Digitalized healthcare for Head and Neck cancer patients

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Word count: 2235 words

Funding source

-Fondation Nuovo Soldati 2019 (J Bouaoud)

-ITMO Cancer 2020, Formation à la Recherche Fondamentale et Translationnelle en Cancérologie (J Bouaoud)

-2017-INCa-DGOS-Inserm_12563 Integrated Site for Cancer Research (SIRIC): LYriCAN

Disclosure of interest: The authors report no conflicts of interest.

Abstract

The ongoing shortage in healthcare services and the increasing cancer incidence, highlight the need for new strategies to ensure optimal treatments, cares and follow-up for all patients. Digitalized healthcare, which includes various concepts (digital health, telemedicine, telemonitoring and digital therapeutics), are a promising option to meet these needs.

In this scoping review, we provide an overview of the recent available research evidence on digitalized healthcare for HNC patients and caregivers.

Through the interrogation of PubMed and Cochrane Library databases, a total of 32 relevant articles reporting the use of digitalized healthcare in different settings of HNC patients' care management, were analyzed.

Overall, HNC patients as well as caregivers were highly satisfied, especially because digitalized healthcare allows the early detection of health disorders, improve patient's management, quality of life, self-confidence and communication. Furthermore, digitalized healthcare were significantly time- and cost- effective. While the benefits digitalized healthcare has been reported to be feasible and clinically relevant, our future efforts should focus on the demonstration of their clinical utility in well-designed clinical trials. It is tempting to anticipate that this approach will improve patients' management and quality of life and change the way patients interact with family and professional health care givers.

Key words: Head and Neck cancer; Digitalized healthcare; eHealth; Telemedicine; Telemonitoring; Digital therapeutics.

Introduction

Head and neck cancers (HNC) are ranked as the eight most common cancer worldwide with a worldwide incidence exceeding 890,000 new cases annually [1] and increasing in some anatomical sites (oro/hypopharyngeal and lip/oral cavity) [2]. HNC treatment requires multimodal approaches including surgery, chemoradiation [3–5] and more recently immunotherapy in recurrent/metastatic disease [6–8]. This management involves multiple caregivers (physicians, nurses, psychologists, physiotherapist, speech therapists...) who should be coordinated. Moreover, treatments are associated with significant morbidity that impact patients both physically and psychologically and can be associated with long-term sequelae that need appropriate management. Finally, the active participation of the patient in his care as well as his motivation are essential elements of management.

Digitalized healthcare refers to a variety of concepts including digital health, telemedicine, telemonitoring and digital therapeutics [9]. Digital health, also called eHealth or telehealth, refers to using the digital technologies or telecommunications to provide healthcare services for prevention, diagnosis, management, and patients' follow-up. Telemedicine describes the provision of medical services using telecommunications platforms. Telemonitoring allows to monitor patients using digital technologies. Digital therapeutics aims at improving patients' management through algorithms continuously enriched by symptoms collection (patients reported outcomes) and evidence-based medical guidelines integration.

In order to meet with patients as well as healthcare professionals and caregivers needs, several authors have evaluated the feasibility and the benefits of digitalized healthcare, especially in oncology [9,10]. The purpose of this review is to provide an overview of the recent available research evidence on digitalized healthcare for HNC patients and their caregivers.

Method

To explore the literature related to digitalized healthcare for HNSCC patients, MEDLINE Public Library of Medicine (PubMed) and Cochrane Library databases were searched for full text articles using the following search string (head [Title/Abstract]) AND (digital health [Title/Abstract] OR telehealth [Title/Abstract] OR eHealth [Title/Abstract]). Inclusion criteria were publications in English language, published from December 1, 2002 to August 30, 2020 and reporting a minimum of five patients. All Editorials, perspectives, seminars, letters to the editor, abstracts, case reports and small case series (less than five patients) were excluded as well as ongoing clinical trials for which results were non-available. Preliminary screening followed by full-text examination was done by one author (J.B) to ensure eligibility. All selected publications as well as the flow diagrams were studied and reported according to the PRISMA statement [11].

