

Using immersive technology and architectural design to assist head and neck cancer patients' recovery from treatment: A focus group and technology acceptance study

Kathleen Greenway^{a,*}, Caterina Frisone^b, Andrea Placidi^b, Sanjay Kumar^c, Will Guest^d, Stuart C. Winter^e, Ketan Shah^f, Catherine Henshall^a

^a Oxford Institute of Nursing Midwifery and Allied Health, Faculty of Health and Life Sciences, Oxford School of Nursing and Midwifery, Oxford Brookes University, Jack Straws Lane, Marston, Oxford, OX3 0FL, UK

^b Faculty of Technology, Design and Environment, School of Architecture, Oxford Brookes University, Gipsy Lane, Oxford, OX3 0BP, UK

^c Faculty of Health and Life Sciences, Department of Psychology, Oxford Brookes University, Gipsy Lane, Oxford, OX3 0BP, UK

^d Faculty of Technology, Design and Environment, School of Computing and Communication Technologies, Oxford Brookes University, Gipsy Lane, Oxford, OX3 0BP, UK

^e University of Oxford, Consultant Head and Neck Surgeon, Oxford Cancer Centre, Churchill Hospital, Oxford, OX3 7LE, UK

^f Oxford Cancer Centre, Churchill Hospital, Oxford, OX3 7LE, UK

ARTICLE INFO

Keywords:

Head and neck cancer
Immersive technology
Self-management
Virtual reality
WebXR technology

ABSTRACT

Purpose: Head and neck cancer patients can face debilitating treatment related side-effects, resulting in requirement for support and negatively impacting on care outcomes. This study aimed to develop a digital recovery support package and assess its acceptability with head and neck cancer patients to support their information needs and assist with their self-management. It provided additional support through development of a WebXR platform 'recovery' package, which allowed patients to live a 'virtual reality' experience, entering and moving inside a 'virtual room', accessing targeted resources and specific learning materials related to their cancer.

Method: A qualitative intervention development study consisting of three phases. This study followed the COREQ checklist for qualitative research. Phase 1- Focus groups with seven head and neck cancer patients and six healthcare professionals. Phase 2- Development of 'recovery' package based on the focus group data which informed the content and design of the WebXR recovery platform. Phase 3- Technology acceptance study. Once developed, the platform's acceptability of the experience lived inside the virtual room was assessed via qualitative interviews with six different patient participants.

Results: Most participants felt comfortable using the virtual reality platform, finding it a realistic and useful support for identifying resources and signposting to relevant materials. Participants agreed the WebXR platform was a feasible tool for the head and neck cancer setting and helped reduce anxiety.

Conclusions: Head and neck cancer patients welcome specific targeted, information and advice to support their ability to self-manage their rehabilitation and thus focus their nursing care. The platform was implemented during the Covid-19 pandemic, demonstrating its versatility and accessibility in providing complementary support to head and neck cancer patients, to empower them to adjust to their 'new' normal as part of their ongoing cancer journeys.

Credit author statement

Kathleen Greenway: Conceptualization, Methodology,

Investigation, Data curation, Writing – original draft preparation, Writing- Reviewing and Editing, **Caterina Frisone:** Conceptualization, Writing – original draft preparation, Writing- Reviewing and Editing,

* Corresponding author.

E-mail addresses: kgreenway@brookes.ac.uk (K. Greenway), cfrisone@brookes.ac.uk (C. Frisone), aplacidi@brookes.ac.uk (A. Placidi), skumar@brookes.ac.uk (S. Kumar), 16102434@brookes.ac.uk (W. Guest), Stuart.Winter@ouh.nhs.uk (S.C. Winter), Ketan.Shah2@ouh.nhs.uk (K. Shah), chenshall@brookes.ac.uk (C. Henshall).

<https://doi.org/10.1016/j.ejon.2022.102261>

Available online 22 December 2022

1462-3889/Crown Copyright © 2022 Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

Andrea Placidi: Conceptualization, **Sanjay Kumar:** Conceptualization, Writing- Reviewing and Editing, **Will Guest:** Methodology, Software, Investigation, Validation, **Stuart Winter:** Resources, Writing- Reviewing and Editing, **Ketan Shah:** Resources, Writing- Reviewing and Editing, **Catherine Hensall:** Funding acquisition, Investigation, Conceptualization, Methodology, Writing – original draft preparation, Writing- Reviewing and Editing.

1. Introduction

In 2012 head and neck cancer (HNC) was estimated to affect 833,000 patients worldwide and 151,000 in Europe by 2020 (Ferlay et al. 2015), with the incidence anticipated to rise 30% by 2030, men being four times more likely to receive a HNC diagnosis than women (Ferlay et al. 2019). Risk factors for HNC include tobacco and alcohol use linked to oral cavity and larynx cancer, as well as the Human Papillomavirus associated with tongue base, tonsil and oropharyngeal cancers (Gatta et al. 2015). Primary HNC treatment usually involves surgery, radiotherapy with or without chemotherapy, with patients frequently experiencing long-lasting physical, emotional and psychological side-effects (DOH 2013). HNC treatments can be disabling and debilitating (Covrig et al. 2021), impacting on patients' body image, sexuality and vocation, increasing the likelihood of social isolation and reducing quality of life (QoL) (Semple et al. 2008). Consequently, HNC patients often have very specific post-cancer needs and a high requirement for support, with commonly experienced problems including altered appearance, changes to speech, swallowing and breathing, fatigue, pain, xerostomia, shoulder dysfunction and mucositis (Semple et al. 2013). These issues can be detrimental to patient care outcomes, resource use, health service efficiency and economic costs (Massa et al. 2019).

