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Perspectives of healthcare professionals on the use of immersive virtual reality in teenage and young adult oncology: a qualitative interview study

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Abstract

Background Applications of Virtual Reality (VR) in healthcare continue to grow at a rapid pace, yet the challenges and opportunities associated with VR from the perspective of clinicians and healthcare staff remain underexplored, particularly in the context of Teenage and Young Adult (TYA) oncology. This study aims to bridge this knowledge gap by interviewing clinicians and staff regarding the use of VR in TYA cancer care.

Method Fourteen semi-structured qualitative interviews were conducted with a diverse range of healthcare professionals working in TYA oncology within the United Kingdom including oncologists, hematologists, clinical nurse specialists, clinical psychologists, radiographers, play specialists, clinical social workers and youth support coordinators. Data were analysed thematically with three themes and ten sub-themes developed.

Results The findings reveal that TYA healthcare professionals are optimistic and enthusiastic about the potential of using VR to enhance cancer care for teenagers and young adults. However, they also expressed notable concerns related to the practical implementation of VR in clinical settings. These concerns included infection and safety risks, privacy and security concerns, cost implications, storage requirements and staff burden. Clinicians and staff proposed valuable applications for VR in TYA oncology specifically in patient distraction, physiotherapy, procedure preparation, and the delivery of psychotherapy, including acceptance and commitment therapy.

Conclusions This research has demonstrated that despite an enthusiasm to adopt VR in TYA oncology there are still many challenges, both practical and ethical, that must be addressed to enable the successful implementation of VR in hospitals within the UK. Further research into applications of VR for TYA oncology is warranted, particularly in areas of psychology, physiotherapy, and procedure preparation.

Keywords TYA oncology, Virtual reality, Medical virtual reality, Qualitative, Digital health

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Introduction

Virtual Reality (VR) has become increasingly popular around the world, largely due to the increased accessibility and affordability of VR headsets [1]. Immersive VR allows users to interact within simulated 3D virtual environments, typically via a head-mounted display.

Users can experience a sense of physical presence when immersed in VR, this phenomenon has been exploited in healthcare [2]. Over the last decade, the use of VR in healthcare has grown, with many potential applications emerging from academia, clinical settings and industry. Applications of VR in healthcare have demonstrated considerable success in rehabilitation, psychotherapy, surgical training and as a distraction mechanism [3–7]. Recently, VR has been implemented across different phases of the oncology pathway [8, 9]. Most notably in the distraction of patients during treatment to lower pain and anxiety [5, 10]. Other applications include the use of VR to decrease hospital anxiety, improve cancer-related symptoms, alleviate symptoms of psychological distress and promote patient autonomy [9, 11]. Despite a growing literature base, clinical applications of VR in oncology remain limited and predominantly focused on the adult population. There are currently no studies to date exploring the use of VR in Teenage and Young Adult (TYA) oncology.

As avid technology users, teenagers and young adults stand to benefit greatly from the integration of digital technologies into care pathways [12–14]. The TYA population exhibit unique developmental characteristics meaning that they differ from the paediatric and adult population both in physical and neurocognitive maturation [15]. Despite this, studies exploring applications of VR in healthcare continue to group the TYA population with young children or adults. This limits our knowledge and understanding of TYA specific outcomes. In the UK, there are designated hospital units for TYAs diagnosed with cancer. The units are designed specifically to meet the needs of teenagers and young adults aged 16–24 years of age. TYA units differ from adult wards in that there are additional specialised staff members, clinical and non-clinical, employed to meet the holistic care needs of young people. These roles include designated TYA social workers, clinical nurse specialists and Youth Support Coordinators (YSC). TYA units in the UK present as novel environments to explore applications of VR for young people with cancer. No studies to date have conducted qualitative VR research within TYA units thus our understanding of the challenges and opportunities for VR in this population within this context are limited.

While VR technology continues to accelerate at a rapid pace, it is of paramount importance that the design, development and deployment of medical VR applications take a human-centered and collaborative approach. This ensures that applications of VR in clinical settings are driven by a clinical need rather than by technological advances. Qualitative studies exploring the perspectives of healthcare professionals on the use of VR have been conducted in areas of healthcare such as psychiatry [16], nursing education [17] and in care homes [18]. These studies revealed that while healthcare professionals are enthusiastic about adopting VR technology, they have many concerns regarding the feasibility and safety of using VR technology in care settings as well as concerns about the effectiveness of using VR to deliver treatment (e.g., delivery of psychotherapy). Qualitative studies involving healthcare professionals in VR research remain scarce and there is currently a gap in the literature, namely the lack of comprehensive insight into the specific needs and requirements of healthcare professionals regarding the use of VR in TYA oncology. This study was conducted to address this gap by examining the opinions and perspectives of healthcare professionals working in TYA oncology. The primary aim of the study was to provide insights into the use of VR in TYA oncology through qualitative research that can lead to the generation of novel hypotheses.

This paper reports on an in-depth qualitative interview study conducted with clinicians and healthcare staff working in TYA oncology in the United Kingdom (UK). The interviews explored participants perspectives on VR technology and potential use cases in TYA oncology. The study also explored the feasibility of introducing VR into TYA oncology, with discussions around the practical considerations for successfully deploying VR in clinic. By interviewing a diverse range of healthcare workers spanning the full range of disciplines in oncology including oncologists, haematologists, radiographers, clinical nurse specialists, play specialists, physiotherapists and social workers, this study outlines the barriers for VR adoption and highlights potential areas for future VR research and development in TYA oncology.

Background

Applications of VR in oncology

Oncology is a complex care pathway involving a wide range of treatments and disciplines. VR therefore has potential across different areas of the pathway. Below, current uses of VR in oncology have been presented, specifically in the areas of physiotherapy, rehabilitation, treatment, mental health and procedure preparation.

