# An exploration into the efficacy of virtual reality for managing pain in hospitalized patients, with a focus on cancer pain

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## ABSTRACT

Cancer pain is highly complex and associated with a great global and individual burden. Due to its multifactorial nature, it must be addressed with a combination of pharmacological and non-pharmacological approaches. Many people with cancer feel their pain is inadequately managed, pointing to the critical need for new management approaches. Virtual reality (VR) is a promising management strategy for a variety of pain conditions, at the forefront of research. This study aims to explore the use of VR in the management of pain in hospitalized patients, focusing on cancer-related pain. A systematic review was carried out on all eligible articles published before July 2025, in accordance with Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines. Randomized control trials that investigated VR in the pain management of hospitalized adult patients were included. Thirty-three (33) randomized control trials were included in the systematic review following selection processes. Outcome measures such as the visual analogue scale, the numerical rating scale, and graphic rating scale, were commonly used; 79% of articles reported a significant reduction in pain when using VR. None of the studies reported any significant adverse effects. VR is a safe and feasible option for adjunctive, non-pharmacological pain management in hospitalized patients. Few studies investigate the application of VR in the management of cancer pain, however, those available reveal promising results. Future randomized control trials that employ a double blinded study design would be of benefit.

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Key words: virtual reality; pain; cancer.

Contributions: AS, study concept, data analysis and interpretation, original drafting of the manuscript, and critical revision for important intellectual content; MH, AG, contribution to manuscript editing. All authors read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Conflict of interest: the authors declare no conflicts of interest, and all authors confirm accuracy.

Received: 31 July 2025.
Accepted: 24 September 2025.

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*Advancements in Health Research 2025; 2:41*
*doi: 10.4081/ahr.2025.41*



## Introduction

The International Association for the Study of Pain defines pain as "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage".[1] Cancer pain can be described as a general term, referring to a range of different conditions characterized by a variety of characteristics, pathological mechanisms, and aetiologies.[2] Over 50% of people affected by cancer report moderate-to-severe pain. This statistic becomes higher, at 80% of people reporting moderate-to-severe pain in cases of advanced stages of cancer.[2] Cancer pain can be experienced by persons of all ages, at all stages of their disease (including within cancer survivors). There are few predictive factors of cancer pain: younger patients are more likely to experience cancer pain, and those with advanced cancer are more likely to experience a greater severity of pain.[3]

Within the new ICD definition for Chronic Pain, pain was characterised into 7 groups which included chronic cancer pain. Within this categorisation, chronic cancer pain was subdivided based on its location: visceral, musculoskeletal, and somatosensory/neuropathic, and its temporal variation: continuous (background), or intermittent (episodic).[2] As well as categorising cancer pain by its location and behaviour as aforementioned, we can deduce that cancer pain may also be described through 'timing': cancer pain may be described as acute or chronic. However, it is worth noting that within cancer pain, it is often difficult to differentiate between chronic and acute pain, as through disease progression there is often progression of associated tissue damage.[2] Another common type of pain experienced in cancer is breakthrough pain. Breakthrough pain refers to the pain experienced by a person whilst managing their chronic or background pain. Breakthrough pain is often described as intense, coming on sud-

denly and lasting for a short period, and can be unpredictable (spontaneous), or predictable (incidental).[4]

The clinical presentation of cancer pain is highly variable due to the many different aetiologies and underlying mechanisms. Despite this, we are able to observe some common features amongst cancer pain conditions. For example, somatic type pain is widely accepted as the most common type of cancer pain – this is characterised as intermittent or constant, well-localized, and can be described as 'throbbing', 'gnawing', or 'cramping'.[5] Conversely, difficult visceral pain (that which does not improve with conventional methods) occurs in up to 15% of people with cancer,[6] and can be described as 'deep', 'squeezing', or 'colicky'. Visceral pain can be misrepresented as somatic pain, due to cutaneous referral.[5] Thirdly, neuropathic pain, which is also commonly reported by people with cancer (observed in up to 40% of people with cancer), is often described as 'burning', 'shooting' and 'tingling' sensations. This neuropathic pain can be expressed in paroxysms of 'shock-like' pain, and clinically is often described as dysesthesia.[7] Cancer pain can be characterised as neuropathic, somatic or visceral, as well as many with the condition experiencing a mixed picture.

As with all pain syndromes, cancer pain's biopsychosocial factors must be considered, in line with pain theories. The term 'total pain' is commonly applied within oncological and haematological populations, and has been used to describe the experience of pain within palliative care to characterise the multidimensional nature of pain.[8] Several factors have been identified which contribute to the experience of pain within palliative cancer patients, including: physical, spiritual, psychological, and financial aspects.[8] Without consideration of such a concept, it is suggested that optimum pain control cannot be achieved within these populations.

Cancer pain is a complex multifactorial condition, with its pathophysiology driven by inflammatory, neuropathic, and other mechanisms specific to the disease. Cancer pain can affect any bodily tissue, with correlation to the anatomical location of the disease within the body; this includes viscera, bone, soft and nervous tissue. Cancer pain can affect multiple locations throughout the body, particularly when the disease is metastatic.[2]

