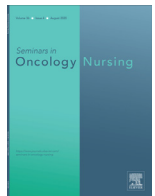




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## Research

## Immersive Virtual Reality Experience of Patients with Cancer During Intravenous Antineoplastic Therapy: A Qualitative Study

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## ABSTRACT

**Objectives:** To explore the experiences patients with cancer using immersive virtual reality (iVR) during antineoplastic infusion therapy.

**Methods:** A qualitative descriptive study was nested in a randomized controlled three-arm trial. Semistructured individual interviews were conducted in person at the end of the 30-minute iVR experience, which included 310 scenarios, depicting beaches, animals, submarine environments, and mountains, available in 4K to 8K 360° sphere video. The interviews were audio-recorded and transcribed verbatim. The transcripts were analyzed using content analysis.

**Results:** Twenty-four patients participated. Content analysis generated three main categories (cognitive and emotional benefits of iVR, customizable intervention with beautiful images, and negative aspects of iVR), and seven subcategories (enrichment of knowledge and experiences, positive emotions, cognitive engagement, variety of scenarios, quality and beauty of the videos, discomfort with the equipment, negative feelings toward the iVR devices).

**Conclusions:** The patients' experience with iVR was positive and enhanced their experience of receiving antineoplastic infusion therapy, with minimal cybersickness.

**Implications for Nursing Practice:** iVR is an innovative intervention that can be implemented in nursing practice to enhance the humanization of care and foster a patient-centered approach in patients undergoing antineoplastic infusion therapy.

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## Introduction

Receiving a cancer diagnosis can radically change a person's life and may lead to severe psychological distress.<sup>1</sup> Questions about survival, a sense of helplessness, and negative emotions such as fear, anxiety, depression, anger, resentment, and concern for one's family, emerge in the minds of people with a cancer diagnosis, decreasing their quality of life.<sup>2</sup> This negative existential condition coexists with the psychosocial impact of antineoplastic therapy (AT) such as worry, fear and anxiety about its side effects.<sup>3</sup> Infusion AT requires individuals to leave their home and families regularly, often for extended periods, to enter a healthcare setting. This setting is characterized by visual, auditory, and olfactory stimuli

that can produce negative perceptions, which can also cause anticipatory nausea and vomiting.<sup>4</sup> While waiting to start AT, individuals might witness the worry and anxiety of other patients and observe the side effects on their bodies. The sight of a healthcare environment filled with technology and drugs to be infused, the sound of device alarms and voices of patients and healthcare providers, and the typical smells of a healthcare setting all serve as stressful stimuli.<sup>5,6</sup> During AT, being forced to sit for extended periods with minimal movement can lead to boredom and a heightened focus on negative stimuli, which may distort patient's cognitive and emotional state.<sup>7</sup> Moreover, patients perceive time as slowing down, making AT feels as though it lasts longer.<sup>3</sup>

To improve this psychological condition, the person must be considered from a holistic perspective, recognizing them as a unique human being with individual experiences.<sup>8</sup> Consistent with this view is "patient-centrality," where the cognitive and emotional world of individuals, represented by their wishes, opinions, needs, sensations,

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## Plain English Summary/Layperson Summary

### What we investigated and why

We explored the experiences of cancer patients who used a new technology called iVR during their antineoplastic infusion therapy in the hospital. This research was motivated by the fact that patients often suffer from various negative psychological symptoms during antineoplastic infusion therapy, making it crucial to study how iVR might improve their experience.

### How we did our research

We asked patients undergoing antineoplastic infusion therapy who used iVR if we could interview them about their experience with the technology. The patients could choose from 310 scenarios, including depictions of beaches, animals, underwater environments, and mountains.

### What we have found

Through analyzing the patients' responses, we discovered that iVR led to several positive outcomes. Patients reported feeling serene, calm, relaxed, and free. They noted that iVR helped them not to think about their illness or chemotherapy, reduced anxiety, and provided enjoyment. They felt fully immersed in the scenarios, which made time seem to pass more quickly and distracted them from the therapy. Patients particularly enjoyed the sea and underwater scenarios, as well as those featuring animals and mountains. They appreciated the colors, music, sounds, and overall beauty of the videos. Additionally, they valued the opportunity to experience new environments, try out modern technology, and explore unknown places, which enriched their knowledge. Only a few negative feelings were reported regarding the iVR device.

### What it means

This study demonstrated that iVR is a highly appreciated intervention by patients, significantly enhancing their experience during antineoplastic infusion therapy. The findings suggest that iVR could be effectively integrated into the daily care of individuals undergoing this type of treatment.

Several quantitative studies have investigated the effectiveness of iVR in alleviating psychological distress among patients during AT<sup>16-23</sup> and in oncology care.<sup>24</sup> While the impact of iVR on physical and psychological symptoms is well documented, its effect on the overall experience remains unclear. In fact, only a few studies have employed qualitative methodologies to explore patients' experiences with iVR during AT.<sup>25,26</sup> Qualitative approaches provide deeper insights into the holistic mind-body impact of iVR, which cannot be fully captured by simply describing its effects on physical and psychological symptoms. To address this gap, we conducted a study aimed at exploring the experiences of cancer patients using iVR during an AT session.