Findings from a qualitative interview study (Bjorklund et al. 2008) reported HNC participants felt more in control and empowered when using health promotion and self-management activities to balance their physical, mental and emotional health. However, these strategies needed to be tailored to improve long term compliance and reduce the likelihood of feelings of abandonment (Dunne et al. 2019). Supported self-management can help reduce the burden on cancer services, by supporting individuals to take control of their health and lifestyles, whilst redirecting resources to those most in need (Davies and Bateup 2011). Thus, it is important to examine ways of improving HNC survivors' QoL and health outcomes, by designing and testing interventions to help patients self-manage their treatment related side-effects.

Digital tools increasingly being developed to provide self-management support in healthcare settings include Augmented (AR) or Virtual reality (VR) immersive interventions which respond to real-time changes, such as movement. Gerup et al.'s (2020) integrative review showed the educational benefits of AR and VR significantly outperformed more traditional learning approaches. VR is commonly used in gaming, military, sports or medical training whereas AR overlays digital information onto the 'real world', enhancing it with images, text or other information such as the *AccuVein* vein visualisation tool (accuvein.com, 2020). AR offers users context-sensitive information directing their attention to relevant aspects of their environment that have been augmented (Guest et al. 2018). Recent reviews have highlighted AR's effectiveness in reducing anxiety and certain phobias using exposure-based therapies (Baus and Bouchard 2014; Chicci, Giglioli et al. 0.2015). AR can facilitate personal change by managing distress from traumatic events and creating psychological well-being (Riva et al. 2016). Despite these benefits, AR has not been used to support post-treatment cancer patients, hence the HNC cancer setting was chosen to develop a 'recovery support package' using the WebXR platform a platform that enables users to provide virtual reality experiences via a web address.

In general, hospitals do not provide enough information on the type of support HNC patients need after surgery, which is why the various existing facilities are often underutilised by HNC survivors, leading to

their unmet needs gaining prevalence (Fang and Heckman, 2016). Maggie's Centres built in the UK and abroad (maggiescentres.org n. d.) and other cancer support facilities, provide compassionate, person-centred care and support based on self-management into cancer patients and a physical setting that encourages social interaction and privacy. However, Maggie's Centres are not always accessed by HNC patients, due to issues regarding body image and lowered self-esteem (Semple 2008). Fallon et al. (2018) report that due to their altered appearance, HNC patients' self-consciousness can often prevent them from engaging in social interactions; social lay organisations such as Heads2gether (www.heads2gether.net) are often perceived to be better suited to their needs.

With improved internet coverage globally, patients increasingly access health information via web-based resources (Bakitas et al. 2017). However, there is recognition that patients should be advised to only access credible websites that are underpinned with up-to-date medical evidence, in order to ensure accuracy of information (Biggs et al. 2018). A recent scoping review by Kelly et al. (2022) reported that web-based interventions for HNC patients focused largely on survivorship, were mainly text based, and lacked theory-based, co-designed content. Other research has highlighted the need for suitable, discernible resources and patient centred information to navigate patients' long term lived experience following treatment (Nund et al. 2014). To overcome some of these challenges, a virtual 'recovery support package' was co-designed by healthcare professionals and HNC patients, to offer HNC patients an alternative way to engage with and access information and support at an early-stage post-treatment. Maggie's Centres' philosophies of 'self-help' and 'design is a form of care' inspired the project, with the aim being to develop a HNC digital recovery support package. This aim was interlinked with the following objectives:

1. To gain insights into the needs, priorities, preferences and fears of HNC cancer patients from the perspectives of HNC patients and the healthcare professionals who care for them.
2. To develop a virtual recovery package based on the findings from objective 1
3. To conduct a technology acceptance study to assess the usability of the recovery package for HNC patients.

2. Methods

2.1. Study design

This qualitative intervention development study which reported in line with the consolidated criteria for reporting qualitative research (COREQ) checklist (Tong et al., 2007) and consisted of three phases:

- 1) Focus groups with HNC patients and healthcare professionals
- 2) WebXR recovery support package intervention development
- 3) Technology acceptance interviews with HNC patients

3. Ethical considerations

Ethical approvals were obtained from Oxford Brookes University Research Ethics Committee (FREC 2018/22) and the NHS HRA (19/WM/0223). Local R&D approvals (R&D14395) were obtained. Written informed consent was gathered from all participants prior to the focus groups and verbal consent was documented over the Zoom platform for the phase 3 interviews. Participants were informed they could withdraw from the study at any time without needing to state a reason. All participant data was anonymised prior to transcription and confidentiality was maintained. Data was stored in line with the EU law of General Data Protection Regulation (GDPR) requirements and University's data protection policies.

3.1. Phase 1- focus groups

Focus groups with HNC healthcare professionals (HCPs) and patients were undertaken to gather a range of perspectives about the key issues affecting patients' post-treatment, informational and support needs. Separate focus groups for patients and HCPs were undertaken to encourage open discussions; moderated and facilitated by at least two researchers.

3.2. Recruitment

3.2.1. Access & setting

The study took place in the cancer centre of a large teaching hospital in South England between March to July 2020 using purposive sampling. The researchers contacted the HNC clinical lead in the participating hospital to obtain permission to invite patients and staff to participate. Once permissions were agreed, three HNC consultants shared participant information sheets (PIS) with clinical colleagues and HNC patients under their care. All clinical staff caring for HNC patients were eligible to participate including the consultants who shared the PIS. All patients who had been diagnosed and treated for HNC at the participating site were eligible, no other demographic or characteristic was deemed important, and the researchers were not known to the patients.

Any eligible patients and HCPs interested in participating in the study were asked to contact the researchers via email or telephone and were invited to attend a focus group at a pre-agreed date and time. Focus groups were held in a room at the hospital and refreshments were provided. Thirteen HNC patients and six HCPs (consisting of three male and one female surgeon and two female speech and language therapists) contacted the researchers to participate.