Review

Study research

A total of 89 studies were primarily identified from PubMed and Cochrane Library databases. After removing one duplicate, n=88 potentially relevant studies were screened (Figure 1). Fifty-six studies were excluded because they were out of the HNC scope (n=43) or because they did not report available/robust results on digitalized healthcare interventions in the population of interest, *i.e.* HNC patients, HNC patients' families and caregivers (n=13). Finally, n=32 full-text relevant articles were included in this review. Briefly, reported digitalized healthcare were studied in different settings of HNC patients' management, from care organization through post-treatment supportive care.

Telemedicine and Telemonitoring

Several authors have evaluated the impact of consultation using telemedicine. Beswick et al., have recently reported a telemedicine model integrating tissue diagnosis and imaging, data review for HNC patients during preoperative (n=15) and post-operative (n=24) teleconsultations [12]. This model enabled timely access to surgical care and allowed considerable savings (about \$900/patient) among HNC patients. Similar results and an overall high level of satisfaction were observed by Hamilton et al., who proposed TeleHealth for radiation oncology consultations to geographically distant HNC patients (n=32) [13]. Stalfors et al., have evaluated the use of telemedicine at a multidisciplinary tumor meeting among n=45 HNC patients [14]. Compare to the classic face-to-face multidisciplinary tumor meeting, telemedicine seemed to bring to HNC patients better consideration feelings and higher satisfaction.

Telemonitoring has also been evaluated for HNC patients' follow-up. Rimmer et al., reported telemonitoring to be safe for the postoperative follow-up in a large population of patients (n=255) [15]. Indeed, telemonitoring enabled early detection of the occurrence of health problems (pain, speech, swallowing, tracheostomy canula...) requiring direct intervention by different stakeholders (n=36 HNC patients, n=24 caregivers/patricians) [16].

Interestingly, Lyu et al., recently investigated the feasibility and benefits of the "WeChat" application, for the clinical follow- up of 99 HNC patients [17]. WeChat application was found to be a viable option for follow- up in discharged patient. Indeed, compared to the classic telephone follow-up, the "WeChat" follow-up was found to be significantly time- effective, cost- effective, and convenient in communication. This study reveals the potential of using available social media tools establish a good physician- patient relationship by enhancing dynamic communications and providing individual health instructions. Sosa et al., reported same conclusions using a similar approach (mobile texting, n=23 HNC patients) [18]. Nevertheless, these options raise many privacy issues.

To finish, care organization (appointment scheduling/reminders) and communication of some treatment planning information using Telemedicine could be beneficial to both HNC patients and care givers [19].

Symptom Management/supportive care

Digital therapeutics aims to improve patient's management through algorithms continuously enriched by symptoms collection (patients reported outcomes [PROs]) and evidence-based medical guidelines integration [9].

Several authors have reported the use of digital therapeutics in HNC patients' cohorts (Table1). Among the different digital solutions, The Health Buddy® System was among the most studied [20–22]. It is a simple telehealth messaging device which requires any available land phone line. Symptom management algorithms are programmed in this device, allowing also daily patients feedbacks. After a pilot study demonstrating the feasibility, use, and acceptance of this digital therapeutic solution in 42 patients newly diagnosed with HNC [20], Head et al. performed a randomized clinical trial (RCTs) comparing the telehealth intervention to the standard of care to assess feasibility and acceptance of this approach during treatment [21]. They showed that the Health Buddy® System was feasible, well accepted, and regularly used by HNC patients even when they experienced extreme symptoms burden and declining quality of life (QoL) during treatment. Moreover, Pfeifer et al., have demonstrated in another RCT including 80 patients with HNC previously treated (post-treatment trial) that the Health Buddy® System improved some aspects of posttreatment QoL and symptom burden measured using the Functional Assessment of Cancer Therapy-Head & Neck Scale [FACT-HN] and the Memorial Symptom Assessment Scale [MSAS] respectively [22].