## Objectives

To study the existential experiences of cancer patients using iVR during AT sessions, focusing on cognitive, emotional, behavioral, perceptual, and sensory variables.

## Methods

### Design

A qualitative descriptive study was embedded in a randomized controlled three-arm trial (RCT) conducted to evaluate the effects of iVR on anxiety, fatigue, and pain in patients undergoing AT.<sup>27</sup>

Inclusion criteria were: (1) age >18 years; (2) diagnosis of cancer with indication for intravenous AT; (3) cognitively able to participate; (4) no significant acoustic deficit; (5) no significant visual impairment; (6) sufficient ability to write and read in Italian. Exclusion criteria were: (1) use of antipsychotic drugs; (2) epilepsy; (3) use of drugs or alcohol. Participants were enrolled through consecutive sampling.

The RCT included two experimental groups: the first group, consisting of 25 patients, received an iVR intervention while the second group, also consisting of 25 patients, received a narrative medicine intervention. The control group, including 24 participants, received standard care.<sup>27</sup> Patients in the iVR group had a 30 minute-session of the iVR.<sup>27</sup> Patients in the narrative medicine group had 30 minutes during AT to freely express their emotions, sensations, and cognitive perceptions by writing their thoughts in a notepad. Patients in the standard care group during AT could choose among activities such as watching TV or videos on their smartphone, listening to music, reading, writing, or talking to healthcare personnel or other patients in the room. The qualitative strand of the study was conducted after the administration of the iVR intervention.<sup>28</sup> The Consolidated Criteria for Reporting Qualitative Research (COREQ)<sup>29</sup> was used to ensure the quality of study reporting.

### Sample

Patients learned about the study involving iVR through advertisements on signs inside the oncology unit, as well as through conversations with oncologists and nurses in the unit. The 25 participants in the iVR group at the beginning of the AT session were approached and asked if they were willing to be interviewed after receiving intravenous AT regarding their experiences with iVR. They were provided with information about the study objective, procedure, and method. The inclusion criteria were age  $\geq 18$  years; diagnosed with cancer with indication for AT; cognitively able to participate; no significant acoustic or visual impairment; and sufficient ability to write and read in Italian. Exclusion criteria were the use of antipsychotic drugs and the abuse of drugs or alcohol because these substances could modify perception, cognitive functioning, and emotional state, thereby altering the experience of the iVR intervention. Cognitive impairments were assessed using the Montreal Cognitive Assessment, a

perceptions, emotions and preferences, becomes fundamental for decision-making process and personal care.

Therefore, during AT, the patients require rapid, deep, and prolonged distraction to from the negative stimuli they encounter.<sup>9</sup>

A nonpharmacological intervention capable of producing rapid, profound, and long-lasting effects is immersive virtual reality (iVR). Virtual reality (VR) is divided into three main categories: (1) immersive, (2) semi-immersive, and (3) nonimmersive. iVR uses wearable devices, such as head-mounted displays (HMDs), to fully immerse users in a multisensory virtual environment. Semi-immersive VR combines screens or headsets, allowing interaction with the virtual world while maintaining a connection to the real one. Nonimmersive VR, on the other hand, employs monitors or projectors, enabling interaction with virtual content without compromising full awareness of the external environment.<sup>10</sup> iVR stands out for its ability to provide a highly immersive experience by engaging multiple senses and creating realistic, interactive virtual environments.<sup>11</sup> This three-dimensional, multisensory technology reproduces virtual content, referred to as scenarios, by isolating perceptual channels from the external environment. As a result, iVR induces a psychological state in which individuals experience an illusion of reality.<sup>12-15</sup>

standardized tool with a maximum score of 30 points. A score of 26 or above was generally considered indicative of normal cognitive function, with the following scoring categories: 27 to 30 indicating normal cognition, 18 to 26 reflecting mild cognitive impairment, and scores below 18 suggesting dementia or severe cognitive impairment.<sup>30</sup> Patients diagnosed with brain tumors were excluded, as they were not managed by the oncology unit. The stage of the illness was not a criterion for eligibility, meaning that patients at any stage of the disease were included. The cancer stage, categorized as I, II, III, or IV, was documented as part of the patients' clinical characteristics.

### *Ethical Considerations*

The study was approved by the Territorial Ethics Committee (Protocol n.97/18/CE and Protocol n 41/24/CET all.3) and was conducted according to the ethical principles of the Declaration of Helsinki. A researcher approached potential participants and asked for their voluntary and informed consent. The patient's personal information was coded to ensure anonymity.

### *Procedure*

The first step of the procedure was evaluating the feasibility of the iVR intervention. The feasibility analysis demonstrated that the study could be carried out successfully. All staff had been trained in the research protocol and the use of iVR technology. Adequate financial resources were available for purchasing the iVR systems, and a 5G internet connection was in place. The intervention had no environmental impact and was deemed sustainable. Additionally, the ethics committee provided a positive review.