3.3. Data collection

One focus group was held for patients ($n = 7$) and one for HCPs ($n = 6$) in a suitable room at the hospital where the head and neck cancer service is based. The facilitators were CH who acted as interviewer, and KG who acted as moderator and took field notes, both are registered nurses and WG who was to create the recovery package. Both focus group interviews lasted 60–90 min, were audio recorded, and no other personnel were present. A second focus group was planned for HNC patients, but due to COVID-19 restrictions suspending participant facing research, this did not go ahead. However, these six patients latterly agreed to participate in phase 3 interviews. Prior to the focus groups commencing, written informed consent and demographic data were collected from participants. Focus groups were informed by a topic guide and lasted around 1 h. Key questions for HNC patients included:

What information would be/was helpful to reduce some of your worries and concerns?

When do you feel it is important to access information about recovering from cancer?

Key questions for HCPs included:

What do you feel are the biggest fears and concerns of HNC patients in the time following their diagnosis?

Are there specific support needs for different HNC patients?

3.4. Data analysis

Interviews were transcribed by a local transcription company with relevant confidentiality agreements in place. Interview data was analysed thematically using the Framework approach. This approach reduces the dataset and allows themes to be developed to interrogate data categories using comparison across and between cases (Gale et al., 2013). Using a matrix, it is possible to compare and contrast data with ease across, as well as between cases (Gale et al., 2013). The process began with data familiarisation by re-listening to the focus group

recordings and reviewing the field notes. Coding was then undertaken by KG, whereby codes were applied to sections of passages of transcripts. The codes were then grouped together to form categories and were charted onto a spreadsheet using the framework matrix, including referencing illustrative quotations from participants; this process was reviewed by CH. Subsequently, narrative summaries from both HCP and HNC patient datasets were created as a way of synthesising the data and aiding the emergence of relevant themes. The narrative summaries were discussed by team members to aid data interpretation and to clarify which aspects of the dataset were relevant for informing any modifications to the intervention and its subsequent user testing.

3.5. Phase 2 - WebXR recovery support package intervention development

The focus group study findings were used to inform the intervention, which was the development of the WebXR recovery package, by identifying relevant content for inclusion.

3.6. The intervention

The intervention used immersive technology to provide support to HNC patients and was designed to be readily accessible to patients, in any setting. The recovery package was built around a virtual room containing supportive resources for HNC patients. The technology used was the WebXR platform, allowing virtual reality experiences to be delivered to users via a web address link. Users could move around a three-dimensional space and interact with available content, via a computer or VR headset. In addition, the 'Unity' game engine, commonly used to create immersive experiences, was integrated with the WebXR platform, optimising the generation of these user experiences. Focus group content was incorporated using a variety of media types such as still images, video, audio and 3D models. The WebXR platform was selected instead of an AR headset due to constraints arising from the COVID-19 pandemic meaning direct contact with patients was not possible. Thus, the ability to deliver immersive experiences remotely was both a requirement and an opportunity to explore how the WebXR platform be made accessible to HNC patients and provide virtual, immersive content.

In addition to the content, design and features incorporated from the focus group findings, the recovery package experience was designed to incorporate two other key elements: environmental design and user experience design. The environmental design was built around design principles evident in the architecture of Maggie's cancer centres which informed the layout and design of the virtual space. The space was bounded with natural landscape from greenspace close to the participating hospital's Maggie's Centre and included open and confined spaces within the virtual room. The ceiling was transparent and crossed with beams and there were several windows along one side of the room, with a view of the sun setting. This was presented as a 360-degree panorama.

The user experience design aspect was built from scratch to enable optimal functionality, with the code written in C#, JavaScript and HTML5. The web server acted as a 'database' for the recovery package content so new content (videos, slides, audio recordings etc ...) could be added with no additional coding and minimal configuration changes. This allowed content to be loaded on-demand, keeping the size of the software down and loading time as small as possible.

The developed virtual room prototype aimed to assist the recovery of HNC patients' post-treatment through the provision of open space to move freely in and via access to resources via the 3D platform. Unlike real life environments, such as Maggie's Centres, where information is generally only included in books or explained in support groups, the virtual room was developed to have multiple resource interfaces on display.

3.7. Phase 3: technology acceptance interviews with HNC patients

The developed recovery package prototype was tested on HNC patients via a recorded remote video call, to evaluate the acceptability of the WebXR interface, to assess the suitability of the content and to determine the added value, if any, from the perspectives of HNC patients.

3.8. Data collection

Six patient participants agreed to take part in phase three and verbally consented via video prior to entering the virtual room. Participants were given a general introduction to the controls for moving around the room by WG, which involved using a mouse and keyboard. They were told which objects in the virtual space they could interact with and that they could ask for prompts or guidance at any time. On entering the room, the first view was of an information screen (Fig. 1). Users could identify intractable objects by pointing the mouse at them and seeing the cursor change, until more information was displayed. At one end of the room were a bookshelf and video player; both could be selected to display readings and viewing materials via a wall monitor (Fig. 2). Reading materials were made available and accessible via a virtual library. There was also a repository of video, e-books and images that could be loaded onto canvases in the room, including the television wall monitor. Users could also interact with the video player to watch short films about patient's experiences.

One end of the virtual room contained a panel showing information and videos of swallowing exercises, whilst another showed written instructions relating to each exercise. There was also a brightly coloured 3D model of a throat and larynx, which the user could dismantle and reassemble by moving different parts of the rotating model (Fig. 3). There was also a poster with information about cancer-related drop-in sessions, webinars and workshops which could be scrolled through and users were encouraged to click on it to access additional information about webinars and workshops (Fig. 4). There was also an avatar in a chair that could be emailed requests for information by users. For demonstration purposes, this was not used, but participants were made aware of its functionality.