Kaiku® (<https://kaikuhealth.com/>) is an internet-based electronic application which enables real-time, online collection of PROs such as treatment side effects and also QoL. In their pilot study (n=5 HNC patients using Kaiku® during and one month after radiotherapy), Peltola et al., 2015 reported that this digital solution improved follow-up and communication between HNC patients and the caregivers [23].

OncoKompas® (<https://www.oncokompas.nl/>) is a web-based application that supports survivors in self-management by monitoring QoL and symptoms (Measure) and obtaining tailored feedback (Learn) with a personalized overview of supportive care options (Act). While feasible and allowing satisfaction (n=56 HNC survivors and n=13 health care professionals), the structure of OncoKompas® seems complex and needs further improvements [24,25]. In a non-blinded RCT including 185 HNC survivors (3 months to 5 years after treatment with curative intent, all treatment modalities), van der Hout et al., evaluated the reach, usage as intended, and efficacy of OncoKompas® to improve knowledge, skills, and confidence for self-management among cancer survivors [26]. They found that OncoKompas® did not improve the amount of knowledge, skills, and confidence for self-management in HNC survivors. Nevertheless, the course of mouth pain, social eating, swallowing, coughing disorders and trismus were

significantly reduced over time (secondary outcomes). Of note, a RCT is ongoing (NTR 7636) to evaluate an OncoKompas® dedicated version to support patients with incurable cancer and their partners in finding and obtaining optimal supportive cares [27].

In a pilot study, Badr et al., showed that the web-based intervention system “CARES”, meaning Computer-Assisted oral cancer REhabilitation and Support, was interesting and usable for both HNC survivors and their family caregivers to improve QoL [28].

Interestingly, using the software CYCORE (CYberinfrastructure for COmparative effectiveness REsearch) which allows collection and analyses of data from multiple domains using a suite of home-based and mobile sensors, Peterson et al., have shown the feasibility of using digital therapeutics for early identification of dehydration risk in 48 HNC patients during radiation therapy [29].

Sterba et al., have developed and tested a survivorship needs assessment planning (SNAP) tool to systematically assess needs in post-treatment HNC survivors (n=42) and their primary caregivers (n=39) and generate tailored care plans [30,31]. Beside the high satisfaction, this web-based interface has allowed to decrease depression and unmet needs while the survivorship knowledge increased.

Swallowing, speech and nutrition disorders are a field in which this type of digital therapeutics have been widely evaluated. Recent reviews, highlight the existing evidence for this type of symptom management and care optimization in order to improve HNC patients’ pre-habilitation as well as post treatment QoL [32,33]. Firstly, Wall et al., have evaluated the accuracy of “ScreenIT”, a web-based screening tool capturing PROs, to detect swallowing, nutrition and distress status in 100 HNC patients receiving chemo/radiotherapy and facilitate appropriate referrals for multimodality treatment management [34]. “ScreenIT” was effective and efficient for disorders monitoring and facilitated clinically appropriate prioritization of supportive cares. Focusing on swallowing disorders, the same team have developed and evaluated “SwallowIT”, a tool designed to support HNC patients to remotely complete intensive swallowing therapy during curative chemoradiotherapy [35,36] (pilot study, and RCT included n=15 and n=79 HNC patients, respectively). “SwallowIT” provided clinically equivalent outcomes to traditional service models delivering prophylactic swallowing therapy. Overall, these digital therapeutics allowing interventions into patients’ homes regarding swallowing, speech and nutrition disorders, have shown to be satisfactory and to significantly reduce costs by decreasing the number and duration of appointments as well as travelling costs, especially in big countries such Australia [37].

The “Head and Neck Survivorship Tool: Assessment and Recommendations” (HN-STAR, <https://hn-star.org/>) is an electronic platform allowing PROs collection and giving automatically access to a clinical decision support tool to improve care coordination and to facilitate late-effects management among HNC survivors. HN-STAR was evaluated in a pilot study (n=5 Human-computer interaction experts, n=10 nurse practitioners, and n=10 HNC survivors more than 3 years from treatment) to provide

elements allowing the improvement of HN-STAR use and usefulness [38]. Of note, a RCT is ongoing to assess the implementation and effectiveness of HN-STAR compared to the standard care in a cohort of HNC patients who have completed chemotherapy and/or radiation therapy less than 6 months prior to enrollment (NCT04208490).