### *Randomization*

An independent researcher generated the random allocation sequence using random number generation software ([www.randomizer.org](http://www.randomizer.org)) based on simple randomization. The randomization list assigned a specific allocation to each of the 74 participants, using three numerical codes to represent the study groups: 1 for the VR group, 2 for the narrative medicine group, and 3 for the standard care group. To maintain allocation concealment, sequentially numbered, opaque, and sealed envelopes were used to implement the random allocation sequence.

### *VR Technology*

The study utilized advanced iVR equipment, specifically the Oculus Quest 2 HMD, which featured high-resolution displays, eye and face tracking sensors, and spatial audio technology to create an immersive experience. The system also included haptic gloves for tactile interaction, enabling users to perceive and manipulate virtual objects. The scenarios featured 4K to 8K resolution 360° video content, organized into nine thematic categories, and hosted on a password-protected YouTube channel. A total of 310 videos were organized into nine thematic categories: (1) Africa; (2) Hills; (3) Rivers, Lakes, and Waterfalls; (4) Islands; (5) Deserts; (6) Beaches; (7) Mountains; (8) Sea; and (9) Submarines. Participants could choose scenarios using a joystick and experienced natural sounds and soothing music through earphones for enhanced immersion.<sup>31</sup> This setup helped divert attention from the hospital environment and chemotherapy, promoting relaxation, positive emotions, and reducing stress and anxiety. The integration of various sensory and perceptual inputs, such as stereoscopic visuals and spatial audio, deepened the sense of reality and immersion. Participants were free to move their eyes and heads, adjust the volume to their preferred level, and end the VR session at any time for any reason. In accordance with an

important previous study,<sup>32</sup> and in line with the guidelines for the safety of Oculus Quest 2 HMD system, immersion duration was 30 minutes. After this period the nurse removed the iVR headset visor from the participant.

### *VR Intervention*

The iVR intervention was administered by oncology unit nurses trained specifically in the research protocol and VR technology. It was conducted in a shared treatment room with two patients receiving therapy at the same time. The VR content was delivered via a password-protected YouTube playlist, ensuring exclusive access for the VR group. The design of the VR scenarios was based on an integrated psychological and neurological model.<sup>15</sup> The use of VR during chemotherapy infusion followed the guidelines established by Burrai et al.<sup>6</sup> As YouTube is a widely trusted platform, no additional testing was required for its implementation.

A nurse trained in the use of VR educated the patient to use VR. The switching of the environments (scenarios) was performed by patients. The patients were trained to use the VR system, so they could easily change the scenarios whenever they wanted, based on their preferences. The VR started a few minutes after the beginning of the anticancer therapy. Patients selected the scenarios that appealed to them most, and those that elicited a psychophysical state characterized by reduced negative emotions and stress, along with an increase in positive emotions, relaxation, calmness, and inner peace. Activating cognitive variables that can influence the study outcomes is essential for deeply immersing participants' consciousness into virtual environments. The patients' actions during the immersion in the scenarios were contemplative. That is, the patients were not asked to perform actions within the scenarios but to be cognitively and emotionally involved in the immersion in the scenarios.

VR sickness was assessed using the VR symptom questionnaire, which evaluates 23 symptoms (12 nonocular, 11 ocular) on a 7-point scale.<sup>33</sup> Symptoms were considered negligible if they occurred at any severity level below 20%. Participant satisfaction with the VR intervention was measured using an eight-item satisfaction questionnaire based on Buche, Michel, and Blanc's framework, rated on a 5-point Likert scale. Higher scores indicated greater satisfaction with the VR session.<sup>34</sup> The average duration of AT in relation to VR sessions was 2 hours and 30 minutes.

### *Data Collection*

Data was collected from June 1 until November 1 2023 in an oncology unit of a public hospital in Italy. The data were collected using semistructured interviews conducted face-to-face in a quiet and reserved space within the AT area, with only the participant and the researcher present, after the conclusion of the iVR session. The interviews were conducted by two researchers: one male with a PhD and another female with a Master in Nursing Sciences, both trained in conducting qualitative studies. The interviewers were also experts in iVR applications and had conducted research in digital health involving new technologies such as iVR, augmented reality, mixed reality, and artificial intelligence. No interviewer knew the patients being interviewed. The interviews were conducted in a permissive, nonjudgmental manner, enabling participants to speak freely and ensuring they had enough time to report their experiences. The interviews were audio-recorded and faithfully transcribed by a research assistant, then checked for accuracy and completeness by a researcher.

An interview guide based on literature review was developed by the research team including open questions on patient' experience with the iVR (Table 1). Participants were asked to describe their experience with iVR, what aspects of the experience struck them most, or if the experience was in some way difficult or challenging and why.

**TABLE 1**  
Interview Guide on Patient' Experience with the iVR

| Categories            | Questions                                                                                                  |
|-----------------------|------------------------------------------------------------------------------------------------------------|
| Introductory question | Can you describe your experience with immersive virtual reality?                                           |
| Transition questions  | Would you repeat the immersive virtual reality experience during your next antineoplastic therapy session? |
| Transition questions  | Would you recommend the immersive virtual reality to patients during antineoplastic therapy?               |
| Key questions         | What was most helpful for you?                                                                             |
| Key questions         | What aspects of the experience struck you most?                                                            |
| Key questions         | What pleasant aspects have you experienced with immersive virtual reality?                                 |
| Key questions         | What problems did it create to you, if any?                                                                |
| Ending question       | Do you have any other thoughts you want to share about your experience?                                    |

Only one interview was conducted for each participant. Field notes were taken during and after each interview.