Participants were encouraged to explore the virtual environment and

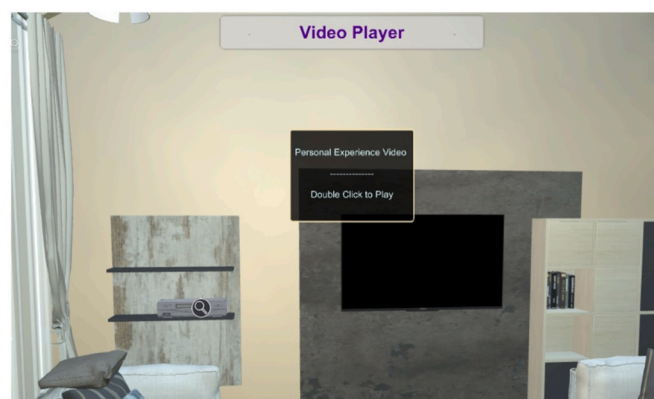


Figure 2: Video player interaction.

Fig. 2. In the large sitting room visitors can find the reading materials available and accessible through a virtual library. Users can also interact with the video player to watch short videos about the treatment experiences of patients participating in the research.

resources independently and to utilise facilitator support as needed. Following the demonstrations, WG as the creator of the platform, exited the video call and each user took part in a video interview facilitated only by KG, lasting between 30 and 60 min. Participants were asked about their experience of using the WebXR technology, their ease of navigation and any perceived benefits or barriers to use. In addition to the qualitative responses, a Likert scale was used to score each question. A final qualitative question asked participants how the package could be improved and how they rated its value. Interviews were transcribed and thematically analysed using the Framework method (Gale et al., 2013) by KG. Participants were informed that they could request to receive a copy of their transcribed interview, though none did so.

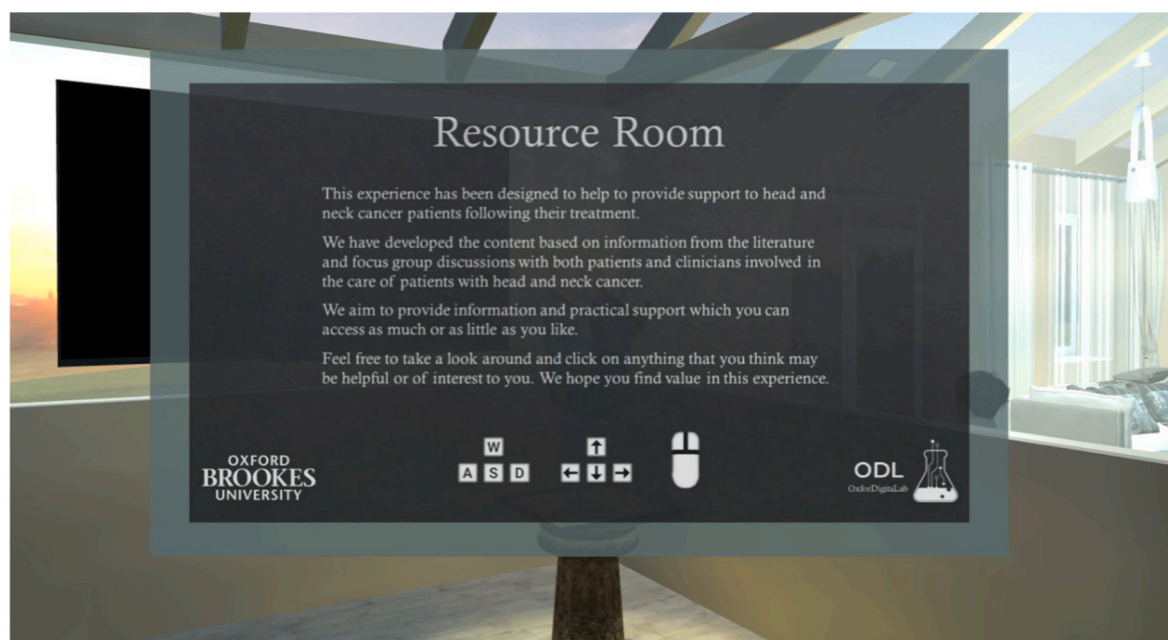


Fig. 1. The screen of the resource room welcomes visitors at the entrance of a space surrounded by a natural landscape (in this case South Park in Oxford) illuminated by a transparent ceiling.

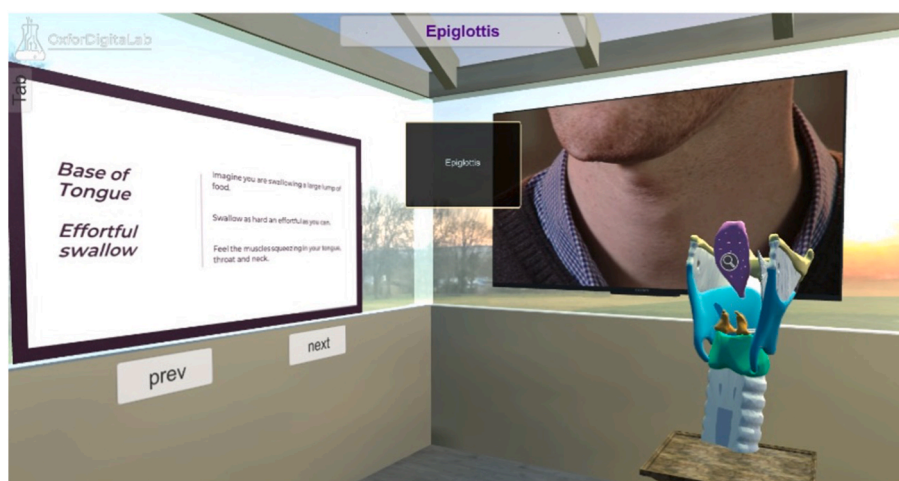


Figure 3: Area with swallowing exercises and model of larynx.