Applications of VR in physiotherapy for oncology patients remain scarce. Uses of VR in other disciplines of physiotherapy such as neurology and rheumatology are steadily increasing, with a recent review of knowledge stating the many benefits of VR physiotherapy [19]. Reported benefits include improved balance and daily actions in a shorter time than expected, reduced pain during physiotherapy and improving patient independence. Of the 152 articles included in the review, only two were specific to cancer [20, 21], both were small-scale feasibility studies focusing on the adult population. The

first study found that using upper-extremity virtual rehabilitation therapy for the management of chronic pain in cancer patients post-surgery, can indicate improvement in cognition, shoulder range, strength, function and depression [20]. The second study found that using VR improved adherence to physical therapy exercises and helped patients with hematologic malignancies receiving chemotherapy to maintain physical fitness [21]. However, the study included elderly patients with cancer therefore had a high-dropout rate of 44% due to declining health during the study period. This was similar to findings from a narrative review which found nine uses of VR in cancer rehabilitation [22]. Of the nine studies in the review, none focused on TYA population. Given that VR has demonstrated increased engagement with physiotherapy exercises, and in some cases even improved treatment outcomes when compared to traditional physiotherapy [23], it appears that the potential advantages of VR in the context of physiotherapy and the rehabilitation of cancer patients remains largely unexplored, especially in younger populations.

VR has been explored as a distraction mechanism for people undergoing chemotherapy and painful procedures [24, 25]. These studies are predominantly conducted in the adult population [25–27], with a recent systematic review reporting only nine studies exploring the use of VR as a distraction for children undergoing chemotherapy [28]. The findings across the nine studies demonstrated that immersion in virtual environments can effectively reduce cancer-related procedural pain. Participants ranged from ages 6–18 years old, with no studies differentiating between the outcomes of younger children and adolescents, despite research demonstrating that children and adolescents experience VR differently [29]. Other studies have investigated the use of VR to reduce procedural pain, such as a mixed-method usability study [24]. This study explored the usability of an interactive mobile-based VR experience for children (0–18 years) with cancer and found high acceptability rates of the VR experience. Many studies outside the oncology context have demonstrated the success of VR as a distraction tool [27, 30–32], suggesting the potential value of further exploration into additional applications of VR as a distraction intervention in teenage cancer care.

VR has been applied extensively in the field of mental health and psychiatry [33, 34]. With significant research in this area demonstrating the effective use of VR to deliver various forms of psychotherapy including Cognitive Behavioural Therapy (CBT) and exposure therapy [3, 35]. In oncology, novel VR applications have been developed to deliver psychological interventions tailored to cancer patients. For example, VR-Calm, a VR app used to manage symptoms of cancer, relieve psychological distress, and improve the quality of life in breast cancer survivors [36]. Immersive VR has the potential to widen access to psychological therapies and reduce the burden on healthcare services by providing automated interventions in a safe and controlled environment. This could be of particular benefit to young people with cancer, given that studies in this area continue to highlight the unmet physical, psychological and psychosocial needs of TYAs with cancer [37, 38]. Research has also suggested that using digital technologies to support and deliver psychological interventions may improve the engagement of the TYA population in such therapies [39].

Finally, VR is used as a tool to prepare people for hospitalization, treatment and procedures. In oncology this has included allowing patients to experience virtual radiotherapy, MRI scans and tours of cancer wards. In England, four hospital trusts have created 360-degree video tours of their hospital wards, waiting rooms and theatres [40–43]. The Kings College Hospital in London have a smartphone VR application that allows children to experience an MRI scan remotely before their hospital visit, with a qualitative study reporting that patients felt more positive about their MRI after using the app [44].

While research into VR in oncology continue to increase, there remains limited translational research in this domain, with only a limited number of VR tools for oncology reaching clinical practice [44] and none currently used in TYA oncology. Increasingly, researchers have suggested that the lack of translation of VR into clinical practise is due to the lack of engagement with clinicians during the development phase of VR applications [45]. Moreover, studies of VR in oncology, similar to those reported above, often explore VR within disparate parts of the cancer pathway, rarely adopting a more comprehensive approach that looks at the cancer pathway as a whole. Understanding the perspectives of a wide range of TYA healthcare workers, from play specialists and social workers to clinical nurse specialists and oncologists, could elicit more nuanced use cases for VR in TYA oncology and provide actionable insight into TYA specific challenges of integrating VR technology across different disciplines of TYA oncology [46–48].

Method

Study design

A qualitative study, involving semi-structured one-to-one interviews with healthcare professionals working in TYA cancer services in the UK was conducted. Ethical approval was granted by the University of Bristol Engineering Faculty Research Ethics Committee.

Participants and recruitment

Fourteen clinicians and healthcare staff members working in TYA oncology in the UK were recruited for semi-structured interviews. Clinical and non-clinical staff members (e.g., social workers and youth support coordinators) working in or with TYA cancer units were eligible for participation. This included paediatric staff members who work in transitioning children into TYA units. The inclusion of all staff members working with the TYA unit ensures a wide range of views and perspectives were gathered, helping to create a pragmatic view of the challenges and opportunities for adopting and deploying VR in TYA oncology. The job roles of the participants are detailed in Table 1.

Participants were identified through professional networks of the researcher and supervisory team. Originally, purposive sampling was planned, aiming for diversity with regards to gender, ethnicity, discipline/professional background. However, in practise this proved challenging given the busy schedules of clinicians and staff working in oncology and healthcare worker strikes in the UK. We therefore adopted opportunistic and snowball sampling methods whereby interview participants recruited through professional networks were asked to reach out to people in their professional networks who may be interested in participating.

We undertook iterative sampling, analysis and the sample size was determined using the principles of information power [49]. Participants all had extensive expertise in the field of oncology therefore provided highly specific and in-depth knowledge in the interviews, thus generating a high level of information power. The richness of data collected was sufficient to address the research aims and conduct a thorough thematic analysis.