Cancer pain can be caused by the disease itself, as well as its treatment. The condition is most commonly caused by the tumour compressing structures in the body: this neoplastic pain can affect all parts of the body included viscera, nervous tissue, soft tissue and bone. A study investigating the experience of patients with advanced cancer accessing palliative care services, identified the primary tumour as the principal cause of pain (68%).[9] In this instance, nociceptors are activated about either the viscera, nervous tissue, or soft tissue and bone, either mechanically or chemically, leading to the experience of pain.[5] Metastatic bone disease is a large cause of cancer pain – this occurs through processes of bone destruction with concurrent new bone formation: nociceptors are sensitized by prostaglandins and osteoclast-activating factors which are released through osteolysis and osteoclast activity.[5] As well as in oncological populations, pain is also present in many haematological malignancies. Complex pain syndromes are present in up to 60% of patients undergoing treatment for haematological malignancy, and up to 33% of survivors.[10] Studies have shown that the most common type of pain experienced within haematological populations is deep somatic pain, with others experiencing: superficial somatic, visceral, neuropathic, and mixed.[2] Similarly to mechanisms associated with pain secondary to oncological disease, pain associated with haematological malignancy can occur secondary to bone or soft tissue invasion. This invasion can lead to: necrosis, tumour haemorrhage, thrombosis, neuropathies, viscus perforation, pathological fractures, amongst many other pathophysiologies.[10] Furthermore, paraneoplastic syndromes contribute to the variety of pain conditions observed amongst cancer patients, which occur secondary to an immune reaction to the cancerous tumour (neoplasm). Pain has been shown to occur in 41.3% of patients with paraneoplastic syndromes.[11]

Treatment-related pain can be secondary to surgical intervention, radiation therapy, chemotherapy, diagnostic procedures, targeted therapies, and supportive care therapies.[9] Secondary to chemotherapies, pain can manifest through: peripheral neuropathies, myalgia, steroid-induced complications, mucositis, avascular necrosis, and enteritis amongst other mechanisms.[10] Similarly, radiation therapies can induce conditions such as enteritis and neuropathies, alongside other manifestations including skin breakdown, osteonecrosis and secondary fractures, and lymphedema.[10] Post-operative cancer pain encompasses disorders such as phantom limb pain, local necrosis, and radiculopathy, whereas stem cell transplantation may be associated with pain syndromes that manifest through chronic skin changes, and paraesthesia.

The goal of pain management is to improve quality of life for patients and their families, by relieving pain to a level at which this is achieved.[12] In order to achieve this goal, due to the complexity and multifactorial nature of cancer pain, the management must be multimodal, and individualised. The concept of total pain has led to the endorsement and implementation of a multi-faceted and multidisciplinary pain management team within cancer services addressing cancer pain with a combination of pharmacological and non-pharmacological approaches.[13] Total pain, as described prior, considers the psychological, social, and spiritual facets that compound the physical experience of cancer pain. This concept is perhaps most important within the management of cancer pain due to the cancer-specific associated psychological experience of mortality salience and existential pain.

Clinical guidelines and recommendations ensure that practice is evidence-based. The World Health Organisation have developed guidelines for the safe and effective management of cancer pain within adults and adolescents, to guide the evidence-based initiation and implementation of pharmacological and radiotherapeutic pain management strategies.[12] The European Society for Medical Oncology (ESMO) guidelines for the management of cancer pain in adult patients expand on this by emphasising the importance of the initial and ongoing assessment of cancer pain, which is integral to appropriate and individualised management.[14] As well as clinical assessment through physical assessment and investigations, the impact of the pain on a persons' social, spiritual and psychological wellbeing must be continually assessed: for example, the interference with activities of daily living, sexual functioning, spiritual concerns, degree of awareness of the disease, amongst other items.[14]

There are several facets to pain assessment which contribute to the effective management of cancer pain, including regular screening, determination of the correct modalities of treatment, and correct characterisation of the pain.[9] In order to correctly characterise the pain, features such as the pains intensity, location and quality must be considered. There are several pain assessment tools which are used in the assessment of cancer pain; most commonly used, include the numerical scale (0-10), the categorical scale (none, mild, moderate, severe), and the visual analogue scale (0-100).[9] More comprehensive pain questionnaires can often be

difficult to implement in a clinical setting due to their time-consuming nature and complexity. Assessments to categorize quality of life (such as the Multidimensional QoL Scale – cancer) can also be useful when assessing pain to determine the impact of pain on a person's daily life.[15]

Oncology specific management strategies such as radiotherapy and chemotherapy work to relieve pain by reducing the tumour size/mass, with bisphosphonates supporting to manage bone pain.[16] The National Institute for Health and Care Excellence guidelines for the management of palliative cancer pain advocate for consultation of WHO's analgesic ladder for a stepwise approach to analgesia and opioid prescribing, as well as recommending consideration of a non-opioid adjuvant drug at any stage in the management of a person's cancer pain.[4] Furthermore, the British Pain Society advises that pain management programmes which are founded on cognitive and behavioural concepts are most effective for people with pain negatively impacting their quality of life.[17] Non-pharmacological pain management strategies such as mindfulness-based cognitive therapy and guided imagery have been shown as effective in the reduction of cancer pain.[18] See Table 1 for a simplified non-exhaustive summary of the pharmacological and non-pharmacological (holistic) management strategies implemented in the management of cancer pain based on guidelines.[4,16]

An important aspect of all pain management programmes within chronic disease frameworks, is self-management. ESMO guidelines recommend that patients are informed about pain management and are encouraged to take an active role in their programmes.[14] Self-management strategies help to improve a person's quality of life by enabling and empowering them to become active participants in their care. In the management of cancer pain, self-management encourages patients to use their developed skills of self-efficacy and self-regulation to actively manage their disease and work towards achieving their health goals and negotiate their emotional wellbeing.[19] It is important, due to the specific context of cancer pain, that people are supported to do this and guided based on individualised cultural and social concepts relevant to the patient.