### Data Analysis

The analysis of the transcriptions was conducted using inductive content analysis according to the method by Graneheim and Lundman.<sup>35</sup> The transcriptions were read multiple times to obtain a sense of the whole and ensure a proper understanding; afterward, significant words or phrases were extracted from the transcripts (meaning units). Similar phrases and words were compared and coded. The codes were organized into subcategories and categories based on similarities and differences. The analysis process was conducted by two researchers trained in qualitative analysis. Two faculty members expert in qualitative research provided supervision during the analysis process. The transcripts were not returned to participants for comments or corrections. There was no comparison of the data among different age subcategories.

### Rigor

To ensure the rigor of the study, the criteria of credibility, transferability, dependability, and confirmability proposed by Lincoln and Guba were followed.<sup>36</sup> Credibility was ensured through the selection of an appropriate method for data collection and the amount of data collected. Transferability was guaranteed by describing the culture and context, patient characteristics, data collection, and the analysis process, allowing the reader to judge the transferability of the findings to other settings. Dependability was achieved by structuring a clearly documented, traceable, and logically developed research process. Finally, confirmability was guaranteed through consistency between the interpretations, findings, conclusions, and the data collected.

## Results

### Participant Characteristics

Twenty-four patients of the iVR group consented to participate and were interviewed. The sample size ( $n = 24$  for the qualitative component) was determined based on the inclusion and exclusion criteria, the trial length, the 1:1:1 balanced allocation, the consecutive sampling methodology, and factors such as complexity and accessibility. This sample size is further justified, particularly by the achievement of data saturation. One patient expressed emotional discomfort about being interviewed and refused to participate. The participant mean age was 63 years (range 42–83); 18 were female and 6 males, all of Italian nationality except for one who was Albanian. The primary cancer sites were breast ( $n = 12$  participants, five of whom

**TABLE 2**  
Participant Characteristics

| Characteristics                            | Classification     | <i>n</i>      | %    |
|--------------------------------------------|--------------------|---------------|------|
| Gender                                     | Female             | 18            | 76   |
|                                            | Male               | 6             | 24   |
| Age (years)                                | Mean (SD)          | 62.56 (10.08) |      |
| Nationality                                | Italian            | 23            | 96   |
|                                            | Albanian           | 1             | 4    |
| Employment status                          | Employed           | 18            | 72   |
|                                            | Retired            | 6             | 24   |
|                                            | Unemployed         | 1             | 4    |
|                                            |                    |               |      |
| Education level                            | Primary school     | 1             | 4    |
|                                            | Secondary school   | 11            | 44   |
|                                            | High school        | 11            | 44   |
|                                            | Graduate           | 2             | 8    |
| Primary cancer                             | Breast             | 12            | 48   |
|                                            | Colon              | 2             | 8    |
|                                            | Rectum             | 2             | 8    |
|                                            | Melanoma           | 2             | 8    |
|                                            | Pancreas           | 2             | 8    |
|                                            | Esophagus          | 1             | 4    |
|                                            | Testicle           | 1             | 4    |
|                                            | Prostate           | 1             | 4    |
|                                            | Stomach            | 1             | 4    |
|                                            | Ovary              | 1             | 4    |
|                                            |                    |               |      |
|                                            |                    |               |      |
| Cancer stage                               | I                  | 2             | 8    |
|                                            | II                 | 6             | 24   |
|                                            | III                | 6             | 24   |
|                                            | IV                 | 11            | 44   |
| Duration of chemotherapy session           | <3 hours           | 20            | 84.4 |
|                                            | >3 hours           | 4             | 16.6 |
| Time since diagnosis or recurrence (years) | Mean (SD)          | 1.56 (1.29)   |      |
| Surgical Intervention                      | Yes                | 15            | 60   |
|                                            | No                 | 10            | 40   |
| Antineoplastic therapy                     | Chemotherapy       | 17            | 68   |
|                                            | Chemoimmunotherapy | 1             | 4    |
|                                            | Chemo-biologic     | 5             | 20   |
|                                            | Immunotherapy      | 2             | 8    |

had stage IV), rectum ( $n = 2$ ), colon ( $n = 2$ ), and skin ( $n = 2$ ); pancreas, testicle, prostate, stomach, esophagus, and ovary each had one occurrence. On average, the time since diagnosis or cancer recurrence was 1.5 years, and 60% had undergone surgery. In 84% of cases, the AT session lasted less than 3 hours (Table 2).

The interviews lasted an average of 20 minutes. Participants mostly chose scenarios of beaches, animals, underwater environments, and mountains.

The mean range of Montreal Cognitive Assessment scores among participants was 26 to 30, indicating normal cognition. Fig. 1 presents the participant flowchart for the RCT. Fig. 2 presents the process flowchart.