Table 1 Summary of Interview Participants Job Roles

Participant	Job Title
P1	Therapeutic radiographer
P2	Consultant paediatric and TYA haematologist and oncologist
P3	TYA clinical nurse specialist
P4	Health Play Specialist
P5	TYA clinical liaison nurse
P6	Bone marrow transplant clinical nurse specialist
P7	Clinical psychologist
P8	TYA Social worker
P9	Clinical psychologist
P10	TYA clinical nurse specialist
P11	Clinical psychologist
P12	Youth Support Coordinator
P13	Youth Support Coordinator
P14	Clinical nurse specialist

Data collection

Interviews were conducted remotely via Microsoft Teams and lasted on average 1 hour (range 30 minutes – 1 hour 35 minutes). The interviews were semi-structured and focussed on 3 main areas. Semi-structured interviews allowed for adequate flexibility in the interviews given the diverse range of participants recruited. Data were collected using a semi-structured interview guide (Text file in Additional file 1) jointly developed by the research team. Firstly, participants were asked to summarise their daily routines and general role in oncology. The aim of this was to gather contextual information about TYA oncology pathways, helping to contextualise their perspectives and experience of technology in healthcare.

The second part of the interview focused on their current use of technology within their jobs. This provided insight into what technologies, if any, are currently used in oncology services and how these technologies were deployed. This part of the interview also explored the challenges and opportunities of using technology in oncology and the feasibility of implementing new technologies. This discussion then led to the final part of the interview which focussed on VR. Participants were asked about their opinions on VR technology, specifically immersive virtual reality headsets, and their views on using VR in oncology. They were also asked about the feasibility of using VR in their jobs and discussed potential use cases as well as potential challenges to adopting VR in their role.

Data analysis

We applied an inductive thematic analysis to the qualitative data [50]. The pseudonymised transcripts, created directly after the interviews using audio recordings, were reviewed independently by the first and second authors (MD and DS). The first author has a background in bioengineering and digital health, the second author is a medical doctor with experience working in TYA oncology. Both authors read through each interview transcript independently to familiarise themselves with the data, creating notes of initial impressions and suggesting ideas for codes. The authors then met up to discuss and refine their codes and create a coding framework. Using NVivo 12 software [51], this framework was applied to the rest of the transcripts and refined with each new transcript. In collaboration over the course of several meetings, the authors then created themes around the experiences of participants use of technology in their role and their perspectives on introducing VR into TYA oncology. This

was done by organising and grouping codes together, for example grouping all codes that pertained to the use of technology together under one theme. Sub-themes were also created within each theme. The first author met regularly with the remaining authors AB and KC to discuss codes and refine themes and sub-themes. AB has an academic background in health psychology and digital health and KC has a background in computer science and Human Computer Interaction. Once all authors had agreed on the grouping of codes into themes and subthemes within, the first author read through the transcripts again to ensure no data had been overlooked and the themes accurately captured the sentiments of the participants. The analysis was then stopped and quotes from each theme and sub-theme were extracted from the transcripts and are presented below.

Reflexivity

The author conducting the interviews currently conducts research in the medical VR field; we therefore acknowledge that this may influence the interpretation and analysis of the findings. As such, steps were taken to consider the positions and intentions of each researcher and ensure transparency in the reporting process. Firstly, the two authors conducting the analysis had different academic backgrounds and interests; one was an engineer with research interests in medical VR while the other was a medical doctor with no experience in VR. The medical doctor independently read the verbatim transcripts after each interview and developed codes and initial thoughts before meeting with the author conducting the interview. This ensured the interpretation was not biased by the research interests of the first author and provided a more comprehensive understanding of the data collected from clinical participants. All four authors work in different research areas and have different academic backgrounds bringing diverse perspectives and lenses through which the data was interpreted and analysed. The author conducting the interviews did not discuss their background or interests in VR with the participants in the interview and encouraged participants to discuss their concerns openly. There was no existing relationship between the research team and the participants.

Results

Through thematic analysis, three themes and 10 subthemes were developed. The first theme outlines participants past and present experiences of using technology in their job. The second theme highlights the opportunities for VR in TYA oncology including potential use cases for VR in oncology. The third theme is centred around the perceived challenges surrounding the successful development and adoption of VR in TYA oncology.

Theme 1: technology used in TYA oncology: valuable but burdensome

Participants all had experience using varied forms of technology in their day-to-day roles. This theme describes the experiences of participants using technology within their role. Specifically outlining the value of technology in oncology and the struggles to access and maintain technology in hospitals. The sub-themes within also describe the attitudes of adopting and maintaining new technologies in oncology, which are largely based on their previous experiences with technology.

The burden of tech responsibility

While some participants only had experience using computers to access health records and record notes, others had vast experience using a range of technologies from laptops and tablets to movement sensors and VR headsets. For most participants, any type of technology was considered a valuable and limited resource. While experience with technology differed, all participants explained they were solely responsible for the technology they used daily. For tablets this meant updating, charging and downloading apps for use with patients. For VR headsets this meant finding suitable storage, implementing cleaning protocols and downloading content. This led to technology being viewed as a burden, with participants commenting on the lack of technical support available in the hospitals, attributed mostly to short staffing of hospital IT departments. This left them solely responsible for making sure the technology was functioning correctly which added to their stress and workload.

All participants who had access to an iPad or tablet device, explained that they were responsible for screening and vetting apps to use with patients. For example, P4 discussed finding apps and content online to help prepare children for procedures, scans and surgery. When asked about the process of vetting apps P4 explained:

> *"it's quite often if we find something that we think could be useful we'll just go for it. And that might be shared amongst other play therapists like if someone found something that's particularly good then yeah we'll share it about but mostly just leading ourselves. There aren't many scenarios, I guess, where there's someone external coming into introduce tech to us or show us other Apps now." [P4]*

This same process was described by 5 other participants who were solely responsible for finding suitable apps to recommend and use with young people. This was seen as a barrier to using the technology as they knew they'd have to spend time researching and vetting applications.