Cancer pain has been demonstrated to be a challenging public health issue, with its treatment often suboptimal. Despite the use of guidelines to inform practice, under-treatment is prevalent, with an estimated 20-30% of people with cancer having poorly managed pain.[13] Until recently, the management of cancer pain has heavily relied on pharmacological management. Due to the global under-treatment of cancer pain, it is important to consider new and non-pharmacological approaches that can be employed to treat cancer pain holistically.

Amongst other innovative pain management initiatives at the forefront of pain research, sits virtual reality. Virtual reality is a promising pain management strategy for a variety of pain conditions and describes the non-invasive, non-pharmacological implementation of an immersive experience to aid heightened distraction through the activation and stimulation of visual and auditory senses.[20] Although virtual reality in pain management remains in its infancy, it is steadily becoming a more accessible and therefore viable option for the management of several pain conditions.[20] Several theories have proposed the mechanism by which virtual reality provides analgesic effect. It is suggested that the basis of sensory distractions (tactile, auditory, visual, olfactory) can lead to intercortical modulation within pain pathways creating a distraction effect, as well as the increase in activity within the anterior cingulate cortex and orbitofrontal regions in the brain secondary to sensory distraction, resulting in a concurrent decrease of activity within the pain matrix.[21]

This systematic review aims to identify and appraise existing research investigating the implementation of virtual reality in both acute and chronic pain conditions within patient populations, in order to evaluate the demand for and the feasibility of the application of virtual reality amongst cancer pain populations within a trial capacity.

**Table 1.** A simplified non-exhaustive table to summarize the pharmacological and non-pharmacological (holistic) management strategies implemented in the management of cancer pain based on guidelines.[4,16]

| Pain management category | | Pain management strategy |
|---|---|---|
| Oncological | | Chemotherapy and targeted therapies |
| | | Radiotherapy |
| | | Bisphosphonates |
| Pharmacological | | Opioids |
| | | Non-opioids/Adjuvants e.g. tricyclic antidepressants, local anaesthetics, anticonvulsants, NSAIDs, steroids |
| Non-pharmacological | Psychological | Cognitive behavioural therapy |
| | | Acceptance commitment therapy |
| | | Relaxation techniques |
| | Social | Sleep hygiene |
| | | Social prescribing/support groups |
| | | Carer support |
| | Spiritual | Faith-based therapy |
| | Complementary and alternative medicines (CAMs) | Mind-body therapies (e.g. reflexology, meditation)<br>Hypnosis<br>Imagery<br>Creative (e.g., music or art therapies) |

## Methods

An extensive review of scientific literature was carried out systematically by the researcher in line with the guidelines for Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA), focusing on the efficacy of virtual reality in the management of pain of adult patient populations within a hospital setting.

## Search strategy

The following databases were searched including all trials published between January 2000 and July 2025: PubMed, CINAHLplus (EBSCOHost), AMED (OVID), UCL, Embase, and PsycINFO. The search strategy combined MeSH terms and free-text terms including 'virtual reality,' 'pain management,' 'oncology,' and 'randomized controlled trial.' Boolean operators were applied to increase sensitivity. The search was carried out without any limitation of years. An initial database of papers was extracted and inputted into Excel for data management purposes, before being narrowed down through automated search tools and manually screened further to obtain those eligible for the actual review. Full texts were obtained through institutional access by the researcher. Full texts that were not accessible via open access or institutional log-in were not included in this review.

## Selection criteria

The researcher screened titles and abstracts of retrieved studies to determine their eligibility for this study, filtering papers manually. Randomised control trials (RCTs) were included that were available to read in full-text and in the English language, studying patient populations aged 18+. Only English-language studies were included, which may introduce language bias. This limitation is recognized and was due to translation resource constraints. Studies were included which examined the effects of virtual reality on both acute and chronic pain, permitting that patients were hospitalised. This context was selected to ensure that findings were relevant and applicable to in-patient treatment. Systematic reviews and meta-analysis were excluded. Although studies investigating the effect of virtual reality during medical procedures were included, those investigating dental procedures or childbirth were not. Studies were excluded further if i) they studied child and adolescent populations, ii) subjective pain measures were not clearly identified as primary outcomes, iii) were not clearly carried out in a hospital setting, iv) were carried out in healthy participant groups only, or v) implemented augmented reality. Subjective outcome measures (both qualitative and quantitative) used as primary outcome measures, have been used to shortlist the papers in this review in order to reflect the subjective nature of pain.

For the purpose of this systematic review, pain was defined as "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage" as per described by the International Association for the Study of Pain.[1] Furthermore, this review defines virtual reality as "a three-dimensional computer-generated simulated environment, which attempts to replicate real world or imaginary environments and interactions, thereby supporting work, education, recreation, and health".[22] The selection process was recorded in sufficient detail to complete a PRISMA flow diagram (Figure 1) with selection criteria detailing reasons for paper exclusions.

## Data extraction

The final screening of articles involved the review of complete papers wherein the titles and abstracts had been deemed relevant and were in-keeping with the selection criteria. All studies were imported into 'mybib', a free reference generator, for data management purposes. From the eligible papers, the researcher independently extracted study and patient population characteristics as well as outcomes. The data extracted manually by the researcher included the following items: study population, intervention, comparators, and outcome measures, study design, and timeframe, as per the PICOST model.[23] The data collected also included the year of study, sample size, and type of setting.

## Outcomes

The primary outcomes investigated were pain intensity and degree of analgesia afforded by virtual reality, however secondary outcomes including quality of life, depression, anxiety, general health status, and functional status were also considered.

## Quality assessment

The researcher independently assessed the risk of bias for each randomised control trial (RCT) using the 'Cochrane Risk of Bias 2' tool.[24] This tool aimed to categorise RCTs as either 'low risk', 'some concerns', or 'high risk' based on the respective domains.