### Findings

Data saturation was reached during the qualitative data collection process. Seven subcategories grouped into three main categories were extracted from data: (1) cognitive and emotional benefits of iVR, (2) customizable intervention, and (3) negative aspects of the iVR. The main categories and subcategories, along with excerpts from the interviews, are presented in the paragraphs below and illustrated in Table 3. The participants are identified by alphanumerical codes assigned in the RCTs, which are included within parentheses along with each excerpt.

#### (1) Cognitive and emotional benefits of iVR

This main category included three subcategories: "Enrichment of Knowledge and Experiences," "Positive Emotions," and "Cognitive Engagement." It describes how new experiences with iVR have

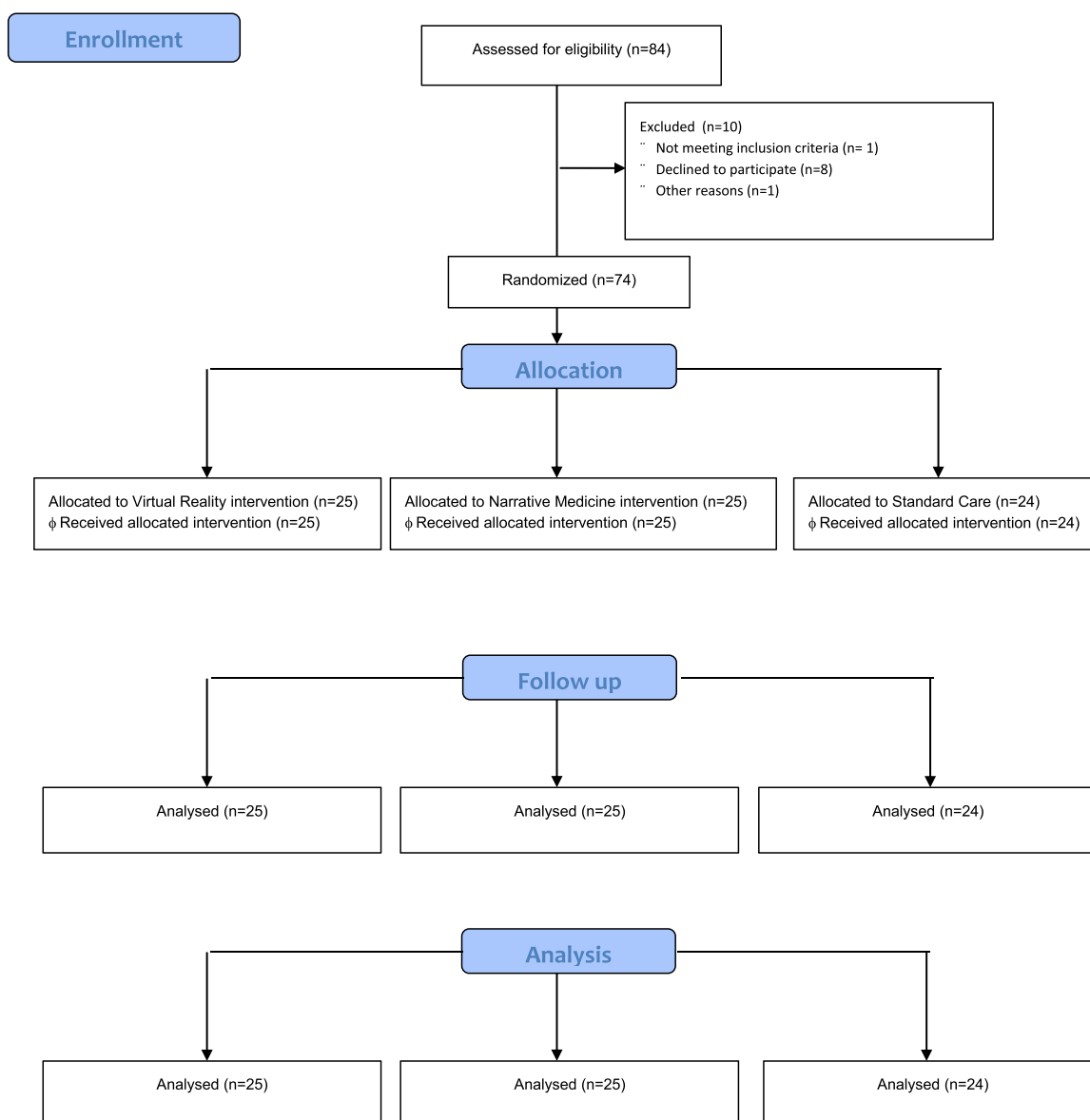


FIG 1. Participant flowchart in the RCT.

enriched participants' understanding of new technology, provided pleasant experiences of new places and scenarios, positively impacting their emotional well-being, and offered cognitive benefits, such as distraction from negative hospital surroundings and a new perception of time.

#### Enrichment of Knowledge and Experiences

Many participants reported an enrichment of knowledge and experiences due to the use of this new and modern technology. They noted: "[it was a] very interesting experience..." (ID 9), and "It was a nice, new experience because I had never tried this Virtual before" (ID61). Participants' knowledge and experiences were further

enriched by encountering unfamiliar and previously unknown places depicted in the scenarios. For instance, participants reported: "Certain places that I saw were beautiful, I didn't know them before" (ID31), and "[iVR was useful] for seeing new places" (ID73).

