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Semi-Immersive Virtual Reality: Distracting Children with Cancer from the Side Effects of Post-Chemotherapy

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Abstract: This study aims to explore the role of semi-immersive virtual reality (VR) as a non-pharmacological distraction technique to alleviate post-chemotherapy side effects among pediatric cancer patients. Using a qualitative descriptive approach through a library-based study, data were collected from peer-reviewed journal articles, clinical reports, and systematic reviews published between 2018 and 2025. The data analysis involved thematic identification, data reduction, categorization, and inductive interpretation to synthesize conceptual and empirical findings. The results reveal that both immersive and semi-immersive VR significantly reduce chemotherapy-related anxiety, pain, nausea, and emotional distress in children, with semi-immersive systems demonstrating comparable efficacy to immersive ones while offering greater practicality and fewer adverse effects. Semi-immersive VR also enhances engagement, emotional well-being, and perceived control during treatment, contributing to improved psychological adaptation. These findings affirm the theoretical basis of the Gate Control Theory of Pain and the Cognitive-Behavioral Distraction Model, highlighting VR's effectiveness in modulating sensory and emotional responses to medical stressors. The study concludes that semi-immersive VR represents an innovative, feasible, and child-friendly therapeutic adjunct in pediatric oncology care. The implications extend to healthcare practice, where VR can be integrated as a supportive digital therapy, and to future research, which should employ triangulated, longitudinal approaches to evaluate its long-term psychosocial benefits.

Keywords: Semi-Immersive Virtual Reality, Pediatric Oncology, Chemotherapy, Anxiety Reduction, Non-Pharmacological Intervention

Introduction

Cancer treatment in children, particularly chemotherapy, poses complex physiological and psychological challenges. Beyond its life-saving potential, chemotherapy often induces distressing side effects such as nausea, vomiting, anxiety, procedural pain, and fatigue (Wong et al, 2022). These adverse experiences significantly reduce children's quality of life and can impede treatment adherence, emphasizing the urgent need for complementary non-pharmacological interventions that alleviate the psychosocial burden of therapy (Tsitsi et al, 2024). Recent technological advancements have turned attention to **semi-immersive virtual reality (VR)** as a novel, engaging distraction technique that can mitigate these effects effectively (Gautama, 2023) .

The integration of VR in pediatric oncology represents a paradigm shift from traditional distraction methods such as storytelling, music therapy, or simple visual aids toward multisensory, interactive approaches. Immersive VR systems have demonstrated measurable reductions in chemotherapy-induced anxiety, pain, and distress through enhanced sensory engagement and attentional redirection (Comparcini, 2023) (Czech, 2023). Yet, while immersive VR dominates current research, semi-immersive VR—offering partial environmental integration—emerges as a promising middle ground that balances therapeutic benefits and safety concerns, particularly cybersickness risk (Wong, 2024).

The global rise in pediatric cancer survival rates underscores the importance of improving treatment experiences. As survival rates increase, so does the need to manage the cumulative psychological toll of repeated hospitalizations and invasive procedures (Burrai, 2023). In this context, semi-immersive VR offers a sustainable solution by fostering engagement without overwhelming the sensory system, providing a feasible alternative for hospital environments (Gerçeker, 2024).

Studies consistently affirm that VR distraction facilitates emotional regulation by redirecting cognitive attention from painful or anxiety-provoking stimuli to pleasant virtual environments (Erdős, 2023). This mechanism of "presence," the subjective sense of being in another world, plays a critical role in modulating pain perception and emotional distress (Alanazi, 2022). As the sense of presence intensifies, so too does the potential for positive emotional distraction.

Despite its demonstrated benefits, a gap persists in the evidence surrounding **semi-immersive** rather than fully immersive VR. Most existing trials employ head-mounted displays that entirely obscure real-world stimuli, which may not be optimal for all pediatric patients—especially those prone to dizziness or nausea post-chemotherapy (Wong et al, 2021) . Consequently, there is a compelling rationale for exploring semi-immersive systems that allow limited real-world awareness while maintaining the therapeutic engagement of VR.

Moreover, empirical inconsistencies across studies underscore the need for standardized protocols regarding exposure duration, frequency, and content type (Tsitsi, 2024). The absence of clear guidelines impedes broad clinical implementation, despite growing enthusiasm among healthcare providers and families (Czech, 2023). Addressing these limitations is crucial to ensuring reproducible outcomes and safety across pediatric populations.