Another digital therapeutics has been recently tested in HNC survivors. Indeed, the “Empowered Survivor” interactive web-based application (computer, mobile phone) was evaluated in a pilot study including 66 HNC patients diagnosed with a first primary oral or oropharyngeal cancer one to 3 years ago and currently cancer-free [39]. Interestingly, a positive impact on self-management and QoL has been reported.

Discussion

The ongoing shortage in oncology services linked to the increasing cancer incidence and treatments options has highlighted the need for new strategies to ensure the provision of optimal treatments, cares and follow-up for all patients [40]. Digitalized healthcare is a cultural transformation of traditional healthcare, and has the potential to meet this challenge [41]. Indeed, a good illustration of this is the ongoing COVID-19 crisis which has led to an unexpected increasing demand, forcing HNC specialists to better organize themselves to manage HNC patients, especially using digital health technologies [42–44].

The design and evaluation of complex interventions such as digitalized health care should follow some fundamentals steps as defined by the UK's Medical Research Council (MRC) framework [45]. The preclinical or theoretical "Phase 0" should respond to the following question "why should this intervention work?". After the modelling of the intervention (Phase 1, "how does it work?"), pilot trials (Phase 2, optimizing trial measures) allow to explore the perceptions, potential interests and challenges from all stakeholders' perspectives. Definitive RCTs are required (Phase 3) before implementation in the routine care (Phase 4). Gemert-Pijnen et al., have recently proposed a Holistic Framework, called "the ceHRes Roadmap" to improve the development of eHealth technologies [46]. This framework is based on several key concepts: i) digitalized healthcare technologies development is a participatory process, ii) it involves continuous evaluation cycles (feedback), iii) are intertwined with implementation, iv) is changing the organization of health care, v) should involve persuasive design techniques and vi) needs innovative methods to assess its impact.

Digitalized healthcare technologies seem to improve communication between HNC patients and health caregivers, to improve education of HNC patients and to help them in self-management [9,47]. Early evidence suggests that digitalized healthcare technologies are effective/cost-effective. However, additional efforts are needed to improve implementation in daily practice [48,49].

Implementation in real life is one of the identified limits of digitalized healthcare [49]. Several factors may participate to this limit. Lower education level and non-working status may be barriers to accessing interventions [9]. Moreover, while patients studied in RCTs are carefully selected, many HNC in real-life may prefer more traditional sources of information compare to information technologies [50]. Furthermore, HNC survivors seem less likely to be eligible to digital healthcare interventions than colorectal, breast and lymphoma cancer survivors [26]. To finish, patient confidentiality and compliance with data privacy regulations could be a barrier to the implementation of these technologies.

Future studies should focus on demonstrating the clinical utility of digital digitalized healthcare in well-designed clinical trials and in its implementation in HNC patients' life to allow PROs analysis and QoL improvement while evaluating the overall costs and ensuring compliance with data privacy regulations.

239 In order to be successful, all stakeholders should be involved, including patients' family and health care
240 professionals.

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Figure and Table legend

Figure 1. Study flow diagram according to the PRISMA statement for systematic review analysis.

Table 1. Description of digital therapeutics technologies which have been studied in Head and Neck cancer cohorts. (HNC: head and neck cancer; RCT: randomized clinical trials; PROs: patient reported outcomes; RT: radiotherapy; CRT: chemo/radiotherapy)