Negative experiences with technology deployment led to technological scepticism. Participants described

experiences where technologies were introduced into their services and later removed. This led to technology scepticism amongst clinical participants as they didn't want to risk introducing technology to patients that may not be permanent. An example of this was in radiotherapy where a tablet was introduced to allow radiotherapy patients to visualise their breathing when learning Deep Inspiration Breath Hold (a technique commonly used during radiation to minimise the dose of radiation reaching the heart [52]). P1 describes how the visual aid was *"really helpful for patients as they could see when they weren't correctly performing the technique and adjust without our help"* [P1]. Unfortunately, due to security and privacy concerns, the tablet device was no longer permitted for use. P1 explained *"I don't know, in the long run, what the actual problem for that is and why they've not implemented it again"* [P1], indicating that there was no clear reason for the removal of the technology or for the future introduction of it despite its success with patients. Other participants shared similar experiences, with three participants describing a mobile app that was launched and then "*paused with no reason given at all*" [P5]. The app was intended as a social media platform for young people with cancer. Participants shared frustrations over this and discussed the negative impact of providing patients with a support platform that they couldn't guarantee would always be available. Ensuring new technologies were reliable, safe and permanent was considered essential for all participants. The lack of clarity around the reasons that technologies are paused or removed also adds to scepticism and uncertainty surrounding future technological implementations.

In some instances, participants viewed using technology as a hindrance to their job and therefore were sceptical about future technology adoption. For some, this was because they did not see themselves as competent technology users and didn't think technology would save them time as described:

> *"I'm not the most sort of technical minded person, so it's not something I naturally gravitate towards. I never sort of think, Oh, I'm gonna get X that could really save me time. Because yeah, I know, personally, by the time I've learnt to use it, or do it, probably could have just done what I need to do myself" [P6]*

Some participants explained that if technology became outdated or stopped working, there would be no replacement unless they could find additional funding:

> *"We did have a couple of ipads on [ward name] which basically got to the point where they weren't updating in terms of like software, they were too old as models. So we're looking at some funding we've got to be able to get a couple that we can just give out to patients" [P4]*

This again led to scepticism of using technology as they couldn't be certain of the reliability and longevity of the technology.

Attitudes towards adopting new technologies: perceived effectiveness and efficiency.

Participants shared past experiences, both positive and negative, of adopting a new technology into their job roles. Most participants indicated that the adoption of a new technology was likely to be driven by its perceived effectiveness and its potential to save time: "*If it works and will save time then I'll learn how to use it"* [P14]. This was a recurring sentiment across participants, whereby the introduction of a technology was measured based on the perceived usefulness and value of the technology both for their patients and themselves. Most participants were passionate about adopting new technologies in their role but explained that time was their most valuable and scarce resource:

> *"is this going to save me a job? you know how is this gonna is this going to stop me needing to sit in the room, with this young person? Does this require my supervision? does this require me to set it up?" [P2]*

These concerns were raised by many participants, particularly the clinical participants who must prioritise their clinical work and have an increasing patient load.

Theme 2: VR is well suited to the TYA population and has potential across oncology disciplines

All participants were enthusiastic about introducing VR into TYA oncology. They discussed the potential use cases for VR in psychological therapy, rehabilitation, alleviating loneliness, distracting patients and procedural preparation. This theme highlights participants views on the opportunities for VR in TYA oncology. The subthemes within discuss current and potential use cases of VR in TYA oncology, the potential impact of VR on patient care and the benefits of VR for staff and clinicians.

Digital health for a digital generation

Participants described the TYA population as "*tech-savvy*" and "*fully equipped with technologies*" [P12]. Participants therefore stated that they were keen to keep up with technology advancements and ensure their patients were benefitting from them. Participants described technologies such as VR had to be the future of TYA oncology care and stated "*for young people, especially their generation you know technology is their world"* [P2], indicating

that there is an enthusiasm to adopt novel and advanced technologies to engage young people.

Potential use cases of VR in oncology

This sub-theme highlights all potential applications of VR in oncology suggested by the participants.

Distraction tool

Most participants suggested using VR as a distraction tool during extended hospital stays and periods of isolation. This was suggested as being particularly useful for bone marrow transplant patients who are often isolated in one room for extended periods of time before and after their transplant. Participants also described using VR as a tool to escape:

> *"So I think just as a distraction tool, you know, the equivalent of like a PlayStation effectively, but difference is like it could be they could be in their room but not in their room. That can be really, really helpful. So a bit of an escape" [P11]*

> *"I think distraction is a huge one. When they're here we get a lot of transplant patients, so they are here from minimum of 3 weeks, and for most of those 3 weeks they can't come out of their room" [P13]*

The use of VR for distracting patients before surgeries and painful procedures was also suggested as this is usually a time of heightened anxiety and stress. Participants described sometimes struggling for resources to distract patients, stating that "*I think, most of us would say in our team that we will take kind of anything that's going to support and potentially distract patients when they are struggling*" [P4].

Psychotherapy and mental health applications

Using VR to support mental health and deliver psychotherapy was suggested by participants. Suggested use cases for supporting mental health included mindfulness applications that would allow patients to be immersed in relaxing environments and "*connect to things outside of hospital*" [P11]. Other suggestions included the use of VR to support social connectedness for patients who were isolated. Participants described that many young people experience isolation and loneliness in oncology wards. Participants therefore suggested using VR to allow patients to socialize and connect with others virtually. Particularly for patients who had been isolated for extended periods of time who were "*unable to kind of have any social interaction*" [P6]. Participants emphasized how every patient was different in terms of how much they wanted to interact with other patients and staff but having the option to provide an anonymous form of communication may offer benefit to some patients. For others, they envisioned VR providing an immersive platform to talk to friends and family in a more realistic way.