#### Positive Emotions

iVR had a significant impact on the emotional well-being of participants. They expressed feelings of tranquility, serenity, calmness, and peace. For instance, participants commented: "[It helps me for] tranquility" (ID1), and "it calms me down and gives me serenity" (ID23). Moreover, emotions of liberation and freedom were reported. Participants felt free from the negative feelings produced by their disease

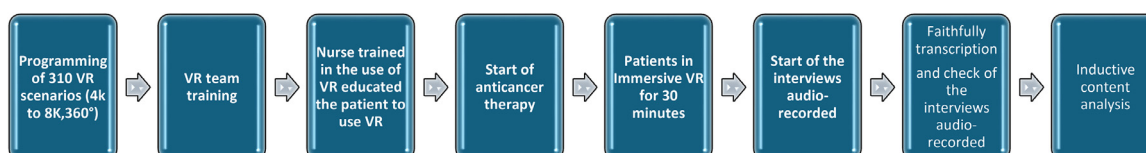


FIG 2. Process flowchart.

**TABLE 3**  
Findings of Qualitative Analysis

| Main categories                                 | Subcategories                            | Codes                                                   | Condensed meaning units                                                                              |
|-------------------------------------------------|------------------------------------------|---------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| Cognitive and emotional benefits of iVR         | Enrichment of knowledge and experiences  | Living new experiences                                  | They lived new experiences                                                                           |
|                                                 |                                          | Knowing new places                                      | They tried a modern technology<br>They could see unknown places<br>They could enrich their knowledge |
|                                                 | Positive emotions                        | Serenity and tranquillity                               | They felt serene, calm, and quiet                                                                    |
|                                                 |                                          | Perception of freedom                                   | They felt free                                                                                       |
|                                                 |                                          | Reduction of negative thoughts                          | They did not think about illnesses and chemotherapy                                                  |
|                                                 |                                          | Relief from anxiety                                     | It helped to relieve anxiety<br>It distracted from anxiety                                           |
|                                                 |                                          | Relaxation                                              | It helped to relax during chemotherapy                                                               |
|                                                 |                                          | Enjoyment                                               | They enjoyed themselves<br>They liked the experience with iVR                                        |
|                                                 | Cognitive engagement                     | Immersion in the scenarios                              | They felt full immersed in the scenarios                                                             |
|                                                 |                                          | Distraction                                             | It distracted them from the therapy                                                                  |
|                                                 |                                          | Perception of time passing quickly                      | They felt that the time passed faster                                                                |
| Customizable intervention with beautiful images | Variety of scenarios                     | Appreciation for the marine scenario                    | They liked the sea and submarine scenarios                                                           |
|                                                 |                                          | Appreciation for scenarios with animals                 | They liked the scenarios with animals                                                                |
|                                                 |                                          | Appreciation for scenarios with mountains               | They liked the scenario with mountains                                                               |
|                                                 | Quality and beauty of the videos         | Appreciation of the quality of the images in the videos | They liked the colors, the music, and the beauty of the videos                                       |
|                                                 |                                          | Heavy Headset                                           | The iVR headset was heavy                                                                            |
| Negative aspects of iVR intervention            | Discomfort with the equipment            | Problem with image focus                                | Some images were perceived as blurry                                                                 |
|                                                 |                                          | Vision problems                                         | Some issues because they were not wearing their glasses<br>Lack of peripheral vision                 |
|                                                 |                                          | Lack of isolation from external sounds                  | They could not isolate completely because they were hearing external sounds                          |
|                                                 |                                          | Unfamiliarity with technology                           | Inexperience in using the devices<br>Difficulty in using joystick or pad                             |
|                                                 | Negative feelings toward the iVR devices | Too fast framing changes                                | Difficulty in following the framing changes                                                          |
|                                                 |                                          | Frustration in using the devices                        | Irritation for not knowing how to use the devices                                                    |
|                                                 |                                          |                                                         |                                                                                                      |

and AT: “*I Feel free while looking at the animals*” (ID27). Participants also experienced a reduction in negative thoughts because they were not focusing on their illnesses and chemotherapy. They noted, for example: “*I forgot that I was having chemotherapy*” (ID37) and “*[it helped me] not to think about it at all*” (ID38). Another significant aspect was that iVR provided relief and distraction from anxiety. As participants shared: “*[I recommend iVR] even to you and anyone suffering from anxiety, even those leading a normal life...*” (ID1); and “*It helps calm you down during therapy and relax, it completely distracts you from all your anxieties and concerns*” (ID23).

Furthermore, iVR helped participants to relax during chemotherapy, positively influencing their mind-body connection. As they noted: “*[It helped] me to relax*” (ID17). Patients enjoyed themselves and found the iVR experience highly engaging, showing deep interest in the scenarios: “*I really enjoyed the experience...*” (ID37); “*A good experience (...). It's a good thing...*” (ID73).

#### Cognitive Engagement

Participants perceived iVR as a distraction from their negative surroundings as they were transported to another place, away from the oncology ward. They felt fully immersed in the scenarios: “*I was thinking of being right inside the image. I really like swimming and seeing fish underwater. And so, watching the video I felt among them...*” (ID17); and: “*The pleasure of hearing sounds and a habitat that I felt like I was physically there*” (ID63). The immersion was closely linked to distraction, which lead to the shift of attention from the negative external environment toward the beneficial internal cognitive experience produced by the iVR: “*It completely distracts you from all the anxieties and all the things.*” (ID23). Moreover, iVR altered

participants' perception of time with time passing more quickly: “*... the therapy went by much faster*” (ID23), and “*It went by fast (...), in fact I didn't realise the time had already run out*” (ID31).

#### (2) Customizable intervention

This main category included two subcategories: “Variety of Scenarios” and “Quality and Beauty of the Videos.” It illustrated the participants' appreciation for the several scenarios available to choose from, and their perceptions of the quality and beauty of the images, scenes, colors, sounds, and music.

##### Variety of Scenarios

Participants found that natural scenarios provided an enjoyable experience. Some patient expressed a sense of enjoyment from the marine environment, represented by seas and beaches or underwater environments with swimming fish scenarios: “*I like the sea a lot ...*” (ID53). Other participants were positively affected by the presence of animals in the scenarios, feeling closeness to them: “*[It struck me] to see the animals from a different perspective*” (ID61). Other patients appreciated the mountain scenarios: “*... Like being in the middle of nature ... Over all the mountains ...*” (ID20).

##### Quality and Beauty of the Videos

Participants appreciated the colors, the music, and the beauty of the videos, which featured realistic, convincing images and sounds: “*The colors are beautiful; the shapes are beautiful... Being able to admire the beautiful things that are there and around us... They are 3D*

images, so the visuals are beautiful. . ." (ID32). *"The beautiful colors, it's just like entering the water, beautiful. Very beautiful: the colors, the movements, the shadows and the music have a great impact"* (ID23).

### (3) Negative aspects of iVR

This main category included the two subcategories, "Discomfort with the equipment" and "Negative feelings towards the iVR devices," which described the negative experiences of the participants regarding the iVR.

#### *Discomfort with the Equipment*

Some participants reported some discomfort with the equipment. They complained about the weight of the iVR headset: *"The mask was very heavy, and I had to support it"* (ID9); *"A little bit of heaviness. . . of the instrument"* (ID30). Other patients noted discomfort with image focus: *"... I saw some things out of focus"* (ID23); and: *"The focus was not perfect. . ."* (ID37). There reported also some visual problems: *"There is also the strain on the eyesight because I usually wear glasses to see close up"* (ID32); and *"[a problem was] I couldn't see sideways with the glasses"* (ID62).

Other issues included a lack of isolation from external sounds during the iVR session: *"It should allow you to isolate yourself completely without hearing external noises"* (ID13). Inexperience in using the iVR devices and difficulty in using joystick or pad were also reported: *"[I would repeat this experience] first knowing well the instrument that makes the device work [in reference to the pad], otherwise, as in this session, I had problems precisely because of not knowing and not being familiar"* (ID9). *"I would like to learn to use the joystick better, because I had seen it done but I had never used it"* (ID17).

Finally, some participants reported difficulty in following framing changes: *"I generally have slow image processing; therefore, there is also a mental effort to follow the changes of shot which are faster than what I would have done, that is, the image is already being modified when I would have turned my neck much more slowly if I had been in reality"* (ID32).

#### *Negative Feelings About the Inability to Use the iVR Device*

Some patient reported irritation for not knowing how to use the devices: *"I had some problems due to not knowing and not being familiar with [the device] (. . .) so I got irritated"* (ID9).

### Discussion

This qualitative study, embedded within an experimental trial, aimed to explore cancer patients' experiences with iVR during an AT session. Our findings revealed several positive experiences associated with the use of iVR. Patients expressed appreciation for the possibility to choose from a variety of beautiful and high-quality scenarios. However, some negative aspects of using iVR devices were also highlighted. To the best of our knowledge, only two qualitative studies were conducted to explore participant experiences with iVR during AT.<sup>24,25</sup> Other studies on the effects of iVR during AT have used poststudy questionnaires to assess participant experiences without qualitative analysis or have measured satisfaction levels with iVR.

Our study revealed positive emotional experiences, including feelings of serenity and tranquility, a sense of freedom, reduced negative thoughts, relief from anxiety, relaxation, and enjoyment. These findings are consistent with those reported by O'Gara et al.<sup>26</sup> who described beneficial effects on mental well-being, mood, anxiety, and stress on English adult patients undergoing AT. Our findings are also similar to those of Wong et al.,<sup>25</sup> who interviewed Chinese pediatric patients, and identified three categories: positive experiences, perceived benefits of the intervention, and suggested improvements.