Table 1

Study Name	Study Type	Objective	Population	Digital solution	Results
Head et al., 2009 [20]	Feasibility, use, and acceptance trial	To design a telehealth intervention to address isolation, develop patient self-efficacy, and improve symptom management during the treatment experience	<u>Algorithm development</u> N=39 HNC patients who had received treatment <u>Users</u> N=42 patients newly diagnosed with HNC (mean age 60y)	The Health Buddy® System (Robert Bosch Healthcare, Inc) Cost: using an existing program on the system for 1 month \$45.00, more if the provider develops its own algorithm to be programmed	Feasible, Well accepted, reassuring 98% no problems setting up 85% easy to use 84% better medical condition understanding
Head et al., 2011 [21]	RCTs	To assess feasibility and acceptance among patients undergoing treatment for HNC	N=44 patients newly diagnosed with HNC (mean age 59y)		96% better medical condition managing 92% recommend the device to others
Pfeifer et al., 2015 [22]		To evaluate the impact of the telehealth intervention on QoL and symptom burden	N=80 patients (45 treatment, 35 control: standard of care) who had been diagnosed with HNC and were receiving ≥ 1 treatment modalities. The study was conducted in the post treatment phase.		Improved some aspects of post treatment QoL and symptom burden.
Peltola et al., 2015 [23]	Pilot study	To assess the suitability of Kaiku®, for collecting PROs on early adverse effects of RT and on health related QoL and also to gain insight into how the patient experienced the system	N=5 patients, treated for a HNC, used Kaiku® during and one month after RT	Kaiku® is an internet-based electronic application which enables real-time, online collection of PROs (https://kaikuhealth.com/)	Seems to improve follow-up and communication between the patient and the care team
Duman-Lubberding et al., 2015 [24]	Feasibility study	To investigate health care professionals' perspectives toward follow-up care and OncoKompas in follow-up cancer care	N=11 Health care professionals involved in HNC care	OncoKompas is a web-based eHealth application that supports survivors in self-management by monitoring health-related QoL and cancer-generic and tumor-specific symptoms (Measure) and obtaining tailored feedback (Learn) with a personalized overview of supportive care options (Act). (https://www.oncokompas.nl/)	Complexity of the navigation structure
Duman-Lubberding et al., 2016 [25]		To investigate the feasibility of the online self-management application OncoKompas among cancer survivors	N=56 HNC survivors (patients treated with curative intent with a maximum of 2 years prior)		Feasible but has to be further improved High adoption, usage, and satisfaction
van der Hout et al., 2020 [26]	non-blinded RCT	To evaluate the reach, usage as intended, and efficacy of Oncokompas to improve knowledge, skills, and confidence for self-management among cancer survivors	N= 185 HNC survivors (3 months to 5 years after treatment with curative intent, all treatment modalities) including n=99 intervention group (access to Oncokompas) and n=86 control group (access to Oncokompas after 6 months).		No improvement of knowledge, skills, and confidence for self-management The course of the symptoms pain in the mouth, social eating, swallowing, coughing, and trismus were significantly reduced
Badr et al., 2016 [28]	Pilot study	To develop and evaluate a dyadic, web-based intervention to improve survivor self-management and survivor/caregiver QoL	N=13 HNC survivors and N=12 caregivers to discern information and support needs as well as preferences regarding website features and tools. N=6 HNC survivors and N=5 caregivers for the usability tests	Computer-Assisted oral cancer REhabilitation and Support (CARES): web-based intervention	HNC survivors and family caregivers were interested in using this online program to improve QoL
Peterson et al., 2013 [29]	Feasibility study	To evaluate the feasibility of using CYCORE to address early at-home identification of dehydration risk in HNC patients undergoing radiation therapy	N=48 HNC patients treated by radiotherapy	CYCORE (CYberinfrastructure for COmparative effectiveness REsearch) is a software-based prototype for a user-friendly cyberinfrastructure supporting the comprehensive collection and analyses of data from multiple	> 90% easy to use, satisfaction and suitability Clinician assessments indicated a high degree of satisfaction with the ease of using the CYCORE system and the resulting ability to monitor their patients remotely.