## Results

The initial search using key words 'virtual reality' and 'pain' across three databases revealed 3627 articles. Of these, 2973 articles were excluded through automated tools filtering 'randomised control trials' only. These articles were exported to Excel for data management purposes and a further 90 articles were excluded due to duplications. In accordance with PRISMA reporting guidelines, titles and abstracts of each article were then manually screened with selection criteria, leading to the exclusion of a further 283 articles. On the researchers attempt to access full-texts for the remaining 281 articles, 138 were not able to be retrieved due to either a lack of availability of texts in the English Language, or accessibility issues met by the researcher. The final screen of full-text articles excluded papers that were not carried out on hospitalized patients, those which did not use immersive virtual reality, those which were carried out on healthy participants, and those which did not employ subjective measures for pain as primary outcomes. This left a final 33 studies which were examined, with key characteristic data extracted and inputted into a table.

## Study selection

See Figure 1 for a flow diagram for study selection based on PRISMA guidelines.[25]

## Study characteristics

See Table 2 for a summary of relevant study characteristics: populations, interventions, comparators, outcome measures, study designs and timeframes (PICOST), among other items.

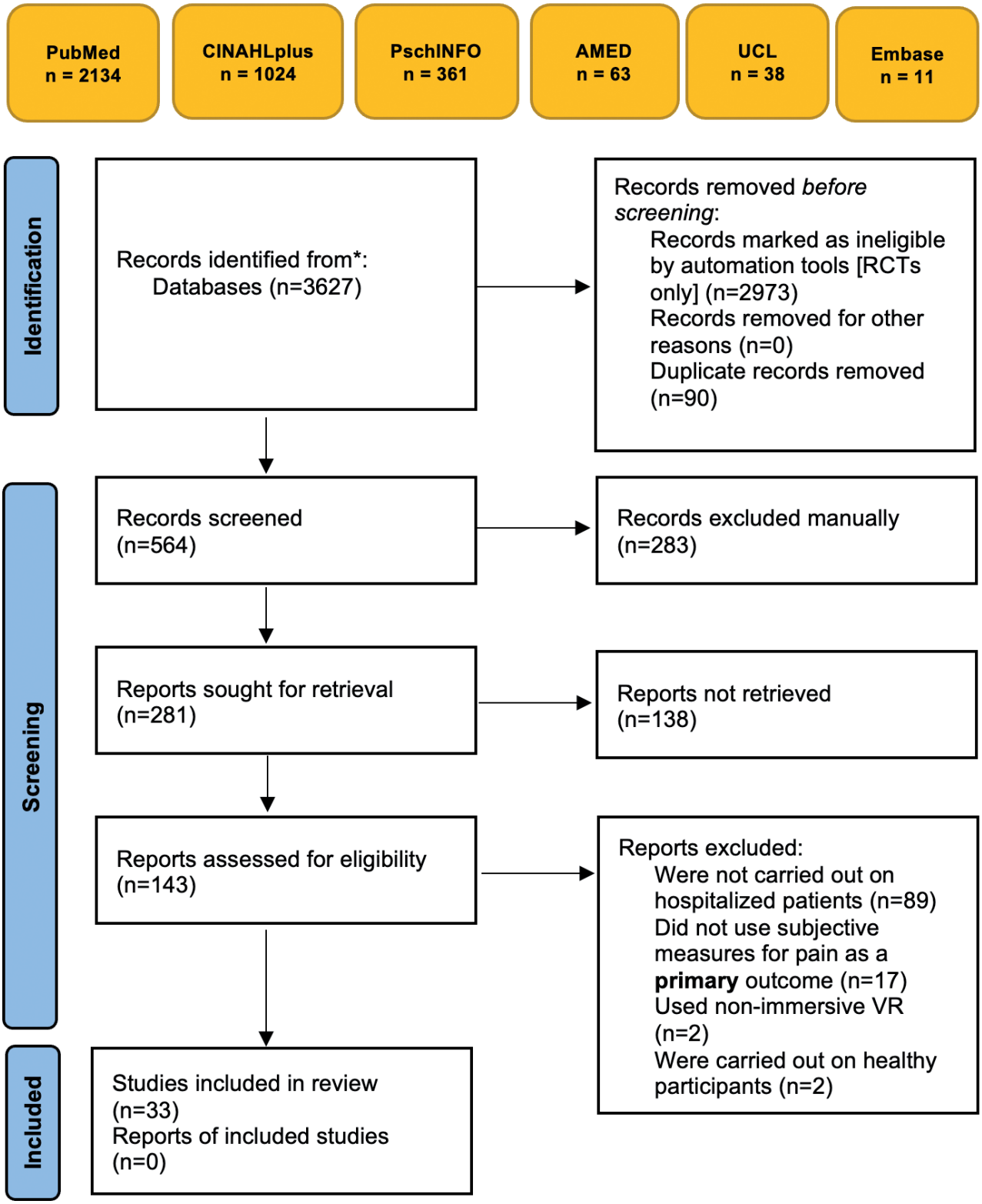


**Figure 1.** A flow diagram for study selection based on PRISMA guidelines.[25]

**Table 2.** A table to summarize relevant study characteristics: populations, interventions, comparators, outcome measures, study designs and timeframes (PICOST), among other items.

| Author | Year | Study design | Intervention | Comparator | Time frame | Population | Setting | Sample size |
|---|---|---|---|---|---|---|---|---|
| Rousseaux et al. | 2021 | Prospective randomised controlled clinical trial. | Virtual reality (graphical landscape) | Control, hypnosis, virtual reality hypnosis | October 2018-January 2020 | Adults undergoing cardiac surgery | University hospital | 4 x (n=25) |
| Morris et al. | 2023 | Randomized within-subject crossover clinical trial | Virtual reality environment - theBlu | Two control groups (placebo, and non-immersive digitals) | October 2020 to January 2022 | Adults hospitalized with traumatic injuries | Trauma hospital | n=60 |
| Spiegal et al. | 2019 | Prospective, randomized, comparative effectiveness trial | Virtual reality – television programming | Control group | November 2016-November 2017 | Hospitalized adults | Tertiary care hospital | n = 120 |
| Araujo-Duran et al. | 2023 | Randomized and blinded trial | Virtual reality relaxation and mindfulness | 2D presentations of nature scenes | August 2020 – April 2022 | Adults awaiting elective primary total hip arthroplasty | Hospital | n = 106 |
| Payne et al. | 2020 | Open-label single-centre randomised crossover pilot trial | Virtual reality – Skylights 2 (active/interactive) | Virtual reality – Cosmic You (passive) | April-August 2019 | Women >18 undergoing laparoscopic procedure | Tertiary university teaching hospital | 2 x (n=17) |
| Patterson et al. | 2010 | Randomized control design | Virtual reality – artic canyon (passive or interactive) | Standard treatment | Data unavailable. | Hospitalized trauma patients (adults) | Trauma centre | n = 21 |
| Groninger et al. | 2024 | Prospective randomized controlled trial | Virtual reality – distraction therapy | 2D digital distraction | Data unavailable. | Adults hospitalized with cancer | Academic hospital | n = 128 |
| Hoffman et al. | 2001 | Within-subjects | Virtual reality - interactive | Control (no distraction) | Data unavailable. | Patients hospitalized at major burn facilities | Burn care unit | n = 7 |
| Powers et al. | 2021 | Modified crossover experimental design | Virtual reality – Hamilton pool preserve, Red bud isle, lady bird lake. | Standard care | Data unavailable. | Hospitalized inpatients reporting pain | Hospital | n = 103 |
| Austin et al. | 2022 | Within-subject, randomised cross-over feasibility trial | Virtual reality – nature trek | 2D screen application | July 2020 – May 2021 | Palliative care inpatient unit patients or patients receiving home-based palliative care | Inpatient unit (and home) | n = 13 |
| Wiechman et al. | 2022 | Randomized, controlled trial | Virtual reality – distraction or hypnosis (Snow world) | Usual care | Data unavailable | Patients hospitalized at a trauma center | Trauma centre | n = 153 |
| Maani et al. | 2011 | Within-subject experimental design | Virtual reality – icy canyon | Standard care | Data unavailable | US soldiers (adults) burned in combat attacks | Burns unit | n = 12 |

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**Table 2.** Continued from previous page.

| Author | Year | Study design | Intervention | Comparator | Time frame | Population | Setting | Sample size |
|---|---|---|---|---|---|---|---|---|
| Bozdogan Yesilot et al. | 2022 | Randomized control trial | Virtual reality – 'relaxing video' | Standard care | March 2019 – September 2019 | Patients undergoing lipoma excision | Training and research hospital | 2 x (n = 50) |
| Romano Bruno et al. | 2020 | Single-centre, prospective, open-label, randomised controlled trial. | Virtual reality: nature scenery, an aquarium, flying over a green landscape, diving underwater or walking through a calm forest | Standard care | December 2019-January 2020 | Patients undergoing transfemoral TAVI for severe aortic valve stenosis | University Hospital | 2 x (n = 16) |
| Hoffman et al. | 2000 | Within-subjects | Virtual reality – SpiderWorld | Conventional treatment | Data unavailable | Patients with severe burns and pain | Burn care unit | n = 12 |
| Dalir et al. | 2024 | Randomized clinical trial | Virtual reality – natural landscapes | Routine care | Over 2020 | Adults undergoing CABG surgery | ICU | n = 70 |
| Carrougher et al. | 2009 | Within-subjects, crossover | Virtual reality – Icy canyon | Standard care | Data unavailable | Adults with severe burns and pain | Burn centre | n = 39 |
| Okutan & Saritas | 2024 | Randomized trial | Virtual reality – nature landscapes and scenes +/- music | Standard care | October 2019 – June 2020 | Adult patients who underwent laparoscopic abdominal surgery | Hospital | n = 225 |
| Blockzijl et al. | 2023 | Randomized, between-subjects | Virtual reality (selection of games and videos) | Care as usual | October 2016 – December 2018 | Patients with acute burns >8yrs | Burn centre | 2 x (n = 64) |
| Merliot-Gailhoustet et al. | 2022 | Cross-over randomized | Virtual reality – Deepsen or Healthy Mind. | Standard or Music-Care | July 2019 to December 2019 | Adults admitted to ICU | Intensive care unit | n = 60 |
| Mcsherry et al. | 2018 | Within-subjects randomized, control | Virtual reality - SnowWorld | No virtual reality | October 2013 – March 2015 | Adults undergoing painful wound care procedures | Community hospital | n = 18 |
| Armstrong et al. | 2023 | Pilot randomized control trial | Virtual reality – Town and Cave or City and Forest (Active or passive) | Control – standard care | May 2019 - February 2020 | Adult patients with burn injuries | Hospital | n = 14 |
| Mohammed & Ahmed | 2018 | Randomized control trial | Virtual reality | Control | Over a 4-month period | Adult female patient diagnosed with breast cancer | Specialized cancer center | n = 80 |
| Chiu et al. | 2023 | Assessor-blinded prospective randomized clinical trial | Virtual reality – video of operating theatre and surgery process | Control – standard care | July 2022 – December 2022 | Adult scheduled for their first elective surgery procedure under general anesthesia | Hospital | n = 74 |

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**Table 2.** Continued from previous page.

| Author | Year | Study design | Intervention | Comparator | Time frame | Population | Setting | Sample size |
|---|---|---|---|---|---|---|---|---|
| Sarikose & Turan | 2025 | Parallel randomised control trial | Virtual reality – nature images and sound | No intervention | November 2021-April 2022 | Adults undergoing bronchoscopy | Bronchoscopy unit, hospital | n = 70 |
| Cao et al. | 2025 | Single-centre, triple-arm pilot randomized controlled trial | Immersive virtual reality | Control – placebo VR | October 2021-March 2023 | Post-operative adults | Hospital | n = 61 |
| Gautama et al. | 2024 | Prospective, two-arm, randomized controlled trial | Immersive virtual reality – scenery videos | Standard care | March-May 2023 | Cancer patients undergoing chemotherapy | Chemotherapy unit | n = 99 |
| Sen & Bakar | 2024 | Randomized controlled study. | Virtual reality glasses | No intervention | November 2018 – January 2019 | Patients undergoing haemodialysis in a hospital haemodialysis centre. | HD Unit, haemodialysis centre | n = 60 |
| Kamada et al. | 2025 | Single-centre randomized controlled trial | VR therapy with the Therapeia VR system (xCura) | Control – conventional procedures | July-October 2024 | Adults with cancer undergoing CV port placement | Hospital | n = 10 |
| Kondylakis et al. | 2025 | Stratified randomized controlled design | Virtual reality (CARINAE) | Standard care | September 2021-March2022 | Participants aged 12 to 65 years who underwent various surgeries | Cardiothoracic surgery dept, hospital | n = 74 |
| Lier et al. | 2024 | Multicenter randomized controlled trial | 3D virtual reality | 2D virtual reality | May 2019-May 2021 | Adults undergoing major surgery | University hospital | n = 100 |

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**Table 2.** Continued from previous page.

| Author | Year | Study design | Intervention | Comparator | Time frame | Population | Setting | Sample size |
|---|---|---|---|---|---|---|---|---|
| Ozbas et al. | 2024 | Parallel-group, randomized controlled study | 360-degree VR videos with nature and landscape scenes and relaxing background music | No intervention | June 2022-July 2023 | Adults undergoing chest tube removal | Hospital | n = 40 |
| Wang et al. | 2024 | Prospective, single-centre, randomized, controlled, open-label study | VR video viewing | Standard care | Data unavailable | Adult female patients undergoing gynaecology surgery. | Hospital | n = 115 |

## Characteristics of intervention

The majority of studies examined applied head mounted displays with goggles/headsets to deliver the immersive virtual reality distraction therapy. Various makes of headsets were used, including: Oncomfort, Samsung Gear Oculus, and Oculus Rift. This equipment was selected most frequently dependent on expense, availability, ease-of-use, and portability. Different landscapes and scenes were used amongst different patient groups; often patients were able to choose from a selection. Common themes of landscapes included relaxation and mindfulness – the landscapes included nature scenes, water scenes, and snow scenes, amongst others. Some studies applied audio – either that which was relevant to the scene, music, or narration carried out by the investigator. Whilst the majority of immersive environments were described as 'passive', some offered interactive features which engaged the patients' gaze, and if equipment accommodated, hand movements.

Comparative interventions were most commonly 'standard care', or 'care as usual', however a small amount of studies investigated the difference between immersive and non-immersive digital materials, or between CGI and video-capture programmes. Others investigated a comparison between virtual reality with/without hypnosis, or music therapies. Rousseaux *et al*. concluded that their prospective randomised control trial showed nil significant difference between the results ascertained for the virtual reality group, and the virtual reality hypnosis group.[26] In Table 3 the average time spent in virtual reality for each study is reported.

## Characteristics of outcome measures

This systematic review evaluated all accessible randomized control trials that fit the eligibility criteria – this demanded that the RCTs used a subjective measure for pain as their primary outcome measure. The outcome measures used within the RCTs for measurement of pain were primarily; the Visual Analogue Scale (VAS), Graphic Rating Scale (GRS), and the Numerical Rating Scale (NRS). These outcome measures were assessed at various points depending on the nature of the study: for example, if undergoing an intervention, patients assessed their pain prior to the intervention, during (if appropriate), and following the intervention at different intervals. See Table 4 to visually demonstrate the different subjective outcome measures used across studies to measure pain. Alongside pain rating scales, most studies incorporated secondary outcome measures. These included measures to investigate fatigue, anxiety, mood, patient-reported engagement/satisfaction, length of hospital stay, vital signs, and use of pharmacological analgesia. Demographic data was also gathered, as well as questionnaires to ascertain any negative side effects experienced that were associated with the use of virtual reality equipment/cybersickness.

## Efficacy of virtual reality in managing pain

Of the 33 randomized control trials included in this review, 26 (79%) demonstrated a significant reduction in pain or discomfort, when compared with the alternative (standard-care, or control group). Seven (7) studies therefore revealed no statistically significant difference in reported pain scores between the intervention groups (virtual reality), and no intervention (control) groups. However, of these studies, one study that determined nil significant reduction in reported pain scores, suggested that there was however a significant reduction in opioid usage within the virtual reality group inferring that virtual reality reduced the demand for pharmacological analgesia in this instance. There is a variety of results when considering the comparison of 2-dimensional and 3-dimensional 'virtual reality', with some reporting a statistical difference with 3D VR leading to an increased reduction in reported pain scores, whereas others determined the two interventions produced a similar analgesic effect. The results were similarly inconclusive when comparing active, and passive virtual reality environments.

**Table 3.** A table to demonstrate the average time spent in virtual reality for each study.

| Average time spent in VR (minutes) | Study citations | Total number of studies |
|---|---|---|
| 0-5 | [35]; [30]; [36]; [37]; [29]; [38]; [39] | 7 |
| 6-10 | [40]; [41]; [28]; [42]; [43]; [44]; [45]; [46]; [47]; [48]; [49] | 11 |
| 11-20 | [26]; [50]; [27]; [51]; [52]; [53]; [54] | 7 |
| >20 | [31]; [55]; [56]; [57]; [58] | 5 |
| Data unavailable | [59]; [60]; [61] | 3 |

**Table 4**. A table to visually demonstrate the different subjective outcome measures used across studies to measure pain.

| Outcome measures | Study citation | Total number of studies |
|---|---|---|
| Visual analogue scale (VAS) | [26]; [35]; [57]; [30]; [58]; [54]; [45]; [36]; [38]; [39]; [60]; [48]; [49]; [61] | 14 |
| Numerical (pain) rating scale (N(p)RS) | [50]; [40]; [31]; [42]; [27]; [51]; [52]; [53]; [46]; [47]; [59] | 11 |
| Graphic rating scale (GRS) | [55]; [43]; [56]; [44]. | 4 |
| Other | [41]; [28]; [37]; [29] | 4 |

## Efficacy of virtual reality in managing cancer related pain

Of the studies collated, 6 were carried out on oncological or haematological populations. These included the investigation of the impact of virtual reality on: patients hospitalized with cancer; patients with cancer receiving palliative care; patients undergoing lipoma excision; patients hospitalized with breast cancer; cancer patients undergoing chemotherapy; and adults with cancer undergoing CV port placement. Four out of six studies' control groups consisted of standard care/no intervention, whereas the other two used an active control group where users were exposed to a 2-dimensional equivalent of the digital application on a tablet or TV screen.

All studies utilising control groups identified a statistically significant difference in the reduction of self-reported pain scores, highlighting the analgesic effects of virtual reality in the management of cancer-related pain. The subsequent two studies compared 3-dimensional (3D) virtual reality with 2-dimensional (2D) virtual reality; a study of palliative care patients demonstrated that although the interventions revealed a decrease in pain scores immediately after the intervention, there was no significant difference between the pain scores of the 3D and 2D groups.[27] On the other hand, a study investigating hospitalized patients with cancer highlighted a significant difference in the reduction of pain scores between the 3D and 2D interventions, suggesting there may be benefit to the fully immersive experience 3D virtual reality provides.[28]

## Risk of bias

Out of 33 studies, 2 were assessed as low risk, 16 as having some concerns, and 15 as high risk. Common sources of bias included inadequate blinding and unclear allocation concealment. See Figure 2 to explore the quality of randomized control trials included in this study: a visual traffic light risk of bias summary based on the Cochrane Risk of Bias tool 2.[24]

## Discussion

Cancer pain is a complex multifactorial condition, with a high prevalence and individual burden. Of the high percentage of people with cancer reporting moderate-to-severe pain, an estimated 20-30% of people feel their pain is poorly managed, highlighting the critical need for the exploration of non-pharmacological approaches. Many non-pharmacological approaches have been shown as effective adjunctive treatments for pain. Non-pharmacological approaches are often associated with fewer harmful side effects than drug therapies, and can present more economical and convenient options for pain management. Virtual reality is a promising new non-pharmacological strategy for pain management, based on principles of distraction and mindfulness, with a growing evidence base.

The results of this systematic review show virtual reality to be an effective method of pain management for hospitalized patients. The studies that demonstrated a meaningful association between virtual reality interventions and a significant reduction in pain, suggested that VR worked through means of immersive distraction and/or relaxation. Potential mechanisms for VR's analgesic effect include attentional distraction, engagement of sensory and motor pathways, and modulation of emotional responses to pain. These effects may be underpinned by neuroplastic changes in pain-related brain regions. However, generalizability remains limited due to small sample sizes, single-site studies, and underrepresentation of older adults and those with cognitive impairments. Of the studies that determined no significant difference in the reduction of pain symptoms between virtual reality and control groups, the efficacy of virtual reality was often highlighted by other measures: for example, one study evidenced a significant decrease in level of anxiety following implementation of virtual reality, and another demonstrated a significant reduction in opioid

medication use.[26,29] Both of these studies remained in support of the use of virtual reality for pain management. Due to substantial heterogeneity in study design, VR content, outcome measures, and timing of assessments, a meta-analysis was not performed. The variability across interventions precluded meaningful pooling of effect sizes.

Studies generally utilised similar procedural methodology – headsets or goggles were used with head mounted displays, with immersive environments that generally followed themes of relaxation and meditation (nature, water or snow scenes). A commonly used virtual landscape was 'SnowWorld/Icy Canyon'- a world with which the user can interact. Studies that explored interactive virtual reality opted for more engaging and stimulating environments.[30] One study directly compared passive and interactive virtual reality interventions, concluding that there was no significant difference in the reduction of pain between the two groups.[31] The average time spent in the intervention varied from 3 min to >40 min; across studies this did not seem to impact the effectiveness of the intervention. Most studies carried out interventions for between 5 and 15 min, however for instances in which VR was applied while carrying out an intervention (e.g., medical procedure, physical therapy), this was highly dependent on the length of time taken for the procedure.

Of the populations studied in this systematic review, there was most research investigating the use of virtual reality when managing the pain of adults hospitalized with burns. Virtual reality was applied when carrying out painful dressing changes, or range of movement exercises. These studies provide compelling evidence for the use of virtual reality within burn patient populations. Other populations investigated included: patients undergoing elective surgeries, patients with traumatic injuries, patients in intensive care, and patients with cancer diagnoses. To address the specific focus of this review, all studies that assessed the impact of VR on cancer pain, determined that virtual reality provided a statistically significant reduction in pain symptoms in comparison to the control. However, one study investigating the use of VR in palliative patients with cancer, was unable to determine a significant difference between the analgesic effects of the application of 2-dimensional and 3-dimensional virtual reality.[27]

These results also demonstrated the safety and feasibility of virtual reality as a pain management therapy. The studies investigated in this review highlighted no major adverse effects, assessing for cybersickness-associated symptoms such as nausea and dizziness. Studies generally documented a high level of user-comfort and engagement. Recent developments have also suggested that ongoing developments in technology have made VR more economical and accessible in education, healthcare, and corporate environments.[32]

The Cochrane Risk of Bias tool was used to critically appraise the studies included in this systematic review – the table providing space to collate different sources in order to inform judgement. Common themes included a high risk of observer bias – many of the studies did not employ therapist/investigator blinding, inferring that there may have been a possibility that therapists/researchers favoured their existing beliefs and treated participants accordingly. Due to the nature of virtual reality and the use of headsets, it also appeared difficult to carry out participant blinding which may have led to overestimated treatment effects. Furthermore, many studies employed a within-subjects design – although this design is associated with reduced variability, this may have led to order/time-related effects impacting results.

The compelling evidence for the use of virtual reality in pain management aligns with that revealed in other recent systematic reviews. Dreesmann *et al.*[33] and Huang *et al.*[34] discuss virtual reality as an effective analgesic tool in pain management. Dreesmann *et al.* explores evidence implicating the use of VR in acute pain management, whereas Huang *et al*. reviews the use of VR in pain management across different populations including those in chronic, and acute pain. Huang *et al*. however concludes that although evidence supports the use of virtual reality in acute pain, there was no statistical difference in the reduction of pain when applying virtual reality in chronic back pain and cancer-related pain.[34] It is suggested this may be because whilst VR may provide analgesic effects in the management of acute pain, it does not affect pain threshold/tolerance. It is important to note however, that cancer-related pain can be acute or chronic in nature, and often occurs secondary to medical procedures and surgical intervention (an area in which VR has been shown to effectively reduce pain when compared to standard care).

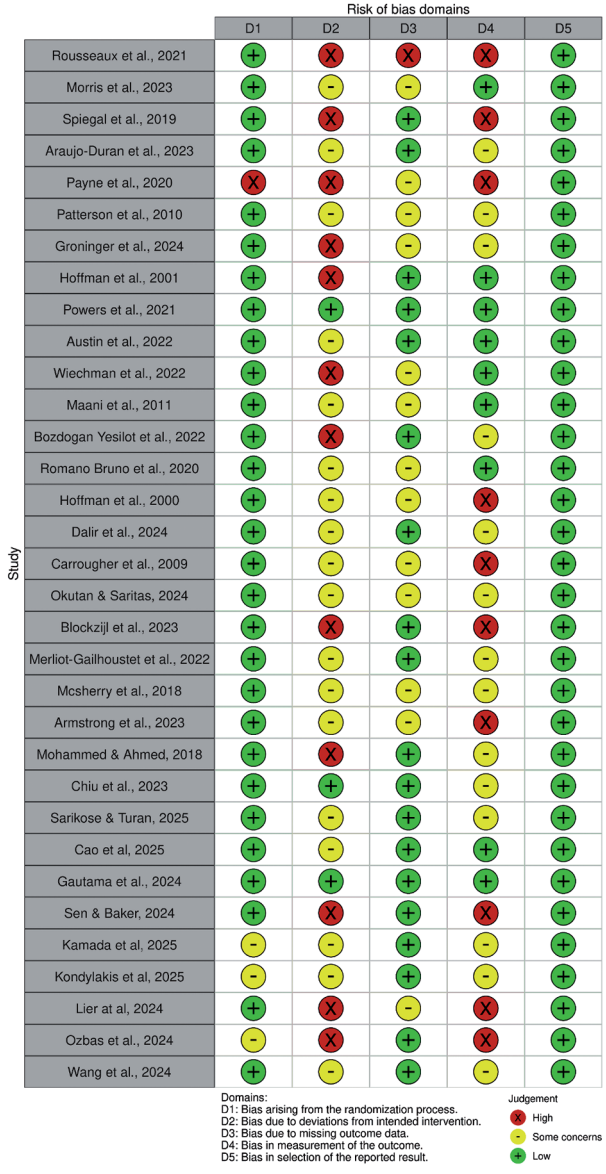


**Figure 2.** Exploration of the quality of randomized control trials included in this study, based on the Cochrane Risk of Bias tool 2.[24]

Although this systematic review concludes initial supporting evidence for the application of virtual reality in the management of cancer pain, as a safe, cost-effective and non-pharmacological adjunctive treatment, it also recognises the presence of bias in designs and methods in the small sample of studies eligible for this investigation. To reduce this bias and improve the evidence-base for the application of virtual reality in the management of cancer pain, this review suggests that further research is implicated; future randomized control trials should employ a double blinded experimental design where possible. Further studies are also required to explore the cost-effectiveness and accessibility of virtual reality in pain management in a hospital environment.

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