Participants working in clinical psychology were aware of VR psychotherapy interventions and research, most commonly the use of VR to deliver exposure therapy. Participants stated they thought VR had potential in this area but were cautious about replacing existing practices of care. Moreover, clinical psychologists stated that they can envision VR being used as a tool to help them deliver exposure therapy but that it would be best incorporated into their current practices and be used in a controlled gradual way, as explained below:

> *"I guess you would do that very gradually. And staged, you know, kind of working up to using a VR headset, and then it might be just like, you just put the headset on, and then you just have 10 seconds, and then you say ok now let's talk about staying in longer…So, you know, obviously, you would have to do that in a very sort of controlled, gradual way." [P7]*

Moreover, a clinical psychologist suggested a shift in research directions for VR in psychotherapy for oncology patients by highlighting that most research in the field was focused on CBT and exposure therapy. In their experience however, Acceptance and Commitment Therapy (ACT) and Compassion Focused Therapy (CFT) were more commonly used in TYA oncology: "*I think there is a role for CBT. But probably more of our work is using ACT, Overall, I'd say.*" [P11].

The participant therefore discussed the possibility of developing, or amending existing apps, to create a value based ACT VR application that may be beneficial for the TYA population:

> *"I'm wondering if with the ACT stuff, there might be already this or not, I talked to people a lot about rather than focus rather than getting kind of caught up and stuck with difficult stuff, focusing more on the values and things that are important for them that come out of focus. So I'm wondering if there's any kind of values based act apps that have already been developed that could be tweaked for this population? Because it would need to be quite sensitive because people aren't. They're not deliberately getting caught in suffering. They're not deliberately ruminating on things or anything like that. It's it's the situation often is that, but that's what I say to people often. This is the situation causing the problem, really. So something like that might be helpful". [P11]*

Physiotherapy and rehabilitation

One of the participants had experience using VR with children undergoing physiotherapy. This participant stated that the "*uptake has been good*" [P6] but that more engaging content that incorporated the full body would be more useful for older patients (aged 13+). The focus on mainly upper body movements and the VR hardware only allowing for head and hand tracking was viewed as a restriction on the potential benefits for virtual physiotherapy. Multiple participants could foresee VR being used in rehabilitation and physiotherapy for oncology patients. Participants also suggested the use of VR for 'prehabilitation', a process used to prepare patients for cancer treatment. This can often be a time of heightened anxiety as patients are preparing to start treatment, the use of VR could make this process feel more engaging and manageable under the condition that the pace of the VR program would be controlled by the user.

Procedure preparation

Procedure preparation was suggested by participants who have experience preparing patients for scans, treatment and procedures/surgeries and visiting the hospital for the first time. Participants described that lack of patient preparation for scans, procedures and surgeries can lead to treatment delays and increased risk of trauma. VR was viewed as a promising tool for "*better preparing*" [P4] young people for clinical experiences. Examples included the use of VR for training patients on breathing techniques (specifically deep inhalation breathe hold) they would have to perform during radiotherapy and graded exposure to the MRI scanning process.

There were varied opinions on the safety of patients using VR unsupervised for preparation. On one hand, P1 described "*If they could do any preparation at home, for example, especially with the younger people who might be anxious, that could be quite helpful*" [P1], this was contrasted by P9 who stated "*from a safety perspective I would want to be in the room, with them so I could probably coach them through that, kind of using together*" [P9]. When probed, participants explained that it depended on what they were preparing for. Both participants, and others in the study, agreed that patients experiencing a VR tour of the hospital and the ward at home would be beneficial and reduce anxiety in patients, therefore deemed this safe. However, agreed that if the patient had particular stress or anxiety around scans or a procedure, then the preparation was better managed in the hospital setting with trained staff present to support them through the preparation.

Information needs

Meeting information needs of young people with cancer was described as being challenging as all young people have very different needs and these needs evolve during their cancer journey. VR was suggested as a tool for explaining medical concepts to patients in an engaging way. Participants stated that *"in terms of meeting information needs, I could absolutely see VR playing a role"* [P2]. This was mainly due to VR being viewed as engaging and visual. Visual mediums, such as pictures and leaflets, had shown to be more effective for participants when explaining concepts and procedures to patients, VR was therefore viewed as a useful tool for explaining concept to young people and saving clinician's time.

Theme 3: VR poses both practical and ethical challenges in TYA oncology

While participants were enthusiastic and positive about the use of VR technology in oncology, all participants shared concerns about the safe, effective and efficient use of VR in their job roles. This theme highlights the perspectives of clinicians and TYA staff members with regards to the challenges for VR in TYA oncology. The subthemes within consider practical challenges such as VR storage, maintenance, cost, infection control and safety as well as ethical considerations and the accessibility of technology for both staff and patients. Perspectives on the lack of clinical data to support the use of VR in pediatric and TYA oncology are also presented.

Practical concerns were considered the main barrier to implementing VR in oncology

Cost of VR equipment and maintenance

A prominent concern raised by participants was the cost of the procurement and maintenance of VR equipment. Participants described not only being concerned about the initial cost of the device but also the cost of maintaining the hardware and buying content:

> *"And actually, a lot of the costs are in the maintenance rather than the just buying the initial kit... you only have a small budget, if any, and you have to think really carefully about how you best allocate resources" [P7].*

The lack of available funds described was common to all participants who described either relying on charities or donations to provide funds for new equipment and technology. Often participants had to apply for grants and funding themselves to procure resources and technologies for their department. Participants noted a lack of collective responsibility for technology, stating that procurement often relied on one person. A participant with experience of having a VR headset describes the lack of

long-term support for VR headsets in clinic and the complexity of procuring VR hardware:

"*we had a VR in TYA. And I heard that it stopped working. And then well we have to get funding for another one, when is that gonna happen? So then there's a gap because it'll fall just to someone with an extremely high pressured job to try and find a time to find funding for another VR set... Because there's no group holding responsibility around it. And there's not the safety nets, that of how that how it's managed long term.*" [P11].