In the last five years, research interest in VR interventions for pediatric oncology has expanded exponentially, reflecting both the maturity of the technology and a broader acknowledgment of its therapeutic promise (Alvarado-Omenat, 2024). Meta-analyses have reported moderate-to-large effect sizes in anxiety and pain reduction, yet few have isolated semi-immersive modalities as distinct study arms (Burrai, 2023) (Gautama, 2023). This knowledge gap invites a focused inquiry into how varying levels of immersion influence outcomes among children receiving chemotherapy.

Furthermore, as digital health tools increasingly integrate into pediatric care, semi-immersive VR aligns with the movement toward patient-centered, low-barrier digital therapies. These systems can be delivered via standard monitors or projection systems,

reducing logistical and financial constraints that limit immersive VR adoption (Rygh et al, 2023). The potential to democratize access to therapeutic distraction technology makes semi-immersive VR particularly relevant in diverse healthcare settings.

Psychological resilience is another important dimension affected by VR-based interventions. Evidence indicates that children who experience greater perceived control during medical procedures report improved emotional outcomes and lower anticipatory distress in subsequent treatments (Tennant, 2020). Semi-immersive VR, by engaging children through partial sensory stimulation without complete isolation, may strengthen this sense of control while maintaining therapeutic comfort.

Furthermore, semi-immersive VR technologies could foster collaborative participation among caregivers and healthcare professionals. Unlike fully immersive systems that isolate the patient visually, semi-immersive setups permit shared viewing experiences, allowing clinicians to monitor and engage during the intervention (Gerçeker, 2024). This design advantage may enhance communication, emotional support, and overall satisfaction with care.

The theoretical rationale behind VR's efficacy lies in the Gate Control Theory of Pain and the Cognitive-Behavioral Model of Distraction, both suggesting that competing sensory stimuli can modulate the central nervous system's processing of pain and anxiety (Wu, 2023). Semi-immersive VR uniquely capitalizes on these mechanisms while mitigating the sensory overload sometimes observed in full immersion environments (Erdős, 2023).

Clinical feasibility studies affirm that children, parents, and nursing staff generally perceive VR as an enjoyable and acceptable adjunct to treatment (Wong et al, 2022). Reported adverse effects, such as mild dizziness or transient nausea, are rare and typically resolve spontaneously (Erdős, 2023). The adaptability of semi-immersive systems further supports their inclusion as part of holistic supportive oncology care frameworks.

Despite promising results, the field faces methodological challenges, including small sample sizes, heterogeneity in VR content, and short-term evaluation windows (Comparcini, 2023). Longitudinal studies are necessary to determine sustained psychological and behavioral benefits, as well as potential impacts on treatment adherence and clinical outcomes (Wong, 2024).

The urgency for innovation in supportive pediatric oncology care compels further exploration of semi-immersive VR as a practical, scalable intervention. Its potential to alleviate the multidimensional burden of chemotherapy—psychological, emotional, and somatic—represents an invaluable advancement in child-centered healthcare (Tsitsi, 2024).

Therefore, this article aims to critically synthesize current findings on semi-immersive VR as a distraction intervention for children undergoing chemotherapy, emphasizing its role in mitigating treatment-related side effects and enhancing psychological well-being. The expected outcomes of this exploration are twofold: (1) theoretically, to elucidate semi-immersive VR's place within the spectrum of distraction-based interventions) (and (2) practically, to inform the design of evidence-based clinical applications that prioritize both efficacy and child comfort.

Methodology

This study employs a qualitative descriptive approach through a library-based research design to explore how semi-immersive virtual reality (VR) functions as a distraction technique for children undergoing post-chemotherapy care. The qualitative descriptive design was selected because it allows for the in-depth exploration of complex psychosocial phenomena in healthcare contexts, particularly those that cannot be quantified but require contextual interpretation (Abraham, 2024) (Doyle et al, 2019). This approach emphasizes rich narrative descriptions that capture existing evidence and conceptual understanding from diverse scholarly sources, aligning with the article's goal to synthesize theoretical and empirical insights regarding VR applications in pediatric oncology (Baillie, 2019).

The data sources in this study consist of peer-reviewed academic journals, official reports, methodological texts, and scientific reviews related to pediatric oncology, chemotherapy side effects, and the use of semi-immersive virtual reality as an intervention. Primary sources include international journal articles published between 2017 and 2025 from databases such as *ScienceDirect, PubMed, and Wiley Online Library*, covering domains like nursing, psychology, and digital health. Complementary theoretical references on qualitative methodology and data analysis were also incorporated from current academic publications in methodological studies (Bingham, 2023) (Pratt, 2025) (Togia, 2017). These references provide a methodological foundation that ensures rigor, transparency, and alignment with qualitative inquiry standards.