The cognitive and emotional benefits of iVR are consistent with various neurological and psychological theoretical models. The stress and adaptation model proposed by Lazarus and Folkman<sup>37</sup> can elucidate a positive cognitive response, characterized by increased control, tolerance, or stress. Additionally, according to Fredrickson's positive psychology framework,<sup>34</sup> the decrease in anxiety levels, and the frequency and intensity of negative emotions could be attributed to iVR's ability to shift attention toward emotional resources in a positive virtual environment.<sup>34</sup>

Among the positive emotions experienced during iVR, enjoyment is particularly significant. Enjoyment represents a temporary sense of well-being derived from the alleviation of sorrow. According to the pleasure principle of psychoanalysis,<sup>38</sup> pleasure and sorrow are central dynamics of psychic life. Two psychological dynamics linked to enjoyment are distraction and immersion in scenarios, facilitated by iVR's ability to deeply, rapidly, and multisensorial immerse individuals in virtual environments over prolonged periods. This foundational capability of iVR to influence neuropsychology is rooted in the complex dual-task neuropsychological model. According to this model, two sensory inputs cannot be perceived simultaneously, thereby preventing consciousness from engaging in dual tasks simultaneously.<sup>39</sup> As a result, unconscious selective attention prioritizes this sensory input, causing virtual scenarios to enter conscious awareness at the level of the dorsolateral prefrontal cortex,<sup>40</sup> while hospital inputs remain unconscious during a psychological refractory period that concludes with the cessation of iVR.<sup>41</sup> iVR also accelerates the perception of the passage of time. This finding is aligned with the studies conducted by Schneider et al.<sup>42-44</sup> According to the simulation-accumulation cognitive model,<sup>45</sup> iVR shifts attention to environmental scenarios, rendering the processing of temporal information unconscious. The subjective perception of time passing more slowly could be linked to virtual scenarios influencing the activity of dopaminergic neurons in the *substantia nigra*, which encode information regarding variability in time estimates. According to Soares et al.,<sup>46</sup> the transient activation or inhibition of dopamine neurons can either slow down or accelerates time estimate.

Our results showed that the iVR is a customizable intervention featuring beautiful images across a variety of scenarios characterized by video and aesthetic appeal. Patients expressed appreciation for the scenarios, which deeply resonated with their interest in iVR content, in accordance with O'Gara et al and Wong et al.<sup>25,26</sup> The most appreciated natural scenarios included the marine environments, animals, and mountains, elements known to contribute to well-being. The immersive and distracting qualities of natural scenarios are attributed to their diverse chromatic characteristics, sounds, and variety.<sup>23</sup> These multisensory features induce relaxation, inner calm, and peace, thereby reducing anxious and depressive states.<sup>47</sup>

Our study also revealed negative aspects of the iVR intervention, such as discomfort with the equipment and negative feelings related to the inexperience in using the iVR devices. As in previous studies, patients reported discomfort with the VR headset and expressed the need for easier adjustments.<sup>48</sup> Although the HMDs were the best on the market during the study period, they presented several technological problems, such as visor heaviness, image blurriness, lack of peripheral vision, lack of isolation from external sounds, and framing changes. Such technological issues have now been overcome by the latest generation of iVR devices, which are increasingly lighter, more wearable, and manageable, with more precise and sophisticated automated focus systems. Reported focusing problems may be due to the patient's difficulty in managing ocular variables because of inexperience with the iVR headset or a lack of understanding of the instructions and tests performed with the healthcare professional.

#### *Limitations*

Our study findings should be considered in light of some limitations. The length of an iVR intervention during AT was only 30

minutes, therefore it covered only a part of the AT session. This time limitation, imposed by safety requirements that restrict the use of iVR to no more than 30 consecutive minutes, may have diminished the quality and depth of the experience for patients. Moreover, the interviews were conducted immediately after the AT session, focusing only on the immediate experience with iVR and missing an understanding of the long-term effects on emotional and mental states. Lastly, some interviews were brief because they were conducted at the end of AT, and patients wanted to return home as soon as possible and to avoid keeping their family members waiting to accompany them. The small sample size subjected to qualitative analysis was obtained based on the inclusion and exclusion criteria, the trail length, the 1:1:1 balanced allocation, and the consecutive sampling methodology.

## Conclusions

iVR is an innovative intervention that can be implemented in nursing practice to enhance the humanization of care and foster a patient-centered approach in patients undergoing AT. Our study in fact shows the perceived cognitive and emotional benefits of iVR which enhances the knowledge and experiences of patients undergoing AT, evokes positive emotions, and fosters cognitive engagement. iVR was appreciated for its customizable features, beautiful images, variety of scenarios, and high-quality videos. However, negative experiences were also reported, including discomfort with the equipment and frustration due to unfamiliarity with the iVR devices. To improve the patients' experiences, greater attention should be given to familiarizing them with iVR by dedicating more time to training and utilizing the latest technology. Additionally, exploring patients' experiences not only immediately after the iVR session but also at follow-up could provide deeper insights into their long-term perceptions of the experience.

## Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work, the authors used OpenAI to improve the readability and language of the manuscript. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

## CRediT authorship contribution statement

**Francesco Burrai:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Maria Matarese:** Writing – review & editing, Validation, Supervision, Methodology, Formal analysis. **Valentina Micheluzzi:** Writing – review & editing, Writing – original draft, Investigation, Data curation. **Giulia Cadeddu:** Writing – review & editing, Investigation, Data curation. **Maria Grazia De Marinis:** Writing – review & editing, Validation, Supervision. **Michela Piredda:** Writing – review & editing, Validation, Supervision, Methodology.

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