Patient safety

Mitigating the risk of infection is critical in oncology wards given that many patients have weakened immune systems either due to their cancer or their cancer treatment. Participants raised concerns that VR hardware could significantly increase the risk of infection spread among patients, particularly if VR headsets were being passed around different wards and rooms. One participant who is currently trialing VR headsets in pediatric oncology described cleaning protocols had been implemented by the nursing team and explained that parents were occasionally nervous about the introduction of VR headsets in their child's shielded room:

> *"there is a cleaning policy in place for the headsets and there's not just one we've got three headsets as well, maybe parents might be a little bit funny about that, but we've had no issues with that so far." [P6]*

Hardware security and maintenance

The storage of VR headsets was mentioned by nearly all participants as a challenge given that there is a lack of secure storage facilities accessible on the wards. Given that procuring VR equipment is a complex and difficult process, participants feared they would be responsible for "*covering all the security issues of having expensive equipment*" [P11]. This led to participants being sceptical about VR deployment as *"a lot of people don't necessarily want to take on the responsibility"* [P6]. The need to secure the headsets and ensure they were charged and maintained regularly was also raised by all participants, with one explaining "*it would need quite careful planning on how it was charged, who looked after it etc. The fact is that it would go walkabouts if not, and it would need a secure place to live*" [P3].

Wi-fi access

Wi-Fi access was a recurring theme throughout the interviews with nearly all participants experiencing difficulties with internet access in hospitals on at least one occasion:

> *"Obviously some areas have rubbish wifi as all hospitals" [P3]*

> *"But actually the main issues are like the Wi-fi, is it going to connect to it?" [P12]*

Based on their experience of using tablets and game stations on the wards, participants were hesitant about using VR apps that required a strong and reliable internet connection. Wi-Fi was already viewed as a barrier to technology use in general with participants explaining the impact this had on patients trying to play online games:

> *"So our wi-fi is terrible, and generally that is not strong enough for them to be able to join and play with their friends" [P12]*

Staff shortages and time

Most participants in this study described staff shortages and high staff turnover rates in their departments. This, coupled with the recent COVID-19 pandemic, had led to many healthcare services being overrun. In some cases, this meant participants had long waiting lists to see patients and for others this meant spending less time with their patients. For all participants, time was considered their most scarce and valuable resource. One participant explained that "*the difficulty is that there's a lot of staff shortages, so like the clinical care takes priority*" [P6]. This was a shared sentiment across participants whereby the use of technologies, particularly the use of experimental technologies, was considered a luxury that they could not afford.

The lack of available time also meant there was less time for staff to research technologies that may improve care for patients. One participant even explained that that they had access to VR headsets but due to a lack of time and no provided training the headsets were not used: *"I've got headset in there, but I've never even got out, because I don't know how to link it up to stuff"* [P12]. This led to most participants stating that they wouldn't be best situated to introduce a new technology into their role or department.

The use of VR raises several ethical considerations and concerns

Patient safety

The appropriate "*marketing of the VR*" [P2] was considered essential for the safe and ethical use of the technology. Clinical psychologists in the study discussed their previous experiences using mental health phone apps and how this impacted their view on recommending VR for mental health. A principal concern was that the young people would misuse the technology if it was not properly explained and delivered. This was a particular risk for mental health VR apps intended for patients to use unsupervised. P7 explains their concerns:

"*But again, you know, having to be very clear about this is not somewhere to come. And you know, if you're in trouble medically or otherwise, this is not where you come, you know, we don't monitor it, we don't respond quickly.* [P7]

Participants also agreed that there were some instances where the use of a VR headset would not be safe or appropriate. One participant asked "*would you really want someone using a VR headset when they're having a blood test?* [P4], calling this sort of use "*dangerous*" [P4]. The need for patients to be able to see their surrounding environment and interact with clinicians was considered essential during many appointments and particularly during procedures. VR being viewed as a disruption or barrier to care particularly for participants working with patients in clinic: *"I probably see the headsets maybe as a bit of a barrier to kind of get my main message across"* [P6]. Therefore, the use of VR would have to be carefully planned to not impair or disrupt clinical care.

Data security

Participants raised concerns about data privacy and the safety of VR apps being used in clinic. From experience with previous technologies, participants expected that using VR would be similar in that they would be responsible for screening and vetting VR content for patients. The unfamiliarity with the technology led to participants feeling "*less confident*" [P13] in doing this as they were unsure what data VR would collect during use and how this may vary depending on apps used. More governance and guidelines would be required to allow clinicians and oncology staff to ethically use or recommend VR apps to patients.

Lack of clinical data

The lack of clinical data supporting the use of VR in TYA oncology was noted as a barrier for procuring and adopting VR in clinic. One participant described the situation as a "*Catch 22*" as *"in order to spend that amount of money, you need the robust data behind it, and in order to have robust data, you need the technology to run studies."* [P9]. Some participants were aware of applications of VR that had been trialed in different health populations but stressed that TYA oncology would require its own body of research to understand how VR may best support patients. Participants from TYA units discussed being *"at the forefront of developing things specifically for the TYA population"* [P10] and stated that VR should be no exception, they should be researching and developing tailored VR content to ensure optimal impact for both patients and staff. This view was also shared by the clinical psychologists who discussed how supporting the mental health of a young person with cancer is "*very unique and individual*" [P7] therefore would require VR apps tailored to this specific population.

Discussion

This is the first study to explore TYA healthcare professional views on the challenges and opportunities for VR in TYA oncology. By drawing on previous experiences of using technology in their jobs, we highlight the attitudes of healthcare professionals towards adopting VR in clinic. In particular, we outline participants views on both potential applications of VR in oncology and the practical deployment and adoption of VR technology in the TYA oncology setting. The interviews focused mostly on the latter aspect, indicating a stronger focus on the practical implementation challenges of using VR in TYA oncology.