The data collection technique involved systematic literature searches and document analysis. Literature tracing was performed by identifying relevant keywords such as "semi-immersive virtual reality," "chemotherapy side effects," "pediatric cancer," and "psychological distraction." Inclusion criteria were applied to select literature published between 2015 and 2025, peer-reviewed, and thematically aligned with the objectives of this study. Exclusion criteria eliminated duplicate studies, non-English publications, and research lacking methodological clarity or empirical data (Bandaranayake, 2024) (Jimenez et al, 2024). This process ensured that the review was comprehensive, focused, and based on high-quality scholarly evidence.

The data analysis process followed a structured and iterative cycle that included thematic identification, data reduction, conceptual categorization, and inductive interpretation (Belotto, 2018) (Bingham, 2023) (Kalpokaite & Radivojevic, 2018). During thematic identification, the main ideas from selected articles were extracted to identify recurring patterns related to VR's role in managing anxiety, pain, fatigue, and emotional well-being in children post-chemotherapy. These data were then reduced to eliminate redundancies and classified into conceptual categories such as *therapeutic mechanisms, implementation feasibility, and psychosocial outcomes*. Finally, inductive reasoning was applied to draw generalizable insights from the analyzed evidence, allowing the researchers to construct a holistic understanding of semi-immersive VR's potential in pediatric oncology care (Fife & Gossner, 2024) (Vila-Henninger, 2022).

To maintain data validity and reliability, triangulation of sources and peer review conceptualization were implemented. Triangulation involved cross-verifying findings across multiple independent studies and methodological frameworks to ensure consistency

and credibility (Doyle et al, 2019) (Pratt, 2025). Conceptual peer review, on the other hand, involved revisiting analytical interpretations to assess coherence between the findings and the theoretical models underpinning qualitative inquiry (D. Abraham & P, 2024). Such validation mechanisms were crucial in mitigating researcher bias and enhancing the study's trustworthiness in interpreting the role of semi-immersive VR in clinical pediatric contexts.

This qualitative-descriptive library research method offers a rigorous yet flexible framework for synthesizing diverse strands of empirical and conceptual literature. By integrating inductive data interpretation with transparent analytical procedures, this method yields findings that are contextually relevant, theoretically grounded, and practically applicable in pediatric healthcare settings (Bingham, 2023) (Togia & Malliari, 2017). Moreover, this approach aligns with the article's objective—to produce an evidence-based synthesis on how semi-immersive VR can effectively mitigate chemotherapy-induced side effects in children, fostering both psychological resilience and enhanced treatment experiences.

Result and Discussion

The results of this study highlight the role of semi-immersive and immersive virtual reality (VR) as a promising non-pharmacological distraction method to alleviate both physical and psychological side effects experienced by pediatric cancer patients during and after chemotherapy. Based on a systematic synthesis of recent research between 2018 and 2025, semi-immersive VR demonstrates significant effectiveness in reducing anxiety, procedural pain, nausea, and psychological distress, though the magnitude of its effects is generally lower than that of fully immersive systems (Comparcini, 2023) (Czech, 2023). This section systematically presents findings on VR's effects, mechanisms, acceptability, and research gaps.

1. Quantitative Evidence of Effectiveness

Meta-analyses and randomized controlled trials consistently confirm that VR interventions—especially immersive and semi-immersive systems—reduce anxiety, pain, and chemotherapy-induced nausea and vomiting (CINV) among pediatric cancer patients (Wong et al, 2023). For instance, exploratory RCTs by Wong (2022) involving children aged 6–12 years found significant reductions in acute anxiety and nausea during the first chemotherapy cycle compared with standard care. Similarly, a crossover study by Erdős (2023) on 29 pediatric oncology patients aged 10–18 years showed increased happiness and reduced fear during chemotherapy infusions. Meta-analytic data from Czech, (2023) and Wu, (2023) confirmed medium to large effect sizes for reductions in anxiety, pain, and distress across oncological contexts.

Table 1. Summary of VR evidence types in pediatric cancer patients.

Type of Study	Population	Main Finding	Reference
Exploratory RCT (First Chemotherapy)	6–12 years	Reduced acute anxiety and nausea	(Wong, 2022) (C. Wong et al, 2021)
Crossover Study (Mood/Physiology)	10–18 years	Increased happiness, reduced fear	(Erdős, 2023)

Type of Study	Population	Main Finding	Reference
Systematic Review (Pediatric Oncology)	Multiple	Effective for procedural pain) (anxiety results mixed	(Comparcini, 2023) (Czech, 2023) (Tsitsi, 2024)
Meta-Analysis (General Oncology)	Adults & Children	Reduced anxiety, pain, depression, distress	(Czech, 2023) (Wu, 2023)

2. Mechanisms of Action and Modality Differences

The findings emphasize that **immersion level and interactivity** significantly influence outcomes. Immersive systems employing head-mounted displays (HMDs) create stronger sensory engagement and attentional redirection, leading to higher reductions in pain and anxiety (Wong, 2024) (Wong et al, 2021). In contrast, **semi-immersive VR systems**—such as large-screen or interactive gaming formats—still offer meaningful distraction but with slightly reduced effect magnitudes (Comparcini, 2023) (Czech, 2023). Importantly, semi-immersive approaches have advantages in accessibility and safety, minimizing cybersickness and fatigue risk while remaining suitable for long-term or home-based use (Tennant, 2020).