Fig. 3. Behind the resource room screen, visitors can find two more screens showing information on swallowing exercises along with a 3D model of the throat and larynx that can be taken apart to provide a deeper understanding of its anatomy and physiology.



Fig. 4. Before entering the large sitting room, visitors can obtain information about some of the events and social groups run by the cancer treatment centres that have been displayed as wall posters.

4. Results

4.1. Phase 1 – focus groups

4.1.1. Summary of findings: healthcare professionals

Generally, HCPs stated they provided comprehensive information to patients throughout the whole patient journey, with a variety of sources

and organisations referenced. However, some HCPs reported feeling undermined as a result of HNC patients accessing websites which often contained unreliable information, and conflicted with the information they would normally provide. This could result in the generation of ‘urban myths’ surrounding diet, supplements and miracle cures. The identification of reliable, credible information sources were felt to be important throughout the entire patient journey, with Macmillan viewed as an example of this type of high quality informational support.

HCPs commented that peer support, including peer support groups, could be beneficial to patients, but could also pose challenging if peer support wasn’t facilitated appropriately. The presence of an informed HCP to help facilitate peer support groups was perceived necessary to ensure that patients were properly supported and to avoid situations where patients might not be well suited, in terms of their diagnosis, prognosis or treatment trajectories.

HCPs commented that it was important to support patients to recalibrate in terms of their ‘new normal’, something which was often challenging for many. This was especially felt to be true of the HNC patient population where treatment choices and decision-making were often difficult to navigate and might involve therapies that worsened symptoms in the short to medium term. This made provision of the right support at the right time even more important.

In terms of the recovery package, HCPs commented on the potential for a lot of topics and features to be covered. These included anatomy models showing swallowing and speaking functionality, as well as how to perform exercises; how radiotherapy works and why it is necessary; use and use of radiotherapy masks. Topics covering issues related to impaired speech were raised, as well as a suggestion of the creation of a bank of past patient experiences as a ‘library’ of vignettes that could be accessed by patients on an ad hoc basis.

4.1.2. Summary of findings: head and neck cancer patients

HNC patients commonly reported problems with carrying out speaking, eating and swallowing exercises and felt that the recovery package had the potential to facilitate these being undertaken. They also commented that group-based exercises and person-centred exercise plans could be useful areas of focus.

Many HNC participants reported that they often did not receive relevant information fast enough from HCPs, resulting in them searching for information via the internet or from other people who had been through similar experiences related to their cancer. Key issues that HNC participants reported to want to have rapid access to information on

included cancer recurrence, prognosis, speech issues, xerostomia, swallowing issues and feeling stigmatised, which could often result in social isolation.

Some HNC participants commented that it was important to share their own experiences so that they could give back to others, as they had benefited from learning or hearing from others with similar experiences to themselves. They stated that they liked the idea of a 'library' of vignettes or a 'frequently answered questions' system, to enable HNC to both provide, and have access to, support as required.

Three main themes were identified from the focus group data and subsequent narrative summaries: 'pre-operative preparation', 'support' and 'post-operative issues and rehabilitation'.

4.1.3. Pre-operative preparation

The need for information was highly valued by HNC patients, who felt it was only given by HCPs on a 'need to know' basis.

'I'd rather have that information upfront and they're reluctant to give it to you straight way' (Male patient 1).

As a result, patients reported often seeking information online, sometimes finding valuable literature which hadn't been available through their discussions with HCPs:

'There were all sorts of useful things that would have been good straight away' (Male patient 5).

Staff reported finding it useful to give HNC patients pre-habilitation exercises as a means of reducing post-treatment impairments.

'If you get somebody to do exercises before you treat them (...) functioning should be better afterwards (...) we don't often get long with patients before they're treated' (Male staff 4)

Transparent, tailored information specific to HNC patients' needs was felt by HCPs as essential for informing difficult treatment choices, which might cause debilitating side-effects and lifestyle changes. HCPs felt it was important for patients to find a 'new normal', but that accessing the internet for information was not always helpful.

'[It's] a balancing act of trying to almost re-educate someone who's come in with a very strong idea about a cure they've found on the internet ... [We try] to influence them seeking the right kind of information and accurate information' (Female staff 3).

Staff also reported trying to signpost patients towards correct sources of information.

'[We recommend] video footage on the Macmillan website ... There are leaflets ... But I think they often get tucked into a folder' (Female staff 2).

4.1.4. Support

HNC patients reported actively seeking individuals with similar experiences to engage and get reciprocal support from those who understood their situation.

'Suddenly we're all members of this club ... Somebody [is] telling you what is going to happen and being there with you' (Male patient 2).

Some HNC patients reported seeking support from charities such as Heads2gether, commenting that it was *'helping out with our specific thing'* (Female patient 1). Many also reported that peer support enabled them to get a real understanding of what treatment and its legacy were like, with this lived experience and sharing of practical insights being beneficial.

'Somebody who has been through it before will tell you things that nobody else would even think of (...) all sorts of practical things that only another patient can give you' (Male patient 5).

HNC staff also recognised the need for peer support but commented its success was often dependent on the motivations and drive of

individuals. Macmillan's 'buddy training' programme was cited as helpful for ensuring patients were matched with peers with comparable expectations, disease and treatment pathways and that no harm was caused through matching patients with very different treatment journeys.

'We have seen it to be extremely damaging and quite destructive to other patients when it's not gone well' (Female staff 2).

Regarding diet, patient participants reported varying levels of support, some feeling this was sub-optimal, whilst others recounted receiving excellent advice from their dietician about modifying and reintroducing foods based on their pre-surgery preferences. HNC staff commented on the need to carefully manage dietary misconceptions about what sorts of foods were beneficial and which were detrimental to HNC and QoL.

'[Patients have] very strong preconceptions or even post treatment, about diets that will kill cancer or foods that feed cancer' (Female staff 3).

4.1.5. Post-op issues and rehabilitation

All HCPs agreed the functional impact of treatment for patients could be huge, with minimal likelihood of functionality returning to its pre-treatment status.

'It's rarely that anybody gets back to how they were eating, drinking and talking before any kind of treatment' (Female staff 2).

For patient participants the main functional challenges reported related to issues they felt needed substantial investment to overcome.

'They told me I wouldn't be able to speak for six months. So, I was ... determined to prove them otherwise ... There's nothing better than having that spontaneous ability to try to talk' (Female patient 1).

Limited saliva production was a common issue for many patient participants, as well as loss of smell and taste. Concerns that others felt they seemed drunk due to slurred speech often deterred patient participants from entering restaurants and other eateries.

'It's very difficult to eat after you've gone through this treatment ... I don't know how you'd survive without that support [from partner]' (Male patient 1).

4.2. Results from phase 3 – individual virtual interviews

Three qualitative themes were identified: 'ease of use', 'barriers or issues' and 'ideas for improvement' and the participant's Likert scale scores were summarised and presented (Fig. 5).

4.3. Ease of use

The keyboard, mouse and cursor movements were reported to be intuitive and easy to manoeuvre the virtual room, once participants had become accustomed to them.

'I don't play computer games, but it got easier towards the end as I got used to it' (Participant 2- Male).

The interactive 3D anatomy model evaluated very positively and was reported to provide real value. Its interactive element gave participants the opportunity to visualise the larynx from different angles, which was deemed to be helpful and informative.

'It gives you an idea of what bits of your body being treated look like and where they are' (Participant 1- Male).

'Using the model ... You can reset it, or you can put it back together as a puzzle. It will make an immersive experience on a headset. I would have used it myself a few years ago had it been available' (Participant 4- Male).

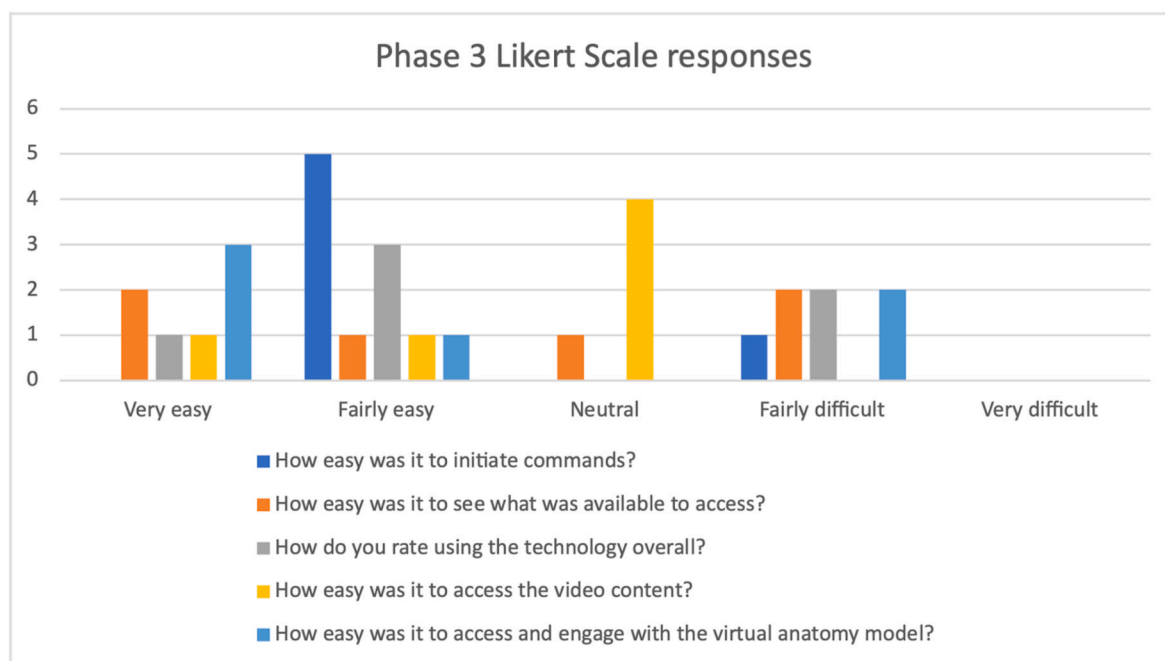


Fig. 5. Phase 3 questions and Likert scale responses.

Participants reported that the platform was more engaging than the usual generic informational materials and resources they were provided with.

'The website is more fun as opposed to using generic materials ... I got insight into a whole new virtual world' (Participant 2- Male).

Additionally, the information provided was deemed to be pitched at the right level, without being too heavy and the different media types were reported to add value.

'The video vignette was good- great to see real people doing the exercises, seeing it demonstrated and being able to read the words simultaneously' (Participant 6- Female).

The immediacy and the accessibility of the platform was positively evaluated, with the ability to access resources from home being beneficial, both due reduced travel time and the Covid-19 restrictions. However, a potential barrier in terms of fitting the headset was raised.

'It will be good when people don't have to travel long distances, sometimes on their own, exhausted from treatment ... and would have been particularly useful in our current circumstances ... [It's] relevant and fun; I enjoyed the interactive nature, the AR product would appeal to younger people and it will be good when on a headset and in fact is a USP ... Whilst remembering that 'some surgery may mean that a headset is difficult to use' (Participant 2- Male).

4.4. Barriers or issues

The biggest barrier to using the platform was reported to be related to technical issues, with some participants needing assistance to use the platform or navigate the room.

'It wasn't obvious that I needed to turn to see the screen and I got caught in the coffee table and couldn't move about' (Participant 1- Male).

Though most participants enjoyed using the WebXR platform and found the resources useful, not all participants could see its benefit or the value of the different media types available.

'I didn't feel it offered anything you wouldn't get from normal information/internet' (Participant 3- Male)

4.5. Ideas for improvements

Participants had numerous ideas about how the recovery package could be refined. These included practical, functional and navigational issues, which could cause frustration at times.

'[The anatomy model] kept rotating and I would have preferred if it had stopped so I could look at it in more detail' (Participant 2- Male).

Additionally, participants commented they would have liked more interactive materials and that it wasn't always clear which features they were meant to be interacting with or what the purpose of the resource was.

'It wasn't obvious as we went round the room what we could engage in or what was even there' (Participant 5- Male).

5. Discussion

The findings have demonstrated that WebXR technology is a feasible way of providing self-management support to HNC patients, by assisting them to take ownership of their health and lifestyle practices (Davies and Batehup 2011). Quality of life and daily functioning have been disrupted by Covid-19 challenges, affecting patients' physical, psychological and social experiences. (Hearn Heath et al., 2022). Participants could see the widespread potential benefits of the WebXR platform for providing a supportive, interactive forum for HNC patients who might be limited in their ability or desire to access real-life patient support settings. HCPs also saw its role as part of the work up and preparation for treatment. As well as being a medium for increasing patient knowledge, confidence and empowerment, the platform also has practical benefits in terms of reducing patient travel time, reducing the need for frequent face to face contact from HCPs and increasing accessibility of resources during a pandemic era. This is increasingly important with the pandemic limiting face-to-face contact; innovative solutions are required to maintain and enhance patient engagement and rehabilitation (Thomas

et al. 2020). Participants' recommendations relating to how they would 'like an events calendar on the wall for those who wish to engage with the [Maggie's] centre' (Participant 4-Male), 'more information on where to go to get information and to be able to read the books more easily' (Participant 6-Female), have shown that there is interest and potential future possibilities for this type of support for HNC patients and other types of cancer patients globally. The study had some limitations; two participants could only access the platform via a mobile or tablet device, both of which have navigation restrictions. These participants received a tour of the virtual space, rather than interacting with the space fully as intended. Further work to make the platform more user friendly on a variety of media is required. The amount and variety of content that could be presented in this study was also limited, due to resource limitations. As such, attention was given to demonstrating a proof of concept platform for a variety of media types in the future. The feedback provided by phase 3 participants relating to the platform's value and potential, whilst suggesting alterations and developments for enhancing user acceptability and interaction, can be incorporated into future prototypes. A larger scale study is needed to develop a more sophisticated prototype and to undertake testing in the HNC setting, including an evaluation of the platform's usefulness to patients and HCPs.

WebXR technology has the potential to be incorporated into clinical cancer care nursing and rehabilitative environments to provide complementary support to HNC patients who might benefit from regular interactive and tailored support, but who are not ready to engage with larger, face-to-face settings due to increased anxiety, lowered self-esteem and functional issues.

6. Conclusion

This study, although interrupted and frustrated by COVID-19, sought opinions of HNC patients and HCPs to evaluate the WebXR recovery platform prototype. Findings will assist in determining the potential development of the technology into an additional treatment resource for HNC patients, as an alternative to traditional information giving routes, utilising patient experience, peer support and HCP advice.

Policy makers, clinicians and hospital managers should consider the real benefits of this technology whereby it designs and tests interventions to help patients self-manage their treatment related side-effects as well as providing complementary support to HNC patients, as a means of empowering them to adjust to their 'new' normal as part of their ongoing cancer journeys.

Funding

This work was supported by a grant from Oxford Brookes University.

Declaration of competing interest

I can confirm that none of the authors have or had a conflict of interest with regard to this study submitted to you for consideration.

Acknowledgements

We would like to express our thanks to the participants of this study, both the health care professionals and the service users who generously gave us their time, and to the Oxford University Hospitals NHS Trust who permitted us to use their premises. CH is a National Institute for Health Research (NIHR) senior nurse and midwife research leader, and also acknowledges the support of the NIHR Oxford Cognitive Health Clinical Research Facility and the Oxford Precision Psychiatry Lab, NIHR Oxford Health Biomedical Research Centre, Oxford, UK. The views expressed in this article are those of the author(s) and not necessarily those of the NIHR, or the Department of Health and Social Care.

References

- accuvein.com, 2020. Vascular Visualisation Technology.
- Bakitas, M., Dionne-Odom, J.N., Jackson, L., Frost, J., Bishop, M., Li, Z., 2017. There were more decisions and more options than just yes or no": evaluating a decision aid for advanced cancer patients and their family caregivers. *Palliat. Support Care* 15, 44–56. <https://doi.org/10.1017/S1478951516000596>.
- Baus, O., Bouchard, S., 2014. Moving from virtual reality exposure-based therapy to augmented reality exposure-based therapy: a review. *Front. Hum. Neurosci.* 8 (112), 1–15. <https://doi.org/10.3389/fnhum.2014.00112>.
- Biggs, T.C., Jayakody, N., Best, K., King, E.V., 2018. Quality of online otolaryngology health information. *J. Laryngol. Otol.* 132 (6), 560–563. <https://doi.org/10.1017/S0022215118000774>.
- Bjorklund, M., Sarvimäki, A., Berg, A., 2008. Health promotion and empowerment from the perspective of individuals living with head and neck cancer. *Eur. J. Oncol. Nurs.* 12 (1), 26–34.
- Covrig, V.I., Lazăr, D.E., Costan, V.V., Postolică, R., Ioan, B.G., 2021. The psychosocial role of body image in the quality of life of head and neck cancer patients. What does the future hold? - a review of the literature. *Medicina (Kaunas)* 57 (10), 1078, 9. <https://doi.org/10.3390/medicina57101078>.
- Davies, N., Batehup, L., 2011. Towards a personalised approach to aftercare: a review of cancer follow-up in the UK. *J. Cancer Survivorship* 5, 142–151.
- Dunne, S., Coffey, L., Sharp, L., Desmond, D., Gooberman-Hill, R., O'Sullivan, E., Timmonds, A., Keogh, I., Timon, C., Gallagher, P., 2019. Integrating self-management into daily life following primary treatment: head and neck cancer survivors' perspectives. *J. Cancer Surviv* 13, 43–55. <https://doi.org/10.1007/s11764-018-0726-4>.
- Fallon, E.A., Driscoll, D., Smith, T.S., Richardson, K., Portier, K., 2018. Description, characterization, and evaluation of an online social networking community: the American Cancer Society's cancer survivors network®. *J. Cancer. Surviv.* 12 (5), 691–701. <https://doi.org/10.1007/s11764-018-0706-8>.
- Fang, C.Y., Heckman, C.J., 2016. Informational and support needs of patients with head and neck cancer: current status and emerging issues. *Cancers Head Neck* 1 (15), 1–9. <https://doi.org/10.1186/s41199-016-0017-6>.
- Ferlay, J., Colombet, M., Soerjomataram, I., Mathers, C., Parkin, D.M., Pineros, M., Znaor, A., Bray, F., 2019. Estimating the global cancer incidence and mortality in 2018: GLOBOCAN sources and methods. *Int. J. Cancer* 144, 1941–1953. <https://doi.org/10.1002/ijc.31937>.
- Ferlay, J., Soerjomataram, I., Dikshit, R., Eser, S., Mathers, C., Rebelo, M., Maxwell Parkin, D., Forman, D., Bray, F., 2015. Cancer incidence and mortality worldwide: sources, methods and major patterns in GLOBOCAN 2012. *Int. J. Cancer* 136. <https://doi.org/10.1002/ijc.29210>.
- Gale, N.K., Heath, G., Cameron, E., Rashid, S., Redwood, S., 2013. Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Med. Res. Methodol.* 13 (117), 1–8. <https://doi.org/10.1186/1471-2288-13-117>.
- Gatta, G., Botta, L., Sánchez, M.J., Anderson, L.A., Pierannunzio, D., Licitra, L., 2015. EUROCORE Working Group: Prognoses and improvement for head and neck cancers diagnosed in Europe in early 2000s: the EUROCORE-5 population-based study. *Eur. J. Cancer* 51 (15), 2130–2143. <https://doi.org/10.1016/j.ejca.2015.07.043>.
- Gerup, J., Soerensen, C.B., Dieckmann, P., 2020. Augmented reality and mixed reality for healthcare education beyond surgery: an integrative review. *Int. J. Med. Educ.* 11, 1–18. <https://doi.org/10.5116/ijme.5e01.eb1a>.
- Guest, W., Wild, F., Vovk, A., Lefrere, P., Klemke, R., Fominykh, M., Kuula, T., 2018. A technology acceptance model for augmented reality and wearable technologies. *J. Univers. Comput. Sci.* 10:3217/jucs-024-02-0192.
- Hearn Heath, J., Rohn, E.J., Monden, K.R., 2022. Isolated and anxious: a qualitative exploration of the impact of COVID-19 pandemic on individuals living with spinal injury in the UK. *J. Spinal Cord Med.* 45 (5), 691–699. <https://doi.org/10.1080/10790268.2021.1949562>.
- Kelly, R., Gordon, P., Thompson, R., Semple, C., 2022. Availability and use of web-based interventions for patients with head and neck cancer - a scoping review. *J. Cancer Surviv.* <https://doi.org/10.1007/s11764-022-01168-1>.
- maggiescentres.org (n. d). Maggie's Evidence based programme web spreads. Retrieved from https://maggies-staging.s3.amazonaws.com/media/filer_public/78/3e/783ef1ba-cd5b-471c-b04f-1fe25095406d/evidence-based_programme_web_spreads.pdf.
- Massa, S.T., Osazuwa-Peters, N., Boake, E.A., Walker, R.J., Ward, G.M., 2019. Comparison of the financial burden of survivors of head and neck cancer with other cancer survivors. *JAMA Otolaryngol.- Head Neck Surg.* 145 (3), 239–249.
- Nund, R.L., Ward, E.C., Scarinci, N.A., Cartmill, B., Kuipers, P., Porceddu, S.V., 2014. Survivors' experiences of dysphagia-related services following head and neck cancer: implications for clinical practice. *Int. J. Lang. Commun. Disord.* 49 (3), 354–363. <https://doi.org/10.1111/1460-6984.12071>.
- Riva, G., Banos, R.M., Botella, C., Mantovani, F., Gaggioli, A., 2016. Transforming experience: the potential of augmented reality and virtual reality for enhancing personal and clinical change. *Front. Psychiatr.* 7 (164), 1–14. <https://doi.org/10.3389/fpsy.2016.00164>.
- Semple, C., Dunwoody, L., Kernohan, W., McCaughan, E., Sullivan, K., 2008. Changes and challenges to patients' lifestyles following treatment for Head and Neck Cancer. *J. Adv. Nurs.* 63 (85–93).

- Simple, C., Parahoo, K., Norman, A., McCaughan, E., Humphris, G., Mills, M., 2013. Psychosocial interventions for patients with head and neck cancer. *Cochrane Database Syst. Rev.* 16 (7).
- Thomas, S., Mancini, F., Ebenezer, L., Price, J., Carta, T., Cordasco, J., Tedesco, C., Gillett, S., 2020. Parkinson's disease and the COVID-19 pandemic: responding to patient need with nurse-led telemedicine. *Br. J. Neurosci. Nurs.* 16 (3) <https://doi.org/10.12968/bjnn.2020.16.3.131>.
- Tong, A., Sainsbury, P., Craig, J., 2007. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *Int. J. Qual. Health Care* 19 (6), 349–357. <https://doi.org/10.1093/intqhc/mzm042>.