The findings in this study align with the broader medical VR literature which emphasises the need for VR implementation frameworks and clinician and healthcare staff involvement from design through to development and deployment of VR applications [6, 16, 53, 54]. We contribute to medical VR literature by discussing potential applications of VR for TYA oncology and highlighting both practical and ethical challenges that present barriers for implementation in clinic. Through a qualitative approach, we provide insights on VR in TYA oncology that can generate novel hypotheses, presented below. Below, we present our findings in the context of medical VR and digital health literature and examine the suggested use cases for VR in TYA oncology.

Applications of VR in TYA oncology

Focusing on a specialised healthcare department and small clinical population allows us to examine the needs and requirements of VR from a clinician and staff perspective and compare them with the broader VR literature. This also allows us to find more nuanced opportunities for VR in TYA oncology.

Most use cases suggested by participants in this study mirror applications being researched and developed in the Medical VR field. However, oncology specific applications of VR specifically in radiotherapy and psychotherapy were also recommended. Suggested uses in this study including applications of VR in rehabilitation, physiotherapy, meeting information needs and distracting patients, were similar to VR applications discussed above in *Applications of VR in Oncology* [9, 55, 56]. Our findings indicate that research and deployment of VR in these areas is indicated for the TYA population, with participants in this study suggesting VR could improve the care of patients and the engagement of patients with treatment, specifically in physiotherapy and rehabilitation. Again, as discussed above in Applications of VR in Oncology, studies using VR for distraction and physiotherapy

are predominantly conducted in the adult population [19, 26]. We therefore recommend the expansion of this research into the TYA population given the clinical needs highlighted by participants in this study regarding the use of VR in these domains. Particularly we refer to the indication that more distraction techniques are required for oncology patients in isolation during treatment and that novel methods of engaging young people in prehabilitation and rehabilitation are required.

The suggestion to use VR to enable virtual social interactions is an area that is underexplored in healthcare. Previous work has been conducted in the VR field demonstrating that social VR apps have been appropriated as mental health and wellbeing tools and can reduce loneliness and improve social connectedness [57]. As highlighted by participants in this study, young people with cancer are often isolated for extended periods of time with restrictions on visitors. Using VR could reduce the negative mental health impacts of this isolation by allowing young people to socialise in an immersive environment. Further research in this area is indicated, particularly for the TYA population who are more accustomed to adopting and utilising novel technologies to socialise and communicate with others.

VR has been used in procedure preparation in various ways, as discussed previously [44, 58]. Our findings are in alignment with previous research in that participants highlighted a need to better prepare young people for scans, procedures and for visiting the hospital for the first time [59]. However, our study also found that there may be scope to expand applications of VR in procedure preparation into preparation for radiotherapy. Specifically, the suggestion to use VR to help patients learn and practise Deep Inspiration Breath Hold (DIBH) before radiotherapy. This could not only improve patient safety but also improve the efficiency of treatment delivery by reducing time spent in the treatment room, thereby increasing patient throughput. A recent systematic review by Grilo et al. [60] conducted to investigate the impact of VR in the role of radiotherapy preparation, found no studies that included training on how to perform DIBH. To our knowledge, only one paper has recommended using VR to assist in the DIBH learning process [61], studies have yet to be conducted in this area. Using technology to assist patients in performing DIBH is well researched in the medical field however there remains no gold standard [62]. VR presents as a novel alternative to current practises and could allow patients to practise this technique before treatment.

VR applications specialising in the delivery of psychotherapy have been widely researched and our findings strengthen the clinical need for this research to continue [63, 64]. Perhaps a less researched area is the use of VR to deliver Acceptance and Commitment Therapy (ACT), an action-oriented approach to psychotherapy rooted in both cognitive behavioural therapy and traditional behaviour therapy [65]. ACT has demonstrated considerable success in oncology with studies demonstrating lower depression scores and an increase in pain acceptance and psychological flexibility in women with breast cancer who received ACT [66]. From the few studies that have developed and trialled ACT based VR apps, none have yet been developed specifically for people with cancer. The participants in our study highlighted the need for cancer-specific interventions to be developed, particularly in the domain of psychological therapies. Given that the psychological needs of young people with cancer are often unmet [67], exploration into technologies that can improve their engagement with evidence-based therapies such as ACT, is of paramount importance. Further research in this area is warranted.

Overcoming practical challenges for VR use in clinic

This study revealed that clinicians and TYA staff have practical concerns about the use of VR in a clinical setting. In most cases, the effective implementation of VR in clinic was of more concern to participants than the intended application of VR. Participants all provided examples of where previous digital technologies or innovations had been deployed in their respective job roles. Common challenges were described in each example such as unreliable internet connections, the lack of a technician to maintain digital equipment, the absence of training, funding concerns and issues regarding security and governance. Most participants indicated that these challenges still remain in their respective hospitals and would make the successful adoption of VR in clinic difficult. These findings reiterate the well-known challenges of adopting new technologies in a clinical setting, particularly the adoption of VR [68].

A scoping review by Kouijzer et al. on the implementation of VR in healthcare settings found 69 different barriers to the implementation of VR in healthcare (reported across 26 studies) [53]. Most barriers in Kouijzer's review were related to the practical challenges highlighted in this study, particularly around insufficient funding for equipment, the absence of training and technical support alongside the lack of robust data indicating the value of VR. Safety issues regarding infection control and the lack of data privacy when using patient data with VR were also mentioned. These challenges are not new in healthcare and have been observed when deploying technologies such as smartphones, personal computers and tablets [69, 70]. Kouijzer recommends developing systematic multi-level implementation strategies by identifying barriers before implementation. Our findings agree with this

recommendation and indicate that analysing the successes and failures of previous technology deployments can allow hospitals to tailor their strategies to align with the unique characteristics of their work environment.

The use of VR in oncology raises significant ethical concerns. In this study, participants were concerned about the privacy and security of VR. Concerns surrounding the privacy and security of patient data are not unique to VR, but rather represent larger concerns relating to the protection of patient data amidst the rise of digital technology use in healthcare [71]. Our findings reinforce the need for VR researchers and developers of medical VR applications to adhere to relevant regulatory standards. Given that VR is a novel technology in TYA oncology, spreading awareness of what data VR can actually collect and how this data is stored and handled will be a priority moving forward both to alleviate the concerns of healthcare professionals and to ensure patient data is secure.

Engaging clinicians and TYA staff in VR research

The diverse professional background of the staff working within TYA cancer services create exciting prospects for exploring novel implementation strategies of VR in clinical settings. For example, exploring the possibility of additional roles such as the youth support coordinator to manage VR technology in the department. Thus, removing the responsibility from clinical staff who must prioritise clinical work over technology adoption. Involving multiple TYA staff members in the implementation of VR into services, may also create a sense of shared responsibility and ownership whilst reducing individual burden.

In the UK, VR remains uncommon in hospitals and is very rarely used in clinical practise. We found that only 2 participants were aware of applications of VR being researched and/or used in their field. This may result from staff priorities being focused on clinical care and managing overloaded services. However, it may also reflect the limited engagement of clinicians and healthcare staff in VR research. Given that clinicians and healthcare workers are expected to be on the frontline of VR delivery and adoption, it is essential that they are involved in the earliest stages of medical VR research. Awareness of current research being done in medical VR is also necessary to allow research outputs to be translated into clinical practise. In this study we found that healthcare professionals wouldn't feel confident using VR due to having limited knowledge and experience using the technology. Effectively communicating medical VR research outputs could therefore reduce the anxiety around using VR and improve the successful implementation in clinic.

Finally, many participants in this study highlighted the lack of governance when it comes to using digital application in clinic. Significantly more work is required to provide hospitals with evidence-based VR applications that meet their respective data privacy and safety standards. This should not be the responsibility of clinicians or healthcare staff and reducing their burden has to be a priority if VR technology is to be successfully and safely deployed in hospitals.

Limitations

This study has several limitations. Firstly, the study was conducted in 2022–2023 following the COVID-19 global pandemic. At this time, the oncology departments in the UK were still operating under COVID-19 safety guidelines and dealing with a significant backlog of patients. Given the overwhelming pressure placed on healthcare professionals during and after the pandemic, the introduction of novel technologies into services may not be viewed as a priority. This could possibly explain a heightened sense of anxiety around the introduction of VR, which was viewed by many participants as an added responsibility and burden. This also could contribute to the participants emphasis on adopting technologies that would offer time-saving benefits.

Secondly, many of the suggested applications of VR in this study were speculative in that the healthcare professionals made assumptions on how the young people would experience VR and where it could improve engagement with their treatment. Future research engaging with young people with cancer is required to understand their perspectives on the use of VR in the oncology pathway. While participants in this study were primarily motivated to use VR in their job roles if it improved patient care, some participants also stated that they would be motivated to adopt technologies if they led to saving time. It is essential that applications of VR do not adversely affect the care of patients to save time, applications of VR that both enhance patient care and reduce clinical burden should therefore be explored.

Finally, this study is specific to the United Kingdom's healthcare service, where the use of VR in clinical practise remains in its infancy. Consequently, the participants had limited experience using VR with only two participants having used VR in a clinical setting. There is a growing body of literature providing implementation frameworks for VR in clinical practise that can be drawn upon to overcome many of the challenges mentioned in this study. Healthcare professionals that have experience using VR in practise and have standards in place to manage infection control, security and hardware maintenance may have more informed perspectives on the challenges and opportunities for VR in TYA oncology.

Conclusion

This study offers insights into the perspectives of healthcare professionals working in TYA cancer services regarding the use of VR in TYA oncology. Our findings suggest that TYA units in the UK represent unique, understudied environments with potential for early adoption of VR in clinic.

This study proposes several applications of VR for use in TYA oncology including applications for VR in physiotherapy, psychotherapy, mental health care, as a distraction tool, in procedure preparation and for helping meet patient information needs. To our knowledge, applications of VR specific to TYA oncology including the use of VR to train patients on breathing techniques for radiotherapy and the delivery of cancer-specific psychotherapy have not been proposed in previous literature. Our study indicates that both healthcare professionals and young people with cancer could benefit from the implementation of VR in clinic. Expanding current medical VR research into the TYA population is therefore warranted.

Whilst participants express positive attitudes towards the use of VR in TYA oncology, they also raised significant concerns surrounding the safe and ethical use of VR in TYA oncology. Furthermore, the scarcity of comprehensive clinical data, funding constraints, staff shortages and the lack of governance and technical support in hospitals, were all viewed as barriers to adoption. Improving the dissemination of medical VR literature amongst healthcare professionals and engaging them in research and deployment strategies should be a priority as the field continues to develop. This will facilitate the adoption of VR in clinics by offering insights into potential practical and ethical challenges and enabling their mitigation. Future work should include working with teenagers and young adults with cancer to examine their perspectives on using VR in the oncology pathway.

Supplementary Information

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Supplementary material 1.

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Authors' contributions
M.D. prepared the main manuscript with all authors reviewing and editing the final manuscript. Key contributions are listed below: M.D. - conceptualisation, methodology, project administration, Interviewer, data analysis, writing (original draft and editing). D.S - Data analysis, writing (review and editing). A.B - conceptualisation, methodology, data analysis, writing (review and editing). K.C - conceptualisation, methodology, data analysis, writing (review and editing).

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Availability of data and materials
The datasets generated and analysed during the current study (audio files and written transcripts) are not publicly available due to privacy considerations. The study recruited participants from a highly specialised care facility therefore releasing the data would lead to participant identification.

Declarations

Ethics approval and consent to participate
Participants provided written informed consent before participating in the interview study. The study was approved by the University of Bristol Engineering Faculty Research Ethics Committee (2022–0252-10725). This study was conducted in accordance with the Declaration of Helsinki.

Consent for publication
Written informed consent for publication has been obtained from the participants in this study.

Competing interests
The authors declare no competing interests.

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