3. Psychological and Emotional Outcomes

Beyond symptom relief, VR consistently enhances mood, engagement, and emotional well-being during treatment sessions. Semi-immersive and immersive interventions promote feelings of joy, calmness, and empowerment, counteracting chemotherapy-related boredom and helplessness (Erdős, 2023). In particular, children reported greater enjoyment and willingness to repeat VR sessions, while parents perceived reductions in fear and isolation (Hélie, 2025). These outcomes align with Tennant et al. (2020), who demonstrated that VR experiences positively influence psychological well-being and adaptability among pediatric oncology patients.

4. Safety, Acceptability, and Feasibility

Across multiple studies, VR interventions were highly acceptable and safe. Minimal side effects were observed, primarily mild dizziness or nausea that resolved spontaneously (Tsitsi, 2024) (Wong, 2022). Qualitative findings revealed that both parents and healthcare professionals valued VR for reducing procedural stress and hospitalization boredom but emphasized its complementary nature rather than substituting human interaction (Hélie, 2025). Semi-immersive systems, due to their partial integration with the real environment, were perceived as easier to deploy in clinical settings and more comfortable for prolonged use (Birnie, 2018) (Comparcini, 2023).

5. Identified Research Gaps

Despite the positive findings, notable research gaps persist. Most existing studies focus on VR use during chemotherapy sessions or procedural interventions, whereas evidence on post-chemotherapy applications—such as managing delayed nausea, fatigue,

and post-treatment distress—is extremely limited (Comparcini, 2023) (Wong, 2024). Furthermore, current studies exhibit variability in session duration, frequency, and VR content types, hindering the establishment of standardized clinical protocols (Alvarado-Omenat, 2024) (Tsitsi, 2024). Researchers highlight the need for larger sample sizes, longitudinal follow-ups, and comparative analyses between immersive and semi-immersive modalities.

6. Summary of Findings

Overall, the synthesis confirms that **semi-immersive and immersive VR systems** both yield measurable benefits for children undergoing chemotherapy, notably in reducing pain, anxiety, nausea, and distress while improving emotional well-being. Immersive VR achieves greater sensory distraction and symptom reduction, whereas semi-immersive VR excels in practicality, safety, and clinical feasibility. For post-chemotherapy care, semi-immersive VR offers unique opportunities for continued emotional support and home-based rehabilitation, warranting further investigation to optimize its therapeutic potential.

Discussion

The findings from the reviewed studies collectively reinforce the conceptual framework that Virtual Reality (VR)—both immersive and semi-immersive—acts as an effective non-pharmacological distraction mechanism for managing chemotherapy-related side effects in pediatric cancer patients. The theoretical underpinning of this phenomenon draws on the Gate Control Theory of Pain, which posits that attentional and sensory modulation can inhibit pain signal transmission by activating competing neural pathways. In VR applications, particularly immersive ones, this mechanism operates through the sense of presence, a psychological state where users feel completely absorbed in the virtual environment, effectively diverting cognitive focus from pain or anxiety stimuli (Czech, 2023) (Wong, 2024).

1. Interpretation of Main Findings

The data indicate that both immersive and semi-immersive VR modalities yield substantial improvements in anxiety reduction, pain relief, and mood enhancement among pediatric oncology patients. Studies such as Wong et al. (2022) and Wong et al. (2024) demonstrate statistically significant decreases in chemotherapy-induced nausea and vomiting (CINV), while Czech et al. (2023) and Wu et al. (2023) confirm broad psychological benefits across cancer populations. These outcomes align with prior theories on cognitive distraction and attentional modulation, which suggest that diverting sensory focus to visually and auditorily rich stimuli can decrease the subjective experience of discomfort.

Interestingly, semi-immersive VR systems—which employ large displays or interactive projections without fully isolating the patient—produce moderately reduced but still meaningful therapeutic outcomes (Comparcini, 2023). This suggests that the degree of immersion is a modulating factor rather than a binary determinant of efficacy. In pediatric settings, this balance may actually favor semi-immersive VR because it reduces sensory overload and risk of cybersickness, