no longer take place. The right actions would occur for the individual patient, while healthcare professionals would feel valued and able to fulfil their vocational drive by genuinely supporting patients toward improved well-being.

This may seem utopian and cannot, of course, be achieved overnight. It is also not possible to prove in advance that such an approach will yield positive

outcomes, a reality at odds with the current culture and practices of healthcare. Nevertheless, every practitioner who already strives to work in this way, as far as the current system allows, knows that it works. Subsequently, both quantitative and qualitative research methods can be employed to evaluate outcomes across all stakeholder groups.

Let us therefore employ technology wherever it helps us to better serve patients, guided by the needs of both patients and healthcare professionals, without first questioning its financial returns. In this way, healthcare can once again focus on the well-being of the patient, while also remaining fulfilling for the caregiver.

8.8 References

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Appendices



A. Supplementary Data Chapter 2

Table 3 Summary of studies, population and interventions.

Study/ intervention category	Target patient population	Aim intervention	Characteristics intervention
Online counselling interventions			
Lowry 2001	Patients with facial injury	- Improve remote diagnosis - Deliver a cost-effective, high-quality specialist service	Teleconsultation via video - Linking accident & emergency (A&E) departments of three peripheral hospitals to a central site with an OMF surgery unit for realtime patient visualisation - Remote post-operative monitoring of patients - Remote assessment of radiographs and photographs
Stalfors 2003	H&N cancer patients	- Avoid travel time - Reduce costs	Teleconsultation via video - Patients participating in multidisciplinary tumour meetings (MDT) via videoconferencing
Myers 2005	H&N cancer patients	- Remote speech therapy - Psychosocial support - Education - Peer support - Consultation	Teleconsultation via video: 3 case reports on different applications - Providing speech rehabilitation and psychosocial support in a remote location - Education of patients and family and local healthcare providers - Peer support for family and patients, consultation and education for clinicians
Dorrian 2009	H&N cancer patients	- Provide specialist assessment of laryngoscopy at a distance	Teleconsultation via video - ENT consultant assessed telelaryngoscopy images realtime for diagnosis
Burns 2012	H&N cancer patients	- Enhance access to specialist speech pathology support	Teleconsultation via video - Patient consultations

Study/ intervention category	Target patient population	Aim intervention	Characteristics intervention
			- Case discussions between clinicians - Clinical training sessions for specific patient management
Whitehead 2012	Children with cleft lip and/or palate	- Provide speech assessment at a distance	Teleconsultation via video - Simultaneous speech assessment by two speech assessment pathologists (SLPs), one in person, one via videoconferencing
Costa 2015	Children with cleft lip and/or palate	- Avoid travel time	Teleconsultation via video Patient consultations for screening, pre- and post-operative visits at local clinics at the Southwestern USA and Northern Mexico with hospital for children in Los Angeles
Beswick 2016	H&N cancer patients	- Improve access to care - Safe time and costs	Teleconsultation via video - Tissue diagnosis and imaging acquisition at local site - Review of clinical, pathological and imaging data at tertiary centre - Pre-operative teleconsultation via video to finalize treatment plan and counsel patient (with possibility for real-time naso-pharyngoscopy) - Teleconsultation in follow-up for post-operative care and cancer surveillance
Fonseca 2016	Patients with facial injury	- Improve access to care	Teleconsultation via video Patient consultations at local emergency department by resident in general surgery with remote specialist (plastic surgeon)
Wood 2016	Pre-operative OMF patients in prison	- Increase efficiency - Avoid travel - Reduce cost	Teleconsultation via video - Pre-operative consultation with • Intra-oral airway examination by intra-oral camera • Electronically forwarded radiographs



Study/ intervention category	Target patient population	Aim intervention	Characteristics intervention
			- Electronic stethoscope assisted by nurse/resident on remote site - Diagnosis, treatment plan for surgery and anaesthesia are developed with the data
Burns 2017	H&N cancer patients	- Enhance access to specialist speech pathology service	Teleconsultation via video - Consultation between patient with speech pathologist at local health facility and specialist speech pathologist at tertiary centre - General imaging probe for views of oral cavity or tracheostoma and intra-oral probe for detailed views of oral mucosa and dentition Online medical consultation service on which patients can post questions with additional information to a medical team of 6 doctors, who answer within 2 working days
Brockes 2012	Patients with queries regarding OMF surgery	- Providing information for patients	E-mail contact of patients and family members with surgeons and nurses
Kagan 2005 ²⁸	H&N cancer patients and their family members	- Communication with caregivers	E-mail contact of surgeons and nurses with patients and family members
Kagan 2005 ²⁹	Surgeons & nurses in H&N cancer care	- Communication with patients & family	Mobile messaging app (WeChat) during follow-up
Lyu 2016	H&N cancer patients	- Increase efficiency of follow-up after surgery	Quality of life questionnaire sent at 2 weeks, 1,2,3 and 6 months after discharge from the hospital, patients sent a photo of the filled-in form back to the physician
Petruzzi 2016	Patients with oral lesions	- Facilitate faster diagnosis and therapy by removing geographic distance	Mobile messaging app (WhatsApp) Clinical photos and clinical data sent by patients or their relatives, dentists, oral hygienists or physicians were assessed by two specialists in oral medicine

Study/ intervention category	Target patient population	Aim intervention	Characteristics intervention
Sosa 2017	H&N cancer patients	- Empower appropriate patient self-care and decompress provider schedules	Mobile messaging app - Automated text platform sends text message daily after hospital discharge during 7 days - Messages remind about wound care instructions, signs of infection and provide motivational support - Patients have the possibility to send text messages/pictures or call their care team - Messages are triaged by medical student and forwarded to the appropriate professional - Professionals could reply by text message or telephone
Salazar 2012	Patients with TMJ disorders	- Avoid unnecessary travel - Reduce the waiting time for patients by specific patient selection for referral	Web-based screening and referral tool - Radiographs and a questionnaire with clinical information are sent to 2 maxillofacial surgeons - Maxillofacial surgeons wrote diagnostic and therapeutic report, sent it back to primary care centre (patients were referred or completed treatment in primary care centre)
Wall 2016	H&N cancer patients	- Provide efficacious and holistic triaging for allied health supportive care interventions	Web-based screening tool - Patient reports information on side-effects of chemotherapy on swallowing, nutrition, distress and the need for supportive care - Tool creates summary report of data and identifies areas of concern in traffic light system: • Red: referral for face-to-face contact within 4 clinical days • Yellow: contact within clinical 7 days • Green: remain on routine weekly monitoring



Study/ intervention category	Target patient population	Aim intervention	Characteristics intervention
Tesfaiul 2016	Patients with oral lesions	- Improve access and efficient referral to specialist healthcare	Mobile screening and referral app - Clinical photos and clinical data send by dentists to consult specialist (OMF surgeon or oral medicine expert) at distant location - Specialist reviews the data and provides input on diagnosis and management - Dentist submits information on course of illness and treatment to specialist
Bonan 2017	Patients with oral lesions	- Improving and facilitating remote oral cancer screening	Mobile app for oral cancer screening - Questionnaire on patient demographics, risk factors for oral cancer and symptoms - Photo and video function to record the oral lesion - Data are sent to examiner who determines clinical hypotheses
Web-based education interventions			
Polk 2003*	Parents of children with cranial abnormalities	- Providing information and education	Website for parents with 2D interactive animations
Van den Brink 2003, 2005 & 2007**	H&N cancer patients	- Facilitate communication for patients with professionals and fellow patients - Provide information - Facilitate early detection of problems by monitoring	Electronic health information support system - Communication with professionals via messages within the system - Information via specially developed website on H&N cancer - Forum for contact with fellow sufferers - Monitoring via electronic questionnaires after discharge with automated e-mail alerts to 2 nurses - The system was provided at discharge for 6 weeks

Study/ intervention category	Target patient population	Aim intervention	Characteristics intervention
Hosey 2014	Children (5-7yr) undergoing general anaesthesia for tooth extractions	- Improve coping behaviour - Improve quality of information	Online game - Takes 15 minutes to play - Contains information, cartoons and videos on general anaesthesia, role modelling, fasting instructions and oral health messages
Pulijala 2016	Orthognathic patients	- Providing information on orthognathic surgery and its complications	Mobile app - Animations on pre-surgical, surgical and post-surgical information on orthognathic surgery
Human-supported web-based interventions			
Head 2009 & 2011, Pfeifer 2015**	H&N cancer patients	Increase patient self-management of symptoms by - Daily education - Guidance - Encouragement	Telehealth messaging device - Encourages self-management by daily questions for patients to answer - Automated feedback by device based upon patient's previous answers - Nurse feedback in case of unresolved or escalating issues - Patients receive intervention at onset of treatment and continue to use for 3 weeks past the end of treatment
Peterson 2013	H&N cancer patients	Remote monitoring during radiation therapy - Greater insight in therapeutic response - Identify opportunities for early intervention, specific the early dehydration risk - Improving care and patient support	Online platform for - Collecting self-reported outcomes via questionnaire - Collecting outcomes of home based sensors for weight, blood pressure, and pulse - Data are sent to radiation oncologist and assessed daily whether intervention is needed - Patients used device for two 5 day during test periods (week 1, 2, 4 and 5 of radiation therapy)
Buzzachino 2015	H&N cancer patients	- Support empowerment and awareness in outpatients - Improving interaction with the	Mobile app for outpatient support - Education: information on diagnosis and treatment - Peer support: map with all registered users and useful



Study/ intervention category	Target patient population	Aim intervention	Characteristics intervention
		specialists	locations - Monitoring: QoL and symptom questionnaires which can be customized in sort and frequency by the physician for the specific patient. - Data are visualised in the app for the patient in charts - E-mail function which automatically sends report of the monitored data to the physician and by which patient can contact the physician.
Self-help web-based therapeutic interventions			
Bessell 2010	Experts on and individuals with visible differences	- Reduce anxiety and related distress	Web-based cognitive behavioural therapy intervention for individuals with visible differences
Bessell 2012	Individuals with visible differences	- Reduce anxiety and related distress	Web-based cognitive behavioural therapy intervention for individuals with visible differences - During 8 weeks, a weekly computer intervention with facilitator to assist with technical difficulties - Follow-up direct, three and six months after intervention
Duman- Lubberding 2015 & 2016 & Van der Hout 2017 **	H&N cancer patients	- Improve self-management	Online self-management app - Measure: quality of life questionnaire - Learn: tailored feedback, information and advice as result from the outcomes in Measure - Act: personalized supportive care options based on outcome in Measure
Hsieh 2015	Children with cleft lip and/or palate	- Practice speech therapy - Improve access to speech therapy in rural areas	Mobile app with interactive speech game - Requires the child to produce targeted phrases to guide the main character through adventures by following on-screen prompts - Phrases were introduced to the child in face-to-face

Study/ intervention category	Target patient population	Aim intervention	Characteristics intervention
Badr 2016	H&N cancer survivors and their caregivers	- Improve survivor self-management and survivor/caregiver quality of life	speech therapy, the game facilitates at home practice Online platform for self-management after oral cancer - Act: access information on taking charge after oral cancer, managing oral care and oral side effects, nutrition and swallowing problems, social and emotional concerns, healthy lifestyle after cancer. Text, quizzes, visual cues and videos - Track: skill-building by action planning, behavioural monitoring tools, reminders, swallowing exercises, relaxation techniques, identify and challenge irrational thoughts - Share: offer support to peers and each other through facilitated bulletin boards and a survivor-caregiver sharing function - Survivors and caregivers have their own tailored content, depending on their role
Brunner 2016	H&N cancer patients	- Facilitate communication	Mobile app for augmentative and alternative communication - Provides a full-featured communication solution for patients with difficulty speaking in the immediate post-operative setting
Wall 2017	H&N cancer patients	- Support patients at the post-discharge phase to reduce the severity of swallowing deficits	Mobile app to support swallowing practice - Assist patients to complete home-practice of preventative swallowing exercises during chemo-radiotherapy - Instructional videos, images and text to guide patients through the program - Capacity to record repetitions (0–10) and effort (0–100%) achieved for each exercise was available



Study/ intervention category	Target patient population	Aim intervention	Characteristics intervention
			- At the end of each exercise a questionnaire recorded the difficulty and factors contributing to the difficulty of the practice - Clinicians were able to customise patient profiles, remotely monitor therapy adherence, and receive communication from the patient

In this table the interventions are displayed per category according to Barak et al.¹⁸

* Although this paper reports on online patient information, it does not concern quality or use of information but a needs assessment and effect of the website. Therefore it was included in this scoping review.

** Since the three papers form Van den Brink et al, the two papers of Head and Pfeifer et al and the three papers of Duman-Lubberding and Van der Hout et al concern the same interventions, these data were merged in this table.

Table 4 Outcome evaluation eHealth interventions.

Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
Online counseling interventions						
Stalfors 2003	X	X	- Case-control study - Questionnaires	Satisfaction among patients - Meeting was too fast • Telemedicine group 42% • Control group 23% - With the information on their treatment • No significant difference Preference among patients - 69% telemedicine group did not prefer to be in control group - 33% control group would prefer to be in telemedicine group Satisfaction among professionals - 59% very satisfied - 23% satisfied - 3% unsatisfied		Pt 84/104 Prof 61/NR
Dorrian 2009	X	X	Cost-minimisation analysis		- 123kg CO2 saving per person (return journey) - At 35 patients/year tele-laryngoscopy is	Pt 42/NR



Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
Burns 2012	X	X	Pilot trial - Questionnaires after each session	Satisfaction patients - Ease of use: agree + strongly agree 100% - No audio/visual difficulty: agree + strongly agree 100% - Comfortable to use if available: agree + strongly agree 100%. Satisfaction professionals - Ease of use: agree + strongly agree 100%, - No audio/visual difficulty: agree + strongly agree 100%, - Competently assess patient: agree + strongly agree 100%	cheaper than travel - \$66,- saving per patient per avoided trip	Pt 18/NR
White-head 2012	X	X	- Prospective quantitative comparison on speech evaluation - Satisfaction questionnaires for parents	Satisfaction parents - 5/9 items parents strongly agreed intervention was satisfactory	Inter-rater agreement - 5/11 speech evaluation items >77,8% agreement between in-person vs. telemedicine evaluation - No statistically significant differences in speech evaluation	Pt 9/NR
Costa 2015		X	Retrospective chart review	NA	Cost-utility - 239 miles/visit saved	Pt 92/519

Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
					by patients from USA - 578 miles/visit saved by patients from Mexico	
Beswick 2016		X	Quantitative retrospective comparison	NA	Feasibility Control: - Time to surgery: <1 month (mean 28 days; range 17-36 days) Telemedicine: - Time to surgery: <3 weeks (mean 20 days; range 11-30 days) - Average patient: • 28 hours travelling saved • >1600miles saved • \$900 travel cost saved - In total 14.5 ton CO2 emission prevented	Pt 15/NR



Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
Fonseca 2016		X	Prospective clinical trial	Level of concordance in 3 phases: Clinical findings - Overall : $\kappa=0.720$ - Mandibular region: $\kappa=0.894$ - Maxillary region: $\kappa=0.595$ CT scan findings - Overall: $\kappa=0.899$ Treatment plan - Overall: $\kappa=0.891$	NA	Pt 50/62
Wood 2016		X	Retrospective patient record study	Success/failure rates: - Additional in-person examination 7.5% - Adequate medical and physical assessment 98.1% - Correct diagnosis & treatment plan 95.9% - Correct triage 99.6%.	Cost savings - \$60 per patient (SD \$16.10)	Pt 244/335
Burns 2017	X	X	Multicentre randomized controlled trial	Patient satisfaction - Satisfaction was higher on all items in the telemedicine group (not statistically significant) Clinician satisfaction - Significantly higher on all 6 items in telemedicine group	Efficiency - Teleconsultation 43 referrals, standard care 39 referrals - No difference in time from referral to response - No difference in time from response to initial management session	Pt 82/91 Prof 13/NR

Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
					- Significantly less number of contact events for the telemedicine group ($p=0.004$) - Significantly less time required to manage each referral in telemedicine group ($p=0.024$) - Standard care group 36% required to travel for management, telemedicine group 13% required to travel ($p < 0.029$) Technical difficulties - In 3% of telemedicine sessions technical difficulties occurred - 1.2% of all sessions were cancelled due to technical	



Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
rockes 2012		X	Retrospective content analysis	Past physician contact - 50% visited doctor/dentist before contact Reason to contact - 66% additional information Diagnostic symptoms & findings - 56.9% already had a diagnosis Actions by the service - 65.2% general info and advice - 16.2% differential diagnosis - 49.5% advice visit professional - 20.1% additional information	NA	Pt NA/204
Kagan 2005 ²⁸	X		Cross sectional survey	Use of email in communication with professionals - 9.5% by patients - 0% by caregivers Plan to use e-mail in the next year - 27% among patients - 30.6% among caregivers	NA	Pt 74/99 Caregiver 36/72
Kagan 2005 ²⁹		X	Cross sectional survey	Use of email in communication with patients - 37.1% by surgeons - 19.7% by nurses Plan to use e-mail - 11% among surgeons - 14.4% among nurses Would use email if patients asked	NA	Surgeon 245/NR Nurse 178/NR

Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
Lyu 2016	X	X	Randomized controlled trial	- 32.1% surgeons - 65.7% nurses Time consumption - App group: 23.4 ± 6.2 minutes Telephone group: 42.9 ± 7.2 minutes ($p < 0.001$) Satisfaction - App group: 94.3% Telephone group: 80.4% ($p = 0.034$) Lost to follow-up - App group: 7.0% (4/57) - Telephone group: 9.8% (5/51) - No significant difference	Economic costs - App group: RMB 90 Yuan - Telephone group: RMB 196 Yuan - No significant difference	Pt 99/10
Petruzzi 2016		X	Prospective quantitative comparison	Photos - 339 photos for 96 cases - 56 dentists, 20 oral hygienist, 4 physicians, 11 patients - 93% photos of good quality Associated questions submitted - What is your diagnosis is most frequently asked question (56%) - Urgent visit was requested in 17% of cases - Information regarding treatment was asked in 14% - 55% of patients asked about potential neoplastic nature of lesion (none of the patient submitted lesions was malignant) Travel - Mean distance was 70 ± 78 km	Diagnostic outcome - Mean time between first message and examination was 10 ± 4 days - 96% patients underwent clinical examination, 49% of these patients had biopsy - Mean agreement between telemedicine classification by two	Pt 11/NR Prof 80/NR



Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
					external experts and clinicopathologic diagnosis was 82%	
Tesfalul 2016		X	Observational study - Data retrieved directly from telemedicine tool via open data kit database	- Diagnosis was available in 23 cases, concordant in 91.3% - Treatment plans were available in 25 cases, concordant in 36% • In 11 cases (68.8%) the referring dental officer would have referred the patient to the specialist in the absence of the telemedicine system whereas the specialist indicated not to do so	NA	Pt 26/NR
Sosa 2017	X	X	Observational study - Survey on experience	Mobile platform use - 252 text messages sent by patients (mean 12) - 305 provider respond messages (mean 14.5) - 4 pictures send by 3 different patients Patient satisfaction - Mean satisfaction of 3.8 on 4 point scale - No users indicated dissatisfaction - 89% users found the platform extremely easy to use - 95% users stated the platform helped them deal more effectively with their health - 20/21 stated they would like to use a similar platform with other medical providers Reasons for non-participation - 2/5 preferred phone call	NA	Participants Pt 21/32 Non-participants 5/9

Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
Salazar 2012	X	X	- Non-randomized quasi-experimental clinical study, intervention vs. standard care - Both groups 6 months follow-up - Satisfaction survey intervention group	- 3/5 concerned about privacy issues - 5/5 were comfortable with general use of smartphone - Satisfaction survey (n=283/342 pt) - 22% prefer conventional system - 63% very satisfied - Most valued - 62% savings in travel time - 12.5% promptness treatment onset - 12.5% not losing workdays - 25% all three these factors	Online inter-observer rate: 89.2% Resolved consultation - Conventional 74.5% - Teleconsultation 88% (p=0.07) Second consultation - Conventional 4.6% - Teleconsultation 0.8% (p=0.07) Referral rate - Conventional 11.6% - Teleconsultation 10.2% (p=0.28) Time till treatment - Conventional 78.6 days - Teleconsultation 2.3 days (p=0) Cost of lost working hours - Conventional 32 - Teleconsultation 16.8 (p=0.01)	Pt 1052/NR Intervention 342 Control 710 Prof 2/NR



Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
Wall 2016		X	Cross-sectional sample study	Level of agreement compared between web-based screening tool and face-to-face assessment in assessment of side-effects: - Overall extent of symptoms $\kappa=0.362$ - Overall severity of symptoms $\kappa=0.501$ - Swallowing/oral intake/nutrition • Functional Oral Intake Scale: $\kappa=0.727$ • Patient Generated Subjective Global Assessment: $\kappa=0.650$ - Distress $\kappa=0.198$ - Perceived need for supportive care: • Swallowing/oral intake high priority profile $\kappa=0.361$, medium priority $\kappa=0.362$ • Distress high priority $\kappa=0.149$, medium priority profile $\kappa=0.109$	Complaint rate teleconsultation: 0.3% NA	Pt 100/N
Bonan 2017		X	Descriptive	Usefulness & reliability - Sensitivity 82% - 100% (average 91%) - Specificity 81% - 100% (average 90.5%) - Accuracy 87.3% - 95.5% (average 90.9%) - Level of concordance of diagnostic performance of the app compared to oral examination $\kappa=0.597$	NA	Pt 55/NR
Web-based education interventions						
Polk	X		Online survey	Evaluation of prototype		Pt 30/200

Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
2003			multiple choice and open ended	- 94% would recommend site to other parents - 88% indicated that animations on the site enhanced their understanding on sagittal synostosis		
Van den Brink 2005	X	X	Prospective evaluation study: - Analyses log files - Evaluating all messages and e-mail alerts - Questionnaire for use and appreciation	System use - All 36 patients used the system; 8/31 GPs used the system • 982 sessions in total; Average 27.3 sessions per patient in 6 weeks • Average duration per session: 12 minutes - Total 231 actions from messages • 17/231 messages leading to extra appointment - Most used function: monitoring (100%) - Least used function: contact fellow sufferers (8%) Satisfaction patients - Average score 8/10 - 5/36 regretted to have to return the laptop after 6 weeks Satisfaction GP - Average score 5.6/10	NA	Pt 36/59 Prof 31/36
Van den Brink 2007	X		Prospective controlled trial - Compare quality of life between control and intervention group At discharge, 6 and 12	NA	Quality of life (QoL) After 6 weeks follow-up - QoL improved significant in 5/22 parameters - No change in 17/22 parameters	Pt 163/229 Intervention 35/59 Control 128/170



Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
			weeks after discharge - 22 QoL subscales		After 12 weeks follow-up - QoL remained significantly improved in 1/5 parameters	
Pulijala 2016	X		Questionnaire (13-items) Two groups: - App group (multimedia app + instruction to use) - Voice group (audio information + leaflet with this information)	Amount of information retained: Number of correct answers - App group: mean 9.7, SD 1.8 answers - Voice group: mean 7.6, SD 2.8 - $p = 0.0034$	NA	Pt 50/NR App 25/NR Voice 25/NR
Human-supported web-based interventions						
Head 2009 & 2011	X		- Content satisfaction questionnaire, administered via appliance every 90 days - Qualitative feedback from exit	Use & acceptance - 98% no problems setting up appliance - 8% felt the questions were too difficult - 85% appliance was very easy to use - Patient used intervention for an average of 70.7 days, SD 26.7 days (86.3% of total days available for use) Satisfaction - 95% was satisfied with the device	Feasibility - 73% patients required additional contact by a nurse - 65% experienced better care - 84% states intervention	Pt 75/80 Intervention 42/45 Control 33/35

Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
			interviews - Post-study survey several months after completion of the study QoL - Functional assessment of cancer therapy – head & neck scale (FACT-HN) - Memorial symptom assessment scale (MSAS)	- 65% more satisfied with communication as result of intervention	reinforces knowledge - 84% understanding much better - 96% manage better - 92% recommend intervention FACT-HN (group mean scores) - Declined on all subscales during treatment - Returned to baseline post treatment - Significant positive correlation between % use and physical & emotional well-being subscales during treatment MSAS (group mean scores) - Increased during treatment - Global distress index returned to baseline - Physical subscale	



Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
					remains increased post-treatment - Psychological subscale decreased post-treatment	
Pfeifer 2015	X		Randomised controlled trial Measurements at 3 moments: - Pre-treatment - 3 weeks into the treatment - 3 weeks after completion of treatment QoL - Functional assessment of cancer therapy – head & neck scale (FACT-HN) - Memorial symptom assessment scale (MSAS)	NA	Quality of Life (QoL) - Pre-treatment no difference in outcome - During treatment no significant differences - Post-treatment FACT-HN: 8 difference subscale and total scores, of which 2 reached statistical significance: FACT-HN subscale physical well-being - Telehealth 20.6 [SD 12.1] - Control 17.0 [SD 11.7] - p = 0.021 FACT-HN Trial Outcome	Pt 80/86 Intervention 45/48 Control 35/38

Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
					Index - Telehealth 59.9 [SD 26.3] - Control 50.2 [SD 28.4] - p = 0.042 MSAS: 4 different subscale and total scores, of which 1 reached statistical significance: MSAS total - Telehealth 0.9 [0.5] - Control 1.2 [0.6] - p = 0.0440	
Peterson 2013	X	X	- Phone questionnaire on day 2, 4 and 6 of each test period for patients - Questionnaire on clinicians' experience at end of the study	Feasibility - 96% completion rate - 97% questionnaires were completed Clinician's satisfaction - Satisfied with the time spent: mean 6.0, median 6.5 (response scale from 1 strongly disagree to 7 strongly agree) - Quality of my work improved: mean 5.7 [SD NR] - Ease of use: mean 6.2 [SD NR]	Dehydration-related events - 60% had at least one event - 35% had two/more events - Nausea, vomiting and swallowing difficulty were associated symptoms	Pt 48/85 Prof 8/NR



Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
Self-help web-based therapeutic interventions						
Bessell 2010	X	X	Usability - Qualitative analyses: semi-structured interviews - Feedback questionnaires	Satisfaction with: - Visual clarity 94.1% - Consistency 93.1% - Compatibility 88.2% - Informative feedback 94.2% - Explicitness 94.2% - Appropriate functionality 94.1% - Flexibility & control 94.1%	NA	Pt 14/NR Prof 14/NR
Bessell 2012	X		- Randomized controlled trial All scales were administered pre- and post-intervention, plus at three and six months after the intervention ended	NA	Quality of Life parameters Post-intervention (8 weeks) - None of the parameters showed significant improvement Three months after intervention ended, compared to control: - HADS anxiety and FNE improved	Pt 66/83

Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
					significantly Six months after intervention ended, compared to control: - HADS anxiety, DAS, HADS depression and FNE improved significantly	
Duman-Lubberding 2015		X	Mixed method: - Qualitative needs assessment: semi-structured interviews - Evaluate application by cognitive walkthroughs: scenario based think aloud protocol and semi-structured interviews	Needs assessment - Professionals expected the app to be of added value Usability - Importance of tailored advice was emphasized - Navigation structure of the app was too complex Implementation - Different views, but should be incorporated in the HNC care pathway	NA	Prof 11/NR
Duman-Lubberding 2016	X		- Pretest-posttest design - Survey before access, 2 weeks	Feasibility - Adoption 64% - Usage grade 75%-91% - 76% found app user-friendly	NA	Pt 56/106



Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
			after access followed by a structured interview	- 90,6% was able to use without assistance - Satisfaction 60.4% - Facilitators: • User-friendliness • Informative • Clear overview of personal situation and options • Clarity of questionnaire • General usefulness • Usefulness for the very ill - Barriers: • Co-morbidities not taken into account • Too much information • Existential issues difficult and too much religion-oriented • Results not applicable to personal situation • Time from treatment to introduction of app too long • Description of participants well-being was suboptimal • Some items in app confusing		
Hsieh 2015	X	X	- Comparison - Questionnaire on parental feedback	Feasibility - Speech recognition was correct on first attempt in 3 out of 5 phrases - There was high concordance between the game and real-time speech and language pathologist scoring - Parents scored mean of 4 (on 5-item Likert scale) on • Engagement	NA	Pt 10/NR

Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
Wall 2015	X	X	Mixed method: Quantitative 12-item questionnaires - Immediately post-orientation (T0) - Directly after finishing chemo-radiotherapy (T1) Qualitative + 3 yes/no questions: - 15 minute semi-structured telephone interviews at 3-12 months post chemo-radiotherapy	• Replay value • Appropriate difficulty • Positive rewards • Clear goal of game Quantitative - Patients felt comfortable and confident to use (87%) - Supported by (87%) and motivated for (73%) use of the application - Patients found it an effective method (T0 87% and T1 79%) - Disagreed on experiencing technical difficulties (T0 73%, T1 71%) - Agreed in the application replacing face-to-face swallowing therapy in T0 60% and T1 43% - Disagreed on preferring face-to-face therapy over the application T0 67% T1 79% - No significant changes at T0 and d T1 in the 12-item questionnaire Qualitative (n=12) - 58% (n=7) reflected a preference for receiving therapy via app over face-to-face therapy - Preference for self-directed therapy without app had decreased from 50% at end of CRT to only 8% (n=1) by >3 months - All patients would recommend app to other patients	NA	Pt 14/15



Study	Data source*		Design & methods for data collection	Usability outcome	Effectiveness outcome	Number of participants finished/ number of participants included
	Pt	Prof				
				- Four themes distilled from the semi-structured interviews: • The ease of use of app • Motivating influences of app • Inhibiting factors of chemo-radiotherapy which made therapy difficult • Personal preferences for service delivery differ		
Badr 2016	X		- Qualitative design - Needs assessment by semi-structured interviews - Usability testing by think aloud protocol, interviews and survey	Needs assessment - Many similar needs in the groups - Clearer explanation of side effects - Clearer timeline for recovery - 77% survivors and 75% caregivers stated they would use the intervention to learn about side effects and find out about experiences of other survivors/caregivers - Nutrition/swallowing issues were biggest informational concern - Both groups interested in tools to connect with other survivors/caregivers for information and support Usability - 6 survivors and 5 caregivers completed the usability testing - 35 system errors/navigation problems - Total usability score of 80/100 - No significant differences between groups - Unanimously reported the content to be relevant and helpful and would suggest it to other survivors/caregivers	NA	Pt 16/24 Caregiver 12/16

In this table the interventions are displayed per category according to Barak et al.¹⁸

B. Multimedia Appendices Chapter 6

Multimedia Appendix 1

Survey on Video Visits during the COVID-19 outbreak (August-December 2020)

1. *Did you have to wait for the video visit, or was the healthcare professional on time?*

The healthcare professional was on time

I waited less than 5 minutes

I waited more than 5 minutes

I waited more than 10 minutes

I waited more than 15 minutes

I don't know how long I had to wait

2. *Did the healthcare professional read your health record in preparation to visit?*

Yes, my record was well read

My record was read, but not thoroughly

No, my record wasn't read

I don't know (anymore)

3. *Should you have questions for the healthcare professional, did you get answers you could understand?*

Yes, I could understand the answers

Most of the time the answers were understandable, sometimes they weren't

No, the answers were not understandable

I had some questions for the healthcare professional, but I didn't have the opportunity to ask those

I didn't have any questions

4. *Did you trust the healthcare professional?*

Yes, I trusted the healthcare professional

I trusted the healthcare professional less than I wanted

No, I didn't trust the healthcare professional



5. *Was there enough time to talk to the healthcare professional about your disease or problem?*

Yes, there was enough time
There was time, but I needed more time
No, there wasn't time
I don't know (anymore)

6. *Could you participate in the decision-making process about your treatment or diagnostic process?*

Yes, I could as much as I wanted
That was less possible than I wanted
No, I couldn't
That was not necessary
I don't know anymore

7. *Could a relative participate in the conversation about your treatment or diagnostic process?*

Yes, that was possible as much as I wanted
That was more possible than I wanted
That was less possible than I wanted
No, they couldn't participate
There were no relatives present during the visit
That was not necessary
I don't know anymore

8. *Did the healthcare professional explain the advantages and disadvantages of your treatment or diagnostic process?*

Yes, this was clearly explained
Some aspects were not clearly explained
No, this was not explained
There was no explanation
That was not necessary

9. *Did the healthcare professional explain the adverse effects of the new medication?*

- Yes, this was explained
- There was some explanation, but not enough
- No, there was no explanation
- I did not receive new medication

10. *Did the healthcare professional tell you what to do after the visit? Did you have to make a new appointment or see your general practitioner, for instance?*

- Yes, we did speak about this
- We did speak about this, but not enough
- No, I would have preferred to speak about this
- That was not necessary
- I don't know anymore

11. *Could you speak to anyone at the hospital about your worries and anxieties?*

- Yes, I could talk to someone
- Sometimes I could talk to someone, sometimes I couldn't
- No, I couldn't talk to anyone
- That was not necessary

12. *With which mark you would rate your video visit?*

1 means 'Very bad', 10 means 'Very good'.

1 2 3 4 5 6 7 8 9 10

13. *What did we do very well during your video visit? (not mandatory)
Please, do not mention any personal information such as names and telephone numbers.*



14. *What could we improve during a video visit? (not mandatory)*

Please, do not mention any personal information such as names and telephone numbers.

15. *What type of visit was your video consultation?*

First visit on referral of general practitioner or dentist

First visit on referral of another medical specialist

First visit, it concerned a second opinion on my own request

Follow-up visit with a previously known healthcare professional

Follow-up visit with a new healthcare professional

16. *I am satisfied with my video visit*

No, definitely not

I don't think so

Maybe yes, maybe no

Yes, I think so

Yes, definitely

17. *I worried about my privacy*

No, definitely not

I don't think so

Maybe yes, maybe no

Yes, I think so

Yes, definitely

18. *The care I received by video visit was just as good as with an in-person appointment.*

No, definitely not

I don't think so

Maybe yes, maybe no

Yes, I think so

Yes, definitely

19. *It is important to me that the video visit saved me travel time.*

No, definitely not
I don't think so
Maybe yes, maybe no
Yes, I think so
Yes, definitely

20. *It is important to me that the video visit saved me money.*

No, definitely not
I don't think so
Maybe yes, maybe no
Yes, I think so
Yes, definitely

21. *I experienced technical problems during the video visit which caused a disturbance of the visit.*

No, definitely not
I don't think so
Maybe yes, maybe no
Yes, I think so
Yes, definitely

22. *I was comfortable talking by video to the healthcare professional.*

No, definitely not
I don't think so
Maybe yes, maybe no
Yes, I think so
Yes, definitely

23. *I would rather travel to have my next visit in-person than use a video visit.*

No, definitely not
I don't think so
Maybe yes, maybe no
Yes, I think so
Yes, definitely
Not applicable



24. *I was able to develop a friendly relationship with my healthcare professional.*

No, definitely not
I don't think so
Maybe yes, maybe no
Yes, I think so
Yes, definitely

25. *I was able to explain my problems clearly to my healthcare professional during the video visit.*

No, definitely not
I don't think so
Maybe yes, maybe no
Yes, I think so
Yes, definitely

26. *The video visit was convenient.*

No, definitely not
I don't think so
Maybe yes, maybe no
Yes, I think so
Yes, definitely

27. *I would recommend the video visit option to other patients.*

No, definitely not
I don't think so
Maybe yes, maybe no
Yes, I think so
Yes, definitely

28. *What did you agree with your healthcare professional about the follow-up after this visit?*

An appointment for follow-up visit in the out-patient clinic is made
An appointment for follow-up video visit is made
An appointment is made for additional medical examination
I will be referred back to the referral (e.g. general practitioner)
There is no follow-up needed
I don't know what the follow-up will be

29. *What education did you take last (with diploma).*

- Primary education
- Secondary education
- Higher education/university
- Different
- I did not take any education

30. *How would you rate your general health?*

- My general health is excellent
- My general health is very good
- My general health is good
- My general health is not very good
- My general health is poor



Multimedia Appendix 2

CHERRIES Checklist

<i>Item Category</i>	<i>Checklist Item</i>	<i>Explanation</i>
Design		
	Describe survey design	The study is a convenience sample; the questionnaire was distributed to all patients, aged 18 years or older, who received a video visit at an outpatient clinic at the Radboudumc.
IRB (Institutional Review Board) approval and informed consent process	IRB approval	Ethical approval was re-requested and waived by the local Medical Research Ethics Committee of the Radboudumc (CMO Oost-Nederland, registration number: 2021-8415).
	Informed consent	Patients were informed of the purpose of the survey, anonymity, confidentiality and voluntarily filled out the questionnaire.
	Data protection	The questionnaire was anonymous, and patients voluntarily provided their personal information (such as sex and age). The researchers received an Excel file with a randomized patient number, age and sex. The data file was stored on the secure drive of the department. Only specific research members of the team, who signed a confidentiality agreement, were able to view and analyse the anonymized data file.
Development and pre-testing	Development and testing	The questionnaires were automatically dispatched via email through the electronic patient record system
Recruitment process and description of the sample having access to the questionnaire	Open survey versus closed survey	Open survey. Patients could complete the questionnaire voluntarily by clicking on the link to the online questionnaire.

<i>Item Category</i>	<i>Checklist Item</i>	<i>Explanation</i>
	Contact mode	Patients were contacted via email to participate in the questionnaire, which were sent on behalf of Radboud by Expoints, an independent research firm.
	Advertising the survey	The questionnaire was promoted through the official website of the Radboud University Medical Centre.
Survey administration	Web/E-mail	Patients were contacted by email to participate in the questionnaires, which were sent on behalf of Radboud by Expoints, an independent research firm.
	Context	The independent research firm Expoints sent emails on behalf of the Radboud University Medical Centre. We only received the anonymized data file.
	Mandatory/voluntary	Voluntary
	Incentives	No incentives offered.
	Time/Date	Data were collected from August 2020 up to December 2020.
	Randomization of items or questionnaires	Question order was not randomized.
	Adaptive questioning	N/A
	Number of Items	30 items
	Number of screens (pages)	N/A
	Completeness check	Not applicable option was offered. There was no completeness check before submission; therefore some responses were missing.
	Review step	Patients were able to go 'back' in the survey.
Response rates		
	Unique site visitor	N/A



<i>Item Category</i>	<i>Checklist Item</i>	<i>Explanation</i>
	View rate (Ratio of unique survey visitors/unique site visitors)	The survey is voluntary. The system cannot record the number of unique visitors, so the view rate cannot be calculated. It is assumed that the view rate is very low, since only patients eligible for filling out the questionnaire, were approached.
	Participation rate (Ratio of unique visitors who agreed to participate/unique first survey page visitors)	Participation rate cannot be calculated.
	Completion rate (Ratio of users who finished the survey/users who agreed to participate)	Completion rate cannot be calculated. Participants submit the questionnaire on behalf of their consent to participate.
Preventing multiple entries from the same individual	Cookies used	There were no cookies used.
	IP check	The questionnaire was only sent once. If patients had multiple visits that could be reviewed by this questionnaire, only an invitation for the most recent visit was sent. There is no IP check done.
	Log file analysis	N/A
	Registration	N/A
Analysis	Handling of incomplete questionnaires	Missing data was reported.
	Questionnaires submitted with an atypical timestamp	We have a set deadline for data collection, the data filled in after this deadline was not included in the analysis.
	Statistical correction	The dependent variable in this study was not normally distributed and therefore binary logistic regression was used.

Multimedia Appendix 3

Patient- and visit characteristics of patients who answered all three crucial Hanna items positively versus those who did not.

		All 3 crucial Hanna items answered positively (n= 624)	Not all 3 crucial Hanna items positively answered (n= 430)
Patient characteristics		n (%)	n (%)
Sex	<i>Female</i>	336 (58.5%)	250 (56.3%)
	<i>Male</i>	238 (41.5%)	194 (43.7%)
Age (years)	<i>18-34</i>	71 (12.4%)	59 (13.3%)
	<i>35-54</i>	194 (33.8%)	134 (30.2%)
	<i>55-64</i>	146 (25.4%)	116 (26.1%)
	<i>65-79</i>	155 (27%)	131 (29.5%)
	<i>80-99</i>	8 (1.4%)	4 (0.9%)
Level of education	<i>None</i>	2 (0.3%)	2 (0.5%)
	<i>Primary</i>	59 (10.3%)	43 (9.7%)
	<i>Secondary</i>	213 (37.1%)	159 (35.8%)
	<i>Higher/university</i>	253 (44.1%)	201 (45.3%)
	<i>Other</i>	13 (2.3%)	13 (2.9%)
Self-rated health	<i>Excellent</i>	65 (11.3%)	29 (6.5%)
	<i>Very well</i>	103 (17.9%)	61 (13.7%)
	<i>Good</i>	246 (42.9%)	208 (46.8%) ^a
	<i>Not so well</i>	132 (23%)	115 (25.9%)
	<i>Bad</i>	20 (3.5%)	25 (5.6%)
Visit characteristics			
Type of visit	<i>First</i>	292 (50.9%)	176 (39.6%)
	<i>Follow-up</i>	269 (46.9%)	264 (59.5%)
Visited medical specialty	<i>Surgical</i>	49 (8.5%)	45 (10.1%)
	<i>Non-surgical</i>	234 (40.8%)	245 (55.2%)
	<i>Other specialties</i>	291 (50.7%)	154 (34.7%)

a Median value



C. Samenvatting & Algemene Discussie

De brede beschikbaarheid van internet en IT-hulpmiddelen heeft de rol van de patiënt opnieuw gedefinieerd: van een passieve ontvanger van zorg naar een actieve deelnemer in het beheer van de eigen gezondheid.

Introductie

Het gebruik van internet en IT-hulpmiddelen, waaronder mobiele apparaten en computers, voor zorgverlening wordt eHealth genoemd. eHealth is niet louter een technologische ontwikkeling; het vertegenwoordigt ook een houding die gericht is op het verbeteren van de gezondheidszorg door middel van informatie- en communicatietechnologie. De 'e' in eHealth staat daarom niet alleen voor elektronisch, maar ook voor efficiency, enhancing quality, evidence-based, equity, empowerment, education en encouragement.¹ Vooral de laatste drie termen benadrukken een verandering in denkwijze, waarin zowel de rol van patiënten als van zorgverleners verschuift: eHealth maakt patiëntgerichte zorg mogelijk en bevordert een grotere betrokkenheid van patiënten bij hun eigen zorg. De patiënt wordt daarmee een actieve partner binnen het zorgteam.

Hoewel eHealth aanvankelijk slechts marginaal was geïntegreerd in de dagelijkse praktijk, heeft de COVID-19-pandemie de grootschalige implementatie van specifieke toepassingen, zoals videoconsulten, versneld. Tot op heden zijn de potentiële voordelen en beperkingen van patiëntgerichte eHealth-toepassingen binnen de mond-, kaak- en aangezichtschirurgie (MKA-chirurgie) echter nog niet systematisch onderzocht. Het primaire doel van dit proefschrift was daarom om de huidige positie van patiëntgerichte eHealth binnen de MKA-chirurgie te bepalen, evenals de uitdagingen en kansen die gepaard gaan met de implementatie ervan in de routinematige klinische praktijk.

Om deze doelstellingen te verwezenlijken, bundelt dit hoofdstuk de bevindingen van de in dit proefschrift gepresenteerde studies. Het begint met een beknopte samenvatting van de afzonderlijke onderzoeken, gevolgd door een bespreking van hun implicaties voor de klinische praktijk, toekomstig onderzoek en

onderwijs. Tot slot worden aanbevelingen voor de toekomst gedaan voor de integratie van eHealth-interventies in de dagelijkse zorg.

Samenvatting van dit Proefschrift

Sectie I Verkenning

Het eerste deel van dit proefschrift verkent de rol van eHealth binnen de MKA-chirurgie.

Hoofdstuk 2 beschrijft een scoping review die werd uitgevoerd om het bestaande onderzoek (gepubliceerd tot 13 september 2017) naar patiëntgerichte eHealth-interventies binnen de MKA-chirurgie in kaart te brengen. De review richtte zich op de gedetailleerde samenstelling van deze interventies en onderzocht hoe deze werden geëvalueerd door zowel patiënten als zorgprofessionals.

In totaal werden 41 artikelen geïnccludeerd, die 34 unieke patiëntgerichte eHealth-interventies in de MKA-chirurgie vertegenwoordigden. Het merendeel van deze interventies was gericht op hoofd-halsoncologiepatiënten. De meeste interventies betroffen online begeleiding, waarvan de helft gebruikmaakte van videoconsulten. Opvallend was dat slechts 23 van de 41 studies patiënten daadwerkelijk betrokken bij de evaluatie van de eHealth-interventie. Aangezien de meeste interventies zich nog in de haalbaarheids- of pilotfase bevonden, konden definitieve bevorderende factoren en barrières voor implementatie nog niet worden vastgesteld.

Hoofdstuk 3 presenteert een onderzoek naar de kwaliteit van online patiëntinformatie over schisis. De doelen van deze studie waren: (1) het definiëren van kwaliteitscriteria voor online informatie over schisis, (2) het beoordelen van de kwaliteit van beschikbare online patiëntinformatie over schisis, en (3) het in kaart brengen van mogelijke verschillen in perspectief op de kwaliteit van online informatie over schisis tussen patiënten, ouders en zorgprofessionals.

Kwaliteitscriteria voor online patiëntinformatie werden uit de literatuur gedestilleerd en vervolgens door patiënten met schisis, ouders en schisisteamprofessionals geprioriteerd, wat resulteerde in een lijst van 16 definitieve criteria. Een andere groep patiënten en ouders werd vervolgens gevraagd online naar informatie over schisis te zoeken; de vier meest bezochte



websites werden geselecteerd voor kwaliteitsbeoordeling. Nieuwe groepen patiënten, ouders en professionals beoordeelden vervolgens in hoeverre deze vier websites voldeden aan de 16 criteria.

Deze studie liet zien dat patiënten en ouders andere behoeften hebben met betrekking tot de kwaliteit van online informatie dan professionals. Zo hechtten patiënten waarde aan de aanwezigheid van een interne zoekfunctie, een discussieforum en eenvoudige toegang tot informatie zonder extra software te hoeven downloaden (zoals plug-ins), terwijl ouders en professionals dat niet deden. De aanwezigheid van een privacyverklaring werd zowel door patiënten als ouders belangrijk gevonden, maar niet door professionals. Professionals legden juist de nadruk op een professionele uitstraling en gebruikerservaring van de website, evenals op de identificatie van auteurs en hun kwalificaties. Patiënten en ouders gaven hier minder prioriteit aan.

Hoofdstuk 4 beschrijft een verkennende studie naar de kennis en percepties van patiënten over kunstmatige intelligentie (AI) in de tandheelkunde. Het doel van deze studie was het evalueren van de bekendheid en percepties van patiënten met betrekking tot het gebruik van AI in de tandartspraktijk. Een vragenlijst met 18 items werd afgenomen in zowel een universitaire tandheelkundige kliniek als een particuliere praktijk in Duitsland, wat resulteerde in 265 volledige responsen.

De resultaten toonden dat ongeveer de helft van de deelnemers aangaf bekend te zijn met AI, en dat een ruime meerderheid (73,6%) van mening was dat de tandheelkunde zou profiteren van de toepassing ervan. Respondenten noemden zowel voordelen als nadelen. De drie meest genoemde nadelen waren een mogelijke impact op personeelsbehoeften, nieuwe uitdagingen in de arts-patiëntrelatie en hogere kosten van tandheelkundige zorg. De belangrijkste door patiënten verwachte voordelen waren een toename van diagnostische zekerheid, verbeterde tijdsefficiëntie en meer gepersonaliseerd, evidence-based zorgmanagement. Daarnaast verwachtte het merendeel dat AI binnen 1–10 jaar geïntegreerd zou zijn in de tandheelkundige workflow. Opmerkelijk was dat patiënten van 35 jaar en ouder hogere verwachtingen hadden van de prestaties van AI dan jongere patiënten.

Sectie II Evaluatie in de Klinische Praktijk

In het tweede deel van dit proefschrift, **Hoofdstuk 5 en 6**, worden twee patiëntgerichte eHealth-interventies geëvalueerd in de klinische praktijk: (1) een audiovisuele bril tijdens de verwijdering van verstandskiezen, en (2) videoconsultatie in de context van de COVID-19-pandemie.

Aangezien de verwijdering van derde molaren de meest uitgevoerde ingreep binnen de dento-alveolaire chirurgie is en veel patiënten hierbij aanzienlijke angst ervaren, onderzochten wij of eHealth kon bijdragen aan een meer comfortabele behandelervaring. Daarom werd nagegaan of afleiding via een audiovisuele bril ondersteuning kon bieden.

De studie in **Hoofdstuk 5** had tot doel de effectiviteit, veiligheid en verdraagbaarheid van een audiovisuele bril tijdens verwijdering van de derde molaren te onderzoeken, met name met betrekking tot angst- en stressreductie. Ook werd gekeken naar de invloed van de audiovisuele interventie op postoperatieve pijnvaring en het gebruik van pijnmedicatie.

In deze studie vonden wij dat de audiovisuele interventie geen effect had op de gemeten angst, zoals beoordeeld met de STAI Y-6 en VAS-angst. Wel was de hartslag significant lager wanneer patiënten de audiovisuele interventie gebruikten, met name wanneer zij een ontspannende video bekeken. Een hogere ademhalingsfrequentie werd gezien bij patiënten die een video keken vergeleken met reguliere zorg, en deze nam verder toe bij het kijken naar een spannende video. Door beperkte respons op de postoperatieve vragenlijst over pijn en analgeticagebruik konden hierover geen definitieve conclusies worden getrokken.

De tweede patiëntgerichte eHealth-interventie betrof videoconsultatie. De aanleiding hiervoor was de sterke toename van videoconsulten die plotseling moesten worden ingevoerd door de COVID-19-pandemie. Wij wilden onderzoeken hoe patiënten deze vorm van consultatie ervoeren binnen alle specialismen van ons universitair medisch centrum, hetgeen het doel vormde van de studie in **Hoofdstuk 6**. Daarnaast wilden wij patiëntgroepen identificeren voor wie videoconsultatie bijzonder geschikt bleek, om zo meer patiëntgerichte keuzes in consulttype mogelijk te maken.

De ervaringen van patiënten werden onderzocht met behulp van een studiespecifieke vragenlijst die werd geanalyseerd met beschrijvende



kwantitatieve statistiek. Daarnaast werden twee open vragen kwalitatief geanalyseerd en thematisch gecategoriseerd in waarderingen en verbetermogelijkheden. In totaal werden 1054 patiënten geïncludeerd.

De overgrote meerderheid van de patiënten (91,46%) gaf aan tevreden te zijn met hun videoconsult. De kwalitatieve analyse liet zien dat de meest gewaardeerde aspecten betrekking hadden op drie domeinen: het individuele professionele niveau (houding en communicatiestijl van de zorgverlener), het organisatieniveau (duidelijke instructies en tijdsbeheer), het innovatieniveau (gebruiksvriendelijkheid en audiovisuele kwaliteit).

Verbeterpunten werden vooral gerapporteerd op innovatieniveau, organisatieniveau en patiëntniveau. Deze betroffen onder meer slechte audio- of videokwaliteit, onvoldoende informatie over vertragingen, late aanlevering van de consultlink, en gebrek aan persoonlijke ervaring met de technologie. Patiënten die hun eigen gezondheid als beter beoordeelden, hadden een significant grotere kans om het consult positief te evalueren. Dit gold ook voor patiënten behandeld binnen “overige medische specialismen” in vergelijking met chirurgische en niet-chirurgische specialismen.

Deze studie verschafte waardevolle inzichten in de ervaringen van patiënten met videoconsultatie. De kwantitatieve en kwalitatieve gegevens wezen op een overwegend positieve ervaring. Tegelijkertijd brachten de kwalitatieve bevindingen inconsistenties aan het licht op zowel innovatief als organisatorisch niveau: sommige patiënten ervoeren de audiovisuele kwaliteit als zeer goed, terwijl anderen deze als slecht beoordeelden. Ook instructies en tijdsbeheer werden zowel als positief ervaren als verbeterpunt genoemd. Daarnaast gaven sommige patiënten expliciet de voorkeur aan fysieke afspraken vanwege hun beperkte ervaring met digitale technologie.

Sectie III Opkomende Technologie

Het laatste deel van dit proefschrift, **Hoofdstuk 7**, biedt een blik op de nabije toekomst en richt zich op mogelijke toepassingen van AI binnen de MKA-chirurgie. Het hoofdstuk geeft een overzicht van de ontwikkeling van medische beeldvorming en AI, en beschrijft hoe deze technologieën kunnen worden geïntegreerd in diagnostiek, behandelplanning en chirurgische uitvoering binnen verschillende subspecialismen van de MKA-chirurgie.

Uit de huidige literatuur blijkt dat AI binnen vrijwel alle subspecialismen duidelijke voordelen biedt voor diagnostiek, planning en chirurgie. De belangrijkste uitdagingen liggen in het beschikbaar krijgen van voldoende hoogwaardige data, het waarborgen van transparantie en verklaarbaarheid van algoritmen, en het verankeren van AI als ondersteunend instrument binnen klinische besluitvorming.

Implicaties voor de Klinische Praktijk

Tot op heden blijkt de implementatie van eHealth-interventies in de gezondheidszorg in het algemeen nog steeds uitdagend, en veel studies blijven zich richten op de bevorderende factoren en barrières die een succesvolle adoptie beïnvloeden.² In lijn met de conclusies uit **Hoofdstuk 2** rapporteerde een review over digitale zorg voor hoofd-halsoncologiepatiënten dat 11 van de 17 geïnccludeerde onderzoeken beperkt waren tot haalbaarheids- of pilotfasen.³ Hierdoor is een brede toepassing van eHealth-interventies in de routinematige MKA-chirurgische praktijk vooralsnog niet waargenomen. Het huidige onderzoek binnen dit domein richt zich bovendien nog grotendeels op teleconsultatie-toepassingen.⁴⁻⁶

Hoewel de COVID-19-pandemie aanvankelijk leidde tot een snelle en grootschalige adoptie van teleconsultaties binnen diverse medische specialismen, is nadien een afname in het gebruik ervan zichtbaar geworden.^{7,8} Deze trend weerspiegelt zich ook binnen ons eigen universitair medisch centrum, waar het aantal videoconsulten overeenkomstig is gedaald (figuur 1), ondanks de positieve patiëntervaringen die in **Hoofdstuk 6** werden aangetoond.



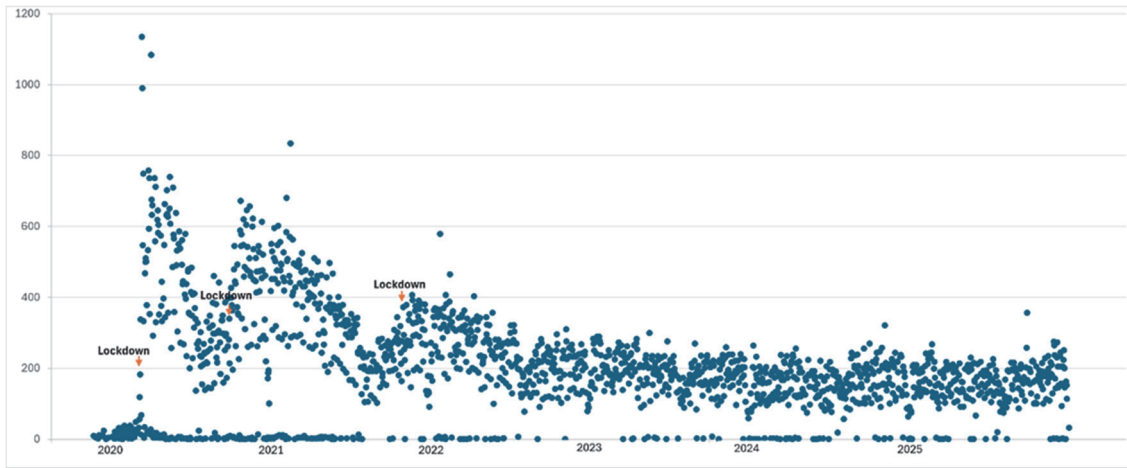


Figure 1 Het totale aantal videoconsulten in het Radboudumc van 2020 tot 2025, waarbij elke stip het totale aantal videoconsulten per dag vertegenwoordigt.

Deze afname in het gebruik van videoconsulten kan worden verklaard door het feit dat tijdens de COVID-19-pandemie een urgente behoefte bestond aan digitale zorg, wat leidde tot een snelle toename van het gebruik van videoconsulten. Nu deze urgentie is afgenomen, is ook het gebruik ervan gedaald, hoewel het nog steeds hoger ligt dan vóór de COVID-19-pandemie. Dit onderstreept de complexiteit die gepaard gaat met de implementatie van interventies zoals videoconsultaties. Het laat bovendien zien dat de implementatie van videoconsulten niet alleen wordt gevormd door structurele omstandigheden, maar ook door individuele autonomie. Deze dynamiek sluit aan bij bredere discussies binnen de sociale wetenschappen over het structuren en agency debat, waarin wordt onderzocht hoe individueel gedrag tegelijkertijd mogelijk wordt gemaakt en beperkt door institutionele, technologische en maatschappelijke structuren, terwijl het ook wordt beïnvloed door persoonlijke voorkeuren, professionele identiteiten en individuele beslissingen. Dit wordt ondersteund door een vergelijkend perspectief op de implementatie van videoconsultaties in vijf Noord-Europese landen.⁸ Zowel het gebrek aan technologische en financiële ondersteuning als professionele waarden en scepsis blijken van invloed op de adoptie van videoconsulten.⁸

Deze complexiteit geldt in bredere zin ook voor eHealth-interventies, gezien het uitgebreide scala aan bevorderende factoren en barrières voor implementatie dat in de literatuur wordt beschreven.⁹ Juridische, ethische, organisatorische,

financiële, technologische en culturele barrières zijn met elkaar verweven en worden in de literatuur nog onvoldoende geadresseerd, wat resulteert in kennishiaten met betrekking tot cruciale aspecten van implementatie.^{2,8} Het feit dat het nieuw is en de dynamische aard van eHealth, gecombineerd met de betrokkenheid van meerdere belanghebbenden, lijken bij te dragen aan de trage vooruitgang in het overwinnen van deze uitdagingen.²

Gegevens over de adoptie van eHealth-interventies in Nederland in de afgelopen vijf jaar laten uiteenlopende trends zien: terwijl het gebruik van videoconsulten is afgenomen, is telemonitoring teruggekeerd naar het niveau van 2021, toen er als gevolg van de COVID-19-pandemie een tweede piek in gebruik werd waargenomen. Het gebruik van schriftelijke digitale communicatiemiddelen (zoals e-consulten en chat) is sinds 2021 gestabiliseerd, terwijl het gebruik van patiëntenportalen verder is toegenomen.⁷ Uit dit onderzoek bleek tevens dat huisartsen vaker telemonitoring en schriftelijke digitale communicatie toepassen dan medisch specialisten.⁷ Deze patronen illustreren de invloed van zowel structurele als individuele barrières.

Daarom is gesuggereerd dat toekomstige inspanningen zich niet alleen moeten richten op de ontwikkeling van nieuwe eHealth-interventies, maar belangrijker nog op governance, datastrategieën, robuuste evaluatie en betrokkenheid van stakeholders om implementatie te waarborgen.^{2, 10}

Gezien de meerlagige complexiteit die gepaard gaat met de implementatie van eHealth-interventies, en in het licht van het huidige tekort aan zorgpersoneel en de reeds hoge werkdruk, is het niet verrassend dat grootschalige adoptie van eHealth beperkt blijft.

Met betrekking tot MKA-chirurgie en de adoptie van eHealth-interventies geldt dat de acceptatie van digitale interventies mogelijk trager verloopt dan in andere domeinen, zoals diabeteszorg. Dit komt deels doordat de patiënten aantallen relatief klein zijn en de meeste patiënten geen chronische aandoeningen hebben. Ook is de klinische behoefte aan telemonitoring binnen deze discipline beperkt. Toch geldt dat zelfs wanneer slechts een klein deel van de patiënten profiteert — bijvoorbeeld door verbeterde toegang tot betrouwbare online informatie — dit nog steeds een betekenisvolle bijdrage levert aan de kwaliteit van zorg. Uiteindelijk roept dit de vraag op wie bepaalt wat de drempel is voor een “succesvolle” interventie, een afweging die moet



worden beoordeeld in relatie tot de aanzienlijke tijd, inspanning en financiële middelen die voor ontwikkeling nodig zijn.

Betrokkenheid van alle Stakeholders

Het onderzoek in dit proefschrift toont het belang aan van het betrekken van alle stakeholders, inclusief patiënten, bij de ontwikkeling, implementatie en evaluatie van patiëntgerichte eHealth-interventies; dit geldt evenzeer voor AI-gebaseerde patiëntgerichte eHealth-interventies.

De bevindingen in **Hoofdstuk 3** laten zien dat gebruikersperspectieven aanzienlijk kunnen verschillen van wat professionals veronderstellen, wat het belang onderstreept van het actief meenemen van de input van patiënten en ouders. In sommige gevallen kan dit zelfs de ontwikkeling van afzonderlijke websiteonderdelen over hetzelfde onderwerp rechtvaardigen, zoals bij schisis, specifiek afgestemd op patiënten en op ouders. Tegelijkertijd blijft de inbreng van professionals onmisbaar om de medische nauwkeurigheid en betrouwbaarheid van de aangeboden informatie te waarborgen.

De ontwikkeling van online gezondheidsinformatie moet worden beschouwd als een dynamisch proces, aangezien de behoeften en voorkeuren van nieuwe generaties kunnen veranderen, zowel wat betreft de inhoud als de manier waarop deze wordt gepresenteerd.^{11, 12} Zo kunnen voorkeuren verschillen met betrekking tot platforms (bijv. websites versus sociale media) en vormen van presentatie (bijv. tekst, animaties of korte videoformaten zoals TikTok-reels).¹¹ Door patiënten en ouders hierbij te betrekken, wordt gewaarborgd dat de informatie toegankelijk, leesbaar en gebruiksvriendelijk is. Dergelijke co-creatie kan bovendien de kans vergroten dat de informatie daadwerkelijk wordt gebruikt, wat de kosteneffectiviteit van de interventie kan verhogen doordat deze beter aansluit bij de behoeften en voorkeuren van eindgebruikers. Verdere studies zijn echter nodig om deze aanname te bevestigen.

Hoewel dit proefschrift zich richt op patiëntgerichte eHealth-interventies, is het belangrijk te erkennen dat ook de perspectieven van zorgprofessionals moeten worden meegenomen bij de ontwikkeling en implementatie ervan. Actieve betrokkenheid van zorgprofessionals is immers essentieel voor implementatie, omdat het eigenaarschap, vertrouwen, acceptatie en werkplezier bevordert.⁹

Het belang van het betrekken van alle stakeholders bij de ontwikkeling en evaluatie van AI-interventies wordt geïllustreerd door een verkennende studie onder tandartsen, orthodontisten en MKA-chirurgen, waarin de bevindingen contrasteren met onze eigen resultaten over de verwachtingen van patiënten ten aanzien van AI. Uit de studie onder professionals bleek dat zij vooral verwachtten dat AI de diagnostiek zou verbeteren, uniformiteit in diagnostische beoordelingen zou stimuleren en meer geïndividualiseerde en evidence-based zorg zou ondersteunen.¹³ De belangrijkste zorgen betroffen aansprakelijkheid bij fouten veroorzaakt door AI, de overdracht van controle in de zorg aan grote technologiebedrijven en kwesties rond privacy en gegevensbeveiliging.¹³ In tegenstelling tot de verwachtingen van de patiënten in onze studie (**Hoofdstuk 4**), werden uitdagingen rond de arts-patiëntrelatie en de mogelijke impact op de personeelsbehoefte als minder belangrijk gezien.¹³ Andere studies hebben eveneens aangetoond dat verschillende stakeholders uiteenlopende behoeften en zorgen hebben met betrekking tot AI-interventies binnen de MKA-chirurgie.¹⁴ Het is belangrijk te erkennen dat niet aan alle individuele behoeften kan worden voldaan binnen één interventie. Terwijl sommige patiënten een duidelijke voorkeur hebben voor digitale informatie, geldt dit niet voor iedereen, en het is niet realistisch om iedere individuele wens te kunnen accommoderen. Wel kan het aanbieden van keuzevrijheid, voor zowel patiënten als professionals, bijdragen aan het tegemoetkomen aan diverse voorkeuren. Het aanbieden van zorg in een hybride format kan daarbij helpen om zorg meer patiëntgericht te maken. Videoconsultaties lenen zich hier bijzonder goed voor, omdat de benodigde infrastructuur al aanwezig is. In de MKA-chirurgie geldt dit eveneens voor het gebruik van audiovisuele brillen tijdens de verwijdering van verstandskiezen (**Hoofdstuk 5**). Deze overweging is even relevant voor zorgprofessionals, aangezien niet iedere professional zich even comfortabel voelt bij, of affiniteit heeft met, bepaalde eHealth-interventies.



Methodologische Beperkingen en Implicaties voor Toekomstig Onderzoek

Het primaire doel van dit proefschrift was om de huidige positie van patiëntgerichte eHealth binnen de MKA-chirurgie te bepalen en zowel de uitdagingen als de kansen in kaart te brengen die gepaard gaan met implementatie in de dagelijkse klinische praktijk. Deze doelen zijn slechts gedeeltelijk bereikt, grotendeels vanwege methodologische keuzes die tijdens het onderzoeksproces zijn gemaakt, keuzes die achteraf bezien mogelijk anders hadden kunnen worden benaderd.

Wat betreft de positie van patiëntgerichte eHealth binnen de MKA-chirurgie is een redelijk duidelijk beeld verkregen, ervan uitgaande dat de beschikbare literatuur een accurate weerspiegeling vormt van het gebruik ervan in de klinische praktijk. Het identificeren van uitdagingen en kansen voor implementatie bleek echter complexer.

In algemene zin kan worden geconcludeerd dat kwalitatieve onderzoeksmethoden een prominentere rol hadden moeten spelen binnen onze studies. In de vragenlijstonderzoeken hadden dergelijke methoden diepere inzichten kunnen bieden in de resultaten, zoals zichtbaar werd in **Hoofdstuk 6**, waarin twee open vragen waardevolle kwalitatieve data opleverden. Evenzo zou het perspectief van patiënten op AI (**Hoofdstuk 4**) duidelijker in context zijn geplaatst wanneer kwalitatieve methoden waren toegepast, wat waarschijnlijk had geleid tot een meer genuanceerd begrip van hun opvattingen.

In **Hoofdstuk 5** was het doel om de patiëntbeleving tijdens de verwijdering van derde molaren te verbeteren. Dit doel werd echter niet bereikt, aangezien de studie de patiëntbeleving niet direct heeft gemeten. Een kwalitatieve onderzoeksoptzet zou geschikter zijn geweest om deze ervaring volledig te kunnen vastleggen. In plaats daarvan richtte de studie zich op de haalbaarheid en effectiviteit van een audiovisuele bril aan de hand van kwantitatieve fysiologische uitkomstmaten zoals hartslag, ademhalingsfrequentie en angst. De interpretatie van de gevonden effecten op hartslag en ademhalingsfrequentie is uitdagend. Het is onbekend welke betekenis het heeft dat de hartslag lager was terwijl de ademhalingsfrequentie hoger lag tijdens het gebruik van de bril. Met de kennis van nu kan worden betwijfeld of dit van doorslaggevend belang is. Indien patiënten de behandeling als comfortabeler ervaren met de bril, zelfs

wanneer dit niet in fysiologische parameters tot uiting komt, mag de subjectieve ervaring van de patiënt niet worden genegeerd. Uiteindelijk profiteren patiënten het meest wanneer de behandeling als comfortabeler wordt ervaren. Het is echter zeer relevant om te onderzoeken of een positieve ervaring ook invloed heeft op herstelsnelheid, ervaren pijn, gebruik van pijnmedicatie of terugkeer naar dagelijkse activiteiten en werk.

Toekomstig onderzoek naar de evaluatie van patiëntgerichte eHealth-interventies zou zich daarom primair moeten richten op de patiëntervaring, en vervolgens de effecten hiervan moeten kwantificeren op uitkomsten zoals herstelsnelheid, werkhervatting en analgeticagebruik. Deze evidence is essentieel om beleidsmakers en verzekeraars te informeren over de meerwaarde van de interventie. Patiënten zouden vervolgens de mogelijkheid moeten krijgen om een weloverwogen keuze te maken over het gebruik van de eHealth-interventie, in dit geval een audiovisuele bril, tijdens de behandeling. Zoals dit proefschrift heeft aangetoond, vereist grootschalige implementatie van eHealth-interventies aanvullende inspanningen, die verder gaan dan het aantonen van meerwaarde van de interventie zelf. Om de brede adoptie van gevalideerde digitale en hybride zorgprocessen die aantoonbaar waarde toevoegen voor zorgprofessionals, patiënten, cliënten en burgers te bevorderen, biedt Digizo.nu gerichte ondersteuning aan zorgorganisaties binnen het Nederlandse zorgstelsel. Dit samenwerkingsprogramma, ingebed in het Integraal Zorgakkoord en ondersteund door het Ministerie van Volksgezondheid, Welzijn en Sport, biedt ondersteuning door digitale toepassingen te selecteren en te beoordelen, kennis hierover te delen en organisaties te begeleiden bij implementatie. Het initiatief bevordert een model van zorgtransformatie waarin brede implementatie pas plaatsvindt na systematische beoordeling en waardebeoordeling van een eHealth-interventie.

Om uitdagingen en kansen voor de implementatie van patiëntgerichte eHealth-interventies binnen de MKA-chirurgie te identificeren, moeten deze factoren voor elke afzonderlijke interventie worden geëvalueerd, aangezien de eerder beschreven meerlagige invloeden allemaal een rol spelen. Daarmee lijkt een overkoepelende beoordeling van uitdagingen en kansen voor het gehele vakgebied van de MKA-chirurgie niet realistisch. Gezien de meerlagige complexiteit die gepaard gaat met de implementatie van patiëntgerichte



eHealth-interventies, kunnen professionals terughoudend zijn om dergelijke oplossingen te ontwikkelen, te implementeren en te evalueren. Deze terughoudendheid is echter niet geheel gerechtvaardigd, aangezien waardevolle lessen kunnen worden getrokken uit de gegevens die in de afgelopen twee decennia zijn verzameld.

Met betrekking tot evaluatie kunnen verschillende doelen en uitkomstmaten geschikter zijn wanneer alle stakeholders worden meegenomen. Het succes van een interventie moet niet uitsluitend worden gedefinieerd op basis van grootschalige impact of financiële opbrengsten, maar ook op basis van de waarde voor kleinere groepen patiënten en professionals, vooral wanneer deze interventies bijdragen aan meer patiëntgerichte zorg voor die specifieke groepen. Dit vraagt om een verschuiving in onderzoeks-benadering, van een exclusieve focus op kwantitatieve uitkomsten voor grote populaties naar diepgaande kwalitatieve analyses die effecten op individueel patiënt- en professionalniveau vastleggen.

Wat betreft de meest prominente opkomende technologie — AI — richten huidige toepassingen zich niet primair op patiëntgerichte interventies, maar vooral op ondersteuning van professionals door efficiëntieverbeteringen in diagnostiek en behandelplanning.¹⁵ Desalniettemin is het uiteindelijke doel van deze toepassingen het verbeteren van zorg, wat indirect ten goede komt aan patiënten. AI-gebaseerde eHealth-toepassingen die bedoeld zijn voor direct gebruik door patiënten zullen onvermijdelijk volgen. Een voorbeeld hiervan is reeds zichtbaar binnen de dermatologische zorg, waar een AI-gestuurde mobiele applicatie telemedische wondzorg ondersteunt.¹⁶ Naarmate deze technologie verder volwassen wordt, is het essentieel alle stakeholders te betrekken en de impact en beperkingen grondig te evalueren. Meer bewijs is nodig, met bijzondere nadruk op patiëntrelevante uitkomsten.¹⁷

Implicaties voor Onderwijs

De beschikbaarheid en het gebruik van eHealth in de dagelijkse praktijk zouden aanleiding moeten zijn voor integratie ervan in het medisch curriculum, aangezien het essentieel is om zorgprofessionals in opleiding te onderwijzen en te toetsen op de vaardigheden die nodig zijn om effectieve virtuele consulten te

voeren.^[18, 19] Daarnaast kan het trainen van toekomstige zorgverleners in het effectief gebruik van deze technologieën bijdragen aan een bredere adoptie ervan in de klinische praktijk.^{20, 21}

De Association of American Medical Colleges heeft specifieke competenties geformuleerd voor het uitvoeren van teleconsultaties (telefonisch of via video voor realtime klinische zorg).¹⁸ De gedefinieerde competentiedomeinen zijn: 1) patiëntveiligheid en gepast gebruik van telezorg, 2) toegang en gelijkheid binnen telezorg, 3) communicatie via telezorg, 4) gegevensverzameling en beoordeling via telezorg, 5) technologiegebruik binnen telezorg, 6) ethische praktijken en wettelijke vereisten voor telezorg.

Sinds de COVID-19-pandemie zijn meer voorbeelden verschenen van eHealth-integratie in medische curricula; echter, de totale ervaring daarmee blijft tot op heden beperkt.²¹⁻²⁴

De mate waarin docenten in staat zijn deze vaardigheden te onderwijzen en te toetsen, benadrukt dat ook voor hen nieuwe onderwijscompetenties noodzakelijk zijn. Tot op heden bestaan er echter slechts zeer beperkte richtlijnen over welke vaardigheden docenten nodig hebben om dit onderwijs effectief te verzorgen.^{18, 24}

Naast teleconsultatie moet het onderwijs zich ook richten op het ondersteunen en begeleiden van patiënten in het gebruik van AI-gebaseerde eHealth-interventies en in de interpretatie van door AI gegenereerde informatie. Hoewel patiënten doorgaans verwachten dat AI de kwaliteit van zorg zal verbeteren, uiten zij ook zorgen over betrouwbaarheid, veiligheid, privacy, mogelijk verlies van menselijke interactie en autonomie in besluitvorming.^{14, 25} Net als bij eHealth in het algemeen lijken ook voor specifieke AI-interventies demografische kenmerken van invloed te zijn op de houding van patiënten ten aanzien van AI.^{7, 14}

Gelukkig wordt de integratie van AI in medische curricula steeds vaker waargenomen.²⁶⁻²⁸ Toch blijft onduidelijk of dergelijke curricula ook onderwijs omvatten over ethische kwesties rondom AI, het beoordelen van betrouwbaarheid en het begeleiden van patiënten bij deze vraagstukken.



Aanbevelingen voor de Toekomst

Aan het begin van dit promotietraject waren wij ervan overtuigd dat eHealth een belangrijke rol kon spelen in het patiëntgericht maken van de zorg binnen de MKA-chirurgie. Door technologie op een doordachte manier in te zetten, zou meer tijd en ruimte ontstaan voor wat écht van belang is: het betekenisvolle gesprek in de spreekkamer of aan het bed. Technologie zou immers kunnen bijdragen aan het verminderen van administratieve lasten, waardoor professionals worden ontlast van taken die hen afhouden van directe patiëntenzorg. Bovendien zou technologie meer persoonlijke betrokkenheid kunnen faciliteren, bijvoorbeeld via videoconsulten in de vertrouwde omgeving van de patiënt. Ook zouden patiënten elkaar gemakkelijker kunnen vinden in online communities, waardoor onderlinge steun wordt bevorderd. Door dit mogelijk te maken, zouden we de patiënt completer kunnen “bedienen”. Het aanbieden van informatie die is afgestemd op de behoeften van patiënten, zowel qua inhoud als qua vorm, zou hen beter kunnen informeren en meer kunnen betrekken bij hun eigen zorg. Dit betreft niet alleen schriftelijke informatie, maar ook video’s, animaties en afbeeldingen, afhankelijk van de voorkeur van de patiënt. Zorg en betrouwbare informatie zouden beschikbaar zijn op het moment dat de patiënt daar behoefte aan heeft. In sommige gevallen zou technologie de zorg zelfs aangenamer kunnen maken (bijvoorbeeld door gamificatie bij informatievoorziening of voorbereiding op een behandeling), of stress kunnen verminderen vóór of tijdens een behandeling (zoals met HappyMed®).

Binnen de MKA-chirurgie heeft deze ontwikkeling zich echter minder sterk doorgezet dan wij aanvankelijk hadden verwacht. Dit proefschrift geeft ten dele verklaringen hiervoor. Vervolgonderzoek kan aanvullende inzichten opleveren in de barrières voor de implementatie van patiëntgerichte eHealth-toepassingen. Mijns inziens is het echter zinvoller om de schaarse tijd, energie en middelen die beschikbaar zijn, in te zetten om nieuwe toepassingen, welke voldoen aan een behoefte van zowel de patiënt als de zorgverlener, te gaan gebruiken in de dagelijkse praktijk. Evidence-based handelen is uiteraard van belang, er zal moeten worden geëvalueerd of de betreffende behoefte voldaan wordt, echter, zoals in dit proefschrift geconcludeerd zal met een specifieke toepassing nooit een hele patiëntengroep in behoefte worden

voorzien. Maar daar begint nu juist persoonsgerichte zorg. Zelfs wanneer slechts een kleine groep patiënten profiteert, kan een interventie nog steeds van grote waarde zijn. Door zorg te bieden op een manier die aansluit bij de voorkeuren van patiënten, en waarin zorgverleners zich ook comfortabel voelen, kan een vertrouwensrelatie ontstaan.

Wat mij betreft zouden we dan ook los moeten komen van puur en alleen protocollair werken, omdat dit per definitie niet persoonsgericht kan zijn. Immers, protocollen en richtlijnen zijn ontstaan uit wetenschappelijk onderzoek geënt op grote groepen patiënten en niet op het individu. Veel patiënten (en zorgverleners) vallen dan tussen wal en schip, waardoor onnodige afspraken volgen, diagnostiek en behandelingen ingezet zullen worden. Protocollen en richtlijnen zouden slechts handvatten moeten bieden, zoals deze ook ooit bedoeld zijn, en geen doel op zich moeten vormen volgens welke te werken. Dit vergt niet alleen van de zorgverlener en patiënten een andere instelling, ook de ziekenhuisbesturen, zorgverzekeraars en overheid hebben hierin een rol. Immers, veel van het handelen op de dagelijkse werkvloer wordt ingegeven door het systeem van vergoedingen en financiële prikkels ("productie draaien") en niet door het welzijn van de patiënt.

Een belangrijke reden waarom veel professionals voor een loopbaan in de zorg hebben gekozen, is de wens om patiënten te helpen. Frustratie ontstaat onvermijdelijk wanneer dit door systeemdruk niet langer de primaire drijfveer kan zijn. Deze frustratie ondermijnt de kwaliteit van zorg, kan leiden tot verzuim en zelfs ertoe leiden het vak te verlaten. Dit verergert de al bestaande personeelstekorten. Het zou evident moeten zijn dat het welzijn van zorgprofessionals eveneens van groot belang is.

Wanneer zorgprofessionals (als experts in hun vakgebied) en patiënten (als experts in hun eigen leven en welzijn) samen en weloverwogen van protocollen en richtlijnen kunnen afwijken, ben ik ervan overtuigd dat de zorg kostenefficiënter kan worden. Veel onnodige activiteiten (afspraken, consulten, diagnostiek, behandelingen) zouden dan niet langer plaatsvinden. De juiste handelingen zouden worden verricht voor de individuele patiënt, terwijl zorgprofessionals zich gewaardeerd zouden voelen en hun professionele roeping kunnen vervullen door patiënten daadwerkelijk te ondersteunen richting een beter welzijn.



Dit lijkt wellicht utopisch en kan uiteraard niet van de ene op de andere dag worden gerealiseerd. Bovendien is het niet mogelijk om vooraf te bewijzen dat een dergelijke aanpak positieve uitkomsten zal opleveren, een realiteit die botst met de huidige cultuur en werkwijzen binnen de zorg. Toch weet iedere zorgverlener die nu al probeert op deze manier te werken, voor zover het systeem dat toelaat, dat het werkt. Kwantitatieve én kwalitatieve onderzoeksmethoden kunnen vervolgens worden ingezet om de uitkomsten voor alle betrokkenen te evalueren.

Laten we daarom technologie inzetten waar deze ons helpt om patiënten beter te bedienen, geleid door de behoeften van zowel patiënten als zorgprofessionals, zonder vooraf de financiële opbrengst als eerste criterium te stellen. Op die manier kan de zorg opnieuw gericht worden op het welzijn van de patiënt, terwijl deze tegelijkertijd betekenisvol en vervullend blijft voor de zorgverlener.

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D. Research Data Management

Ethics and Privacy

The data described in chapters 3, 4, 5 and 6 result from human studies. These studies were conducted in accordance with the principles of the Declaration of Helsinki and the guidelines of Good Clinical Practice. Informed consent was obtained from all participants (both patients and clinicians) to collect and process their data for the research projects in this thesis. The Medical Ethics Committee (CMO) of Radboudumc, Nijmegen, the Netherlands has given approval to conduct the studies in chapter 3, 5 and 6. These concern the following file numbers: 2012/451 for chapter 3; 2016-2589 for chapter 5; 2021-8415 for chapter 6. The study in chapter 4 was approved by the Ethics Committee of the Westphalia-Lippe Medical Association, Westfälische-Wilhelms University Münster (IRB approval no. 2021–616-f-S).

Data Collection and Storage

The following secure storage options were taken to safeguard the availability, integrity and confidentiality of the data:

Anonymized data collected for chapter 3, 5 and 6 were stored in a secured folder at the Radboudumc server of the department of Oral Maxillofacial Surgery. Only authorized project team members have access to these data. Raw and processed data were stored at the previously mentioned server in project folders in SPSS or Microsoft Excel data files. Paper (hardcopy) data (e.g. informed consent forms) were stored in locked cabinets at the department of Oral Maxillofacial Surgery.

The anonymized data collected for chapter 4 were stored in a secured folder at the server of the University of Münster of the department of Oral and Maxillofacial Surgery. Only authorized project team members have access to these data. Raw and processed data were stored at the previously mentioned server in project folders in SPSS or Microsoft Excel data files.

Data Sharing According to the FAIR Principles

All studies have been published as open-access articles (chapter 2, 3, 4, 6 and 7) or have been submitted for open-access publication (chapter 5). The data (chapter 2, 3, 5 and 6) will be archived for 15 years after termination of the study. The data used for chapter 4 are not owned by Radboudumc. The data are archived by Westfälische-Wilhelms University Münster. For chapter 7 no data were used. Reuse of the data for future research is only possible after obtaining renewed consent from the participants (chapter 5). The processed anonymous datasets of published papers included in this thesis are available in the Radboud Data Repository under restricted-access conditions (chapter 2, 3 and 6) and closed access conditions (chapter 5). DOI 10.34973/xh11-6543 (chapter 2), DOI 10.34973/knr5-c817 (chapter 3), DOI 10.34973/hvqh-s749 (chapter 6) and DOI 10.34973/m9yj-aq59 (chapter 5).



E. Portfolio

Department: Oral and Maxillofacial Surgery
 PhD period: 01-02-2013 – 01-10-2025
 PhD supervisors: prof. dr. S.J. Bergé
 PhD co-supervisors: dr. M.J. Meinders

Training activities	Hours
Courses	
AO CMF Advanced Lighthouse Course Orthognathic Surgery, Padova, Italy, 2024	15
Basiskwalificatie Onderwijs, Radboudumc, 2024	NA*
Scientific Integrity course, 2023	16
Masterclass Mond- en kaakziekten voor MKA-chirurgen, Leiden, 2022	16
SORG Comprehensive course OMF surgery, 2021	120
eBROK course, re-registration, 2016	8
Qualitative Research Methods in Health Care, CaRE, 2012	16
BROK course, 2012	32
Total	223

* NA: not applicable, this course involves a comprehensive program in which the development as a teacher and the demonstration of the teacher's didactic competence in scientific education are outlined.

Conferences	
European Conference OMF Surgery, Rome, Italy, 2024	24
Voorjaarscongres NVMKA, Driebergen, 2024	16
Comprehensive management of TMJ pathology, Firenze, Italy, 2023	16
Najaarscongres NVMKA, Enschede, 2023	16
<i>Outpatient video visits during the COVID-19 pandemic; patients' experiences and characteristics</i> , ICOMS Vancouver, Canada, 2023**	32
En Profil, het gezicht zijwaarts belicht, Weacademy, 2020	8
Organisatie najaarscongres, NVMKA, Nijmegen, 2019	40
Najaarscongres NVMKA, Helmond, 2018	16
European Conference OMF Surgery, München, Germany, 2018	24
Connecting Bites, Surgical Orthodontics, 2018	16
<i>Patients and professionals have different views on online patient information about cleft lip and palate</i> , 12 th world congress of the International Cleft Lip and Palate Foundation, Leipzig, Germany, 2018**	24
Biennial Symposium Surgical Orthodontics, Haarlem, 2017	16
Najaarsvergadering NVSCA, Amsterdam, 2017	16
<i>Patients and professionals have different views on online patient information about cleft lip and palate</i> , ICOMS Hong Kong, 2017**	32

<i>Innovatie in de MKA chirurgie</i> Meer dan dokteren, symposium studenten geneeskunde Radboudumc. Nijmegen, 2016**	4
Exponential Medicine, Singularity University, San Diego, USA, 2016	40
<i>eHealth bij kinderen</i> , Symposium Vereniging Chirurgie Medisch Studenten, Radboudumc, Nijmegen, 2016**	4
NVSCA conference, Leeuwarden, 2015**	8
<i>Via de computer bij het schisisteam: FaceTalk in de schisiszorg</i> NVSCA symposium, Rotterdam, 2014**	8
Exponential Medicine, Singularity University, San Diego, USA, 2014	40
<i>ehealth in de schisiszorg</i> , Emerce ehealth convention, Amsterdam, 2014**	8
<i>Wil de MKA-chirurg er wel een collega bij?</i> Voorjaarsvergadering NvMKA, Nijmegen, 2014**	16
Health 2.0 Europe Conference, London, UK, 2013	24
<i>Futuremed; een reis naar de MKA-patiënt als partner</i> . Afdelingsbijeenkomst MKA-chirurgie, 2013**	1
Futuremed, Singularity University, San Diego, USA, 2013	40
<i>ehealth: patient als partner</i> . Algemene ledenvergadering Landelijk patiënten- en oudervereniging voor schedel en/of aangezichtsafwijkingen, 2013**	4
<i>Healthcare 2.0- OMF Surgery 2.0</i> . National Conference of Association of Oral & Maxillofacial Surgeons India, Hyderabad, India, 2012**	8
Health 2.0 Europe Conference, Berlin, Germany, 2012	24
Total	501

** indicates an oral presentation

Teaching activities	12h/week
Bachelor students Dental School Radboudumc	
B1 Teaching intra- and extra-oral examination	
B2 Teaching Anamnesis and intra- and extra-oral examination	
Coordinator Course B2MTI4 Q4	
B3 Teaching oral pathology, oral surgery	
Coordinator Course B3MTI5 and B3MTI6 Q3	
Coordinator Learning Path Medical Dental Interaction	
Master students Dental School Radboudumc	
M1 Daily supervision and mentoring medical interns in their clinical internship	
M2 Coordinator and teaching in the course "MKA Verdieping"	
M3 Coordinator internship "MKA extern coschap"	
Master students Medical School Radboudumc	
Daily supervision and guiding medical interns in their clinical internship	



F. List of Publications

This Thesis

Van den Bosch S, De Vries M, Harder J, Van Goor H, Bergé S. *A different type of distraction: audiovisual intervention during third molar removal to reduce anxiety and stress, a randomized controlled trial*. Submitted for publication

Ayad N, Schwendicke F, Krois J, **Van den Bosch S**, Bergé S, Böhner L, Hanisch M, Vinayahalingam S. *Patients' perspectives on the use of artificial intelligence in dentistry: a regional survey*. Head & Face Medicine. 2023 Jun 22;19(1):23

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G. Curriculum Vitae



Stefanie van den Bosch was born on 18 September 1984, in Nijmegen. She attended secondary school in Apeldoorn. In 2002, she began studying Dentistry at Radboud University Nijmegen. During her fourth year, Stefanie took on a board position at her student association, N.S.V. Ovum Novum, serving as *ab actis*. In her final year, she completed a three-month internship at the University of Pretoria in South Africa, primarily in the department of OMF surgery. In 2008, Stefanie graduated *cum laude*.

Immediately afterwards, she started studying Medicine at Radboud University Nijmegen, graduating in 2013. Subsequently, she began her specialty training in OMF surgery at Radboudumc. During this specialist training, she contributed to the implementation of various patient-centred eHealth applications within the OMF surgery department, including the use of video consultations in post-operative cleft care and the establishment of patient communities for parents of children with cleft lip and palate or craniosynostosis, and for patients undergoing orthognathic surgery.

In 2015, Stefanie completed a five-month junior fellowship in cleft surgery at St. Thomas' Hospital in London. After finishing her specialisation in OMF surgery in 2017, she worked as an OMF surgeon at Amsterdam Medical Centre for one year. In early 2019, she worked at Spaarne Gasthuis in Haarlem and Red Cross Hospital in Beverwijk.

Since late 2019, she has been staff member in the department of OMF surgery at Radboudumc. In addition to her clinical work, Stefanie is the education coordinator for the department of OMF surgery and is closely involved in the development of the Dentistry curriculum.

Stefanie lives in Nijmegen with Marcel, their son Rembrandt and their two cats Sam and Moos.

H. Dankwoord

En nu mag ik het allerlaatste hoofdstuk schrijven, dit dankwoord. Het leukste hoofdstuk, want wat mij betreft is er niets leuker dan mensen bedanken en in het zonnetje zetten. Riskant is het ook, want het risico om mensen te vergeten is vrij groot. Mocht dat het geval zijn, dat ik jouw naam hieronder niet genoemd heb, weet dat ik iedereen die aan dit proefschrift en mijn ontwikkeling hierin heeft bijgedragen zeer dankbaar ben.

Allereerst bedank ik natuurlijk **alle patiënten**, voor de moeite en het vertrouwen om mee te doen aan de studies. U heeft dit proefschrift mogelijk gemaakt!

Hooggeleerde promotor prof. dr. S.J. Bergé, beste Stefaan, mijn dank naar jou gaat veel verder dan de kaders van dit proefschrift. Dank voor de vele wijze lessen, natuurlijk de chirurgische, maar vooral de levenslessen. Jouw les om steeds weer het goede te doen, elke dag weer een beetje beter dan gisteren. Benedicere, het goede spreken. Het goede voorbeeld geven en ieders talent te laten floreren. Dat zijn voor mij belangrijke lessen geweest, die me nog geregeld terugbrengen naar de essentie. Dank voor jouw grote vertrouwen al sinds het Evoluon in 2009. Dank voor de prachtige opleiding welke ik mocht genieten en de vrijheid hierin. En dank dat ik mijn eigen pad heb kunnen bewandelen tot op de dag van vandaag. Ik hoop dat we ook in de toekomst met enige regelmaat kunnen praten over ons vak, de maatschappij waarin we haar uitoefenen, maar vooral de echt belangrijke, mooie dingen in het leven.

Zeergeleerde copromotor dr. M.J. Meinders, beste Marjan, dank voor jouw fijne begeleiding gedurende mijn lange PhD traject. Jouw kritische, maar constructieve blik heeft de papers en dit proefschrift steeds naar een hoger plan getild. Dank ook voor het geduld en het vertrouwen in het proces.

Hooggeleerden prof. dr. R.J.A. van Wezel, prof. dr. C.R.M.G. Fluit en prof. dr. J. de Lange, veel dank voor de moeite om dit proefschrift kritisch te beoordelen, dit waardeer ik ten zeerste.



Geachte co-auteurs, jullie wil ik natuurlijk bedanken voor alle hulp, de enorme inzet, de vele lessen welke ik van jullie mocht leren op onderzoeksgebied en het verbeteren van de kwaliteit van onze papers.

Beste REshape collega's, lieve Lucien, Leanne, Tom en Jules, jullie dank ik voor de inspiratie die jullie me gaven aan het begin van dit PhD traject. Het enthousiasme was aanstekelijk. Jullie hebben me doen beseffen dat niets onmogelijk is, dat je altijd kunt omdenken en constructieve en creatieve oplossingen kunt bedenken voor mogelijke hobbels op de weg. Ik kijk met veel plezier terug naar die tijd.

Beste stafleden, AIOS MKA-chirurgie en collega's van het 3D lab, dank voor de vele gezamenlijke uren patiëntenzorg en opleiding welke ik met jullie mocht genieten.

Lieve dames PAMmers, oncologie verpleegkundigen, mondhygiënist, secretariaat, administratie en Teuntje van de afdeling MKA-chirurgie, jullie dank ik voor de warme samenwerking, de goede zorgen voor onze patiënten, de gezellige gesprekken, het lachen en de steun al die jaren.

Lieve OK-assistenten, anesthesisten en anesthesiemedewerkers, dank voor de prettige samenwerking, de fijne steun, de vele dropjes en limootjes, de muziek én vooral ook de stilte wanneer dat hard nodig was op OK11 en in de diensten.

Beste collega's van onze **verpleegafdeling**, veel dank voor jullie ongelofelijke harde werk en de goede zorgen voor onze patiënten.

Hooggeleerde prof. dr. P. Haers en hooggeleerde prof. dr. A.G. Becking, beste Piet en beste Eddy, voor jullie beiden geldt dat jullie belangrijke mentoren zijn geweest op momenten in mijn (chirurgische) ontwikkeling die vormend zijn geweest. Zowel in Londen als in Amsterdam heb ik ook nog eens mooie stappen kunnen maken voor dit proefschrift. Dank hiervoor!

Hooggeleerde prof. dr. J.E.E. Keunen, geachte mw. Geerling, dhr. Aarsman en dhr. Villevoye, lieve Jan, Let, Hans en Roy, jullie dank ik voor de vele mooie gesprekken, de werkateliers die ogen opende en de gezelligheid hierbij. Jullie hebben vele collega's, ook mij, geleerd dat een breder perspectief de wereld alleen maar verrijkt.

Collega's van de afdeling Tandheelkunde, dank voor het warme bad waarin ik terecht ben gekomen. Het is me een eer en genoegen om samen met jullie de opleiding Tandheelkunde te mogen vormgeven.

Zeergeleerde dr. E. Hissink, lieve Elske, dank voor de hoognodige schop onder mijn kont eind 2025, het is ons gelukt! Graag wil ik je vooral bedanken voor de fijne gesprekken, jouw lieve motiverende woorden, jouw zachtheid, het luisterend oor en de oprechte interesse. Je bent een voorbeeld in vele opzichten.

Zeergeleerde dr. W.A. Fokkinga, lieve Wietske, jou dank ik voor de inspirerende samenwerking de afgelopen jaren. Ik zie ons nog zitten in onze oude colloquiumkamer op de poli MKA, toen je vroeg of ik leerlijncoördinator wilde worden. Ik had geen idee, dat zei ik je toen ook, maar wat ben ik blij dat je me dat gevraagd hebt en dat ik het ben gaan doen. Jouw kennis en kunde in combinatie met een ongelofelijke inzet en enthousiasme zijn aanstekelijk en heerlijk om een vleugje van mee te pikken.

Geachte collega Lindeboom, lieve Roos, dank voor de fijne samenwerking al sinds ik mij met het onderwijs vanuit de MKA bezig ging houden en in het OMTT kwam. Jouw no-nonsense mentaliteit, vooruitziende blik en jouw droge humor maken dat het een genot is om met je samen te werken.

Geachte collega Ligterink, lieve Francis, wat ben ik je dankbaar voor de samenwerking als een geoliede machine. Maar bovenal veel dank voor de mooie echte gesprekken, de grote steun die je bent geweest in een heel moeilijke tijd en het in korte tijd opgebouwde wederzijdse vertrouwen.

Ik kijk ernaar uit om er de komende jaren samen met jullie iets nóg mooiers van te maken op Tandheelkunde!



Zeergeleerde dr. M.A.T.M. Vorstenbosch, beste Marc, dank voor het delen van jouw wijsheid en kennis met mij. Dank voor het authentieke en aanstekelijke enthousiasme waarmee je dat ook nog eens naar de studenten doet, het fijne mens dat je bent en de grote steun in een bizarre tijd. Een voorbeeld!

Geachte collega Goverde, beste Willibrord, veel dank voor jouw inspirerend leiderschap de afgelopen jaren binnen de MKA en de steun in een verdrietige tijd. Ik waardeer dit enorm!

Lieve Heleen, wat een geluk dat jij op mijn pad bent gekomen. Dank voor jouw fijne energie en de inzichten. Ik verheug me op de vele gesprekken die nog zullen volgen en hopelijk mooie gezamenlijke projecten in de toekomst.

Lieve vrienden en familie, zonder jullie had ik dit proefschrift niet kunnen realiseren. De fijne momenten samen gaven me de energie om dit te kunnen doen. Dank daarvoor!

Amice collega De Koning, lieve Martien, mijn paranimf, dank voor de ongelooflijke steun tijdens en ook na mijn opleiding, wat heb ik ongelooflijk veel van je geleerd. Dank voor de fijne dokter die je bent, het voorbeeld dat je voor mij geweest bent om mijn eigen pad te bewandelen en de fijne vriendschap die we hebben ontwikkeld de afgelopen jaren. En natuurlijk dank dat je jouw lieve Trudy in mijn leven hebt geïntroduceerd.

Zeergeleerde dr. C. Miedema, lieve Christie, mijn paranimf, mijn lieve vriendin, jou dank ik voor de vele jaren vriendschap al sinds Walterbosch. De fijne zelfde golflengte waar we op zitten, jouw mooie eerlijke kijk op de wereld, jouw wijsheid en jouw goedheid. Ik kijk uit naar de volgende 27 jaar vriendschap!

Geachte collega Hekner, lieve Dominique, dank voor jouw tijd en energie in het ontwerp van het omslag van dit proefschrift. Het is een genot om de blik in je ogen en jouw energie te zien veranderen zodra jouw creatieve brein “aan” gaat. Hopelijk werken we de komende jaren nog eens samen in de patiëntenzorg.

Lieve Marleen, dank je wel voor onze jarenlange vriendschap sinds de brugklas toen we nog maar kleine bakvisjes waren en we onszelf al zo wijs vonden. Dank je wel dat je er bent door dik en dun, de fijne gesprekken en de mooie herinneringen. Ik hoop dat de komende jaren meer licht zullen brengen.

Lieve Heik, Lenus, Lies, Maaik, Mick, Soof en Von, mijn jaarcluppie, dank voor de fijne club die we zijn, de lol, de vele mooie avonden (inmiddels vaker middagen), de vele leuke herinneringen, het lief en leed dat we delen. Ik hoop op nog vele mooie nieuwe herinneringen met elkaar.

Lieve Anne-Marie, dank voor jouw vriendschap, de juiste kritische vragen die je kunt stellen en het samen genieten. Hopelijk vinden we tijd om elkaar vaker te zien.

Lieve i-klout, lieve Bas, Loes, Peet, Meik en de jongens, dank voor de warmte en gezelligheid direct vanaf het begin dat ik jullie ontmoette. Het is zo fijn om zulke gastvrije, lieve mensen om ons heen te hebben.

Lieve papa en mama, jullie dank ik voor de mogelijkheid om te gaan studeren wat ik wilde, dat ik al snel op kamers kon gaan en de ruimte kreeg om mijn studentenleven helemaal op mijn manier vorm te geven. Dank voor jullie nooit aflatende steun en hulp waar we altijd op kunnen rekenen tot op de dag van vandaag. *“Als er wat is, gewoon bellen, hè?”* En dat bellen doen we best vaak. En natuurlijk heel veel dank voor de lieve opa en oma die jullie voor Rembrandt zijn.

Lieve broers Alex, Chiel en Maup, schoonzussen Jandwine, Erika en An, nichtjes en neefjes Noa, Suus, Lauren, Lex, Tim, Anne en Olivier. We hebben allemaal ontzettend onze eigen levens en drukte, daardoor zien we elkaar niet heel erg vaak. Het is heel fijn te weten en te voelen dat we er voor elkaar zijn als dat nodig is. Dank daarvoor.

Lieve Hans, graag dank ik je voor jouw rustige, stabiele aanwezigheid, hetzij geregeld van op afstand. Het is altijd fijn als “opa Spanje” op bezoek komt of via facetime even mee mag delen in Rembrandts wereld. Jouw lieve gebaren, je eigenheid en oprechtheid waardeer ik zeer!



Lieve Marcel, mijn rustpunt, mijn relativering, mijn levensgenieter, mijn vriendje die altijd de humor van alles inziet en de beste papa ooit. Dank je wel voor de onvoorwaardelijke steun en dat je me de ruimte geeft die ik vaak zo hard nodig heb. Ik kijk uit naar nog vele jaren samen.

Mijn lieve Rembrandt, mijn knuffelige, wijze, vrolijke mannetje. Wat is het heerlijk om je groot te zien worden met je boevenstreken, humor, welbespraaktheid en prachtige kijk op de wereld. Jij geeft mijn leven licht, lucht en kleur. Ik wil nog heel graag heel veel tijd verliezen met jou.

Lieve Sam en Moos, dank voor jullie onvoorwaardelijke knuffels, vieze prooien en heerlijke gespin.

Eléonore mijn immer kleine meisje, dank voor jouw wijsheid. Ik hoop dat je mij nog lang de goede kant op zult leiden.

Liefs,
Stefanie

Zonder muziek was dit proefschrift er niet geweest.
Hopelijk genieten jullie er net zo van als ik!



Vier vaker, lach veel, hou vast

Bente Fokkens & Paskal Jakobsen,
Hoe hou ik dit vast, 2025