				domains using a suite of home-based and mobile sensors.	
Sterba et al., 2017 [30]	Pilot study	To characterize primary end-of-treatment challenges in HNC to drive the development of a survivorship needs assessment planning (SNAP) tool	N=17 HNC survivors, N=14 caregivers and N=14 healthcare providers	The survivorship needs assessment planning (SNAP) tool for HNC survivors and caregivers: web-based interface designed for ease of data collection	Enthusiasm > 75% reported high comfort of using Strong agreement that the care plan would help families practically and emotionally
Sterba et al., 2019 [31]	Feasibility study	To test the acceptability and feasibility of the SNAP tool for HNC survivors and caregivers To evaluate short-term changes in psychosocial outcomes after completing the SNAP session To develop strategies for system refinement.	N=25 HNC survivors, N=25 caregivers		High satisfaction Compare to baseline, depression and unmet needs decreased, and survivorship knowledge increased significantly in survivors and caregivers
Wall et al., 2016 [34]	Non inferiority trial	To evaluate the accuracy of “ScreenIT” to detect swallowing, nutrition and distress status in HNC patients receiving CRT and facilitate appropriate referrals for multimodality treatment management	N=100 patients receiving multimodality treatment (either surgery + post-operative RT or CRT) for locally advanced HNC Comparison of PROs obtained from ScreenIT vs. blinded face-to-face assessment by speech pathology/dietetic clinicians	“ScreenIT” is a web-based screening tool designed to capture PROs regarding the presence of CRT-induced side-effects, and their impact on swallowing, nutrition and distress, to enable appropriate management by the oncology multidisciplinary team	ScreenIT may provide an effective and efficient means of monitoring swallowing, nutrition and distress status during CRT, and facilitate clinically appropriate prioritization of supportive care intervention
Wall et al., 2017 [35]	Pilot study	To evaluate end-user perceptions of “SwallowIT”	N=15 HNC patients who used SwallowIT and completed supported home swallowing therapy	“SwallowIT” is a web-based tool designed to support patients to remotely complete intensive swallowing therapy during curative CRT treatment for HNC. It includes instructional videos, images and text descriptions for each exercise in the protocol	Well-perceived and may be well-accepted as an alternate service-delivery model for delivering intensive swallowing therapy during CRT
Wall et al., 2020 [36]	RCT	To investigate the clinical efficacy of three service models delivering prophylactic swallowing therapy during CRT	N=79 HNC patients receiving CRT randomized to compare three strategies: (a) face-to-face therapy (b) telepractice therapy via “SwallowIT” (c) patient self-directed therapy Swallowing, nutritional, and functional status were compared at baseline, 6-weeks, and 3-months post-(C)RT.		“SwallowIT” provided clinically equivalent outcomes to traditional service models. The high levels of therapy support provided by SwallowIT was strongly appreciated
Collins et al., 2017 [37]	Feasibility trial	To determine the feasibility of a home-based telehealth model for speech pathology and nutrition and dietetics reviews, to provide patients with more convenient access to these appointments	N=30 patients post HNC curative treatment (CRT): N=15 supported via the standard model of care, and N=15 via the home-based telehealth model of care	Software-based telehealth service allowing interventions into patients’ homes (computer/smart phone/tablet device with camera and microphone)	Reduced number and duration of appointments until discharge Significant patient cost savings Easy to use; good audio/visual quality; high satisfaction
Salz et al., 2018 [38]	Pilot study	To refine “HN-STAR” by eliciting and incorporating feedback on its ease of use and usefulness, from different stakeholders	N=5 Human-computer interaction experts, N=10 nurse practitioners, and N=10 HNC survivors (≥ 3 years from treatment)	Head and Neck Survivorship Tool: Assessment and Recommendations (HN-STAR): is an electronic platform that incorporates PROs into a clinical decision support tool for use at a survivorship visit. (https://hn-star.org/) .	This study provides elements to improve the ease of use and usefulness of HN-STAR

Manne et al., 2020 [39]	Pilot study	To assess the development, feasibility, and pilot testing of a web-based self-management tool called “Empowered Survivor”	N= 66 patients diagnosed with a first primary oral or oropharyngeal cancer between 1 and 3 years ago; currently cancer-free (but could experience a recurrence)	“Empowered Survivor”: interactive web-based application (computer, mobile phone)	<p>Significant beneficial impact on self-management self-efficacy, preparedness for survivorship care, and QoL.</p> <p>Improved engagement in oral self-exams and head and neck strengthening exercises,</p> <p>Improved ability to address barriers, and decreased information and support needs</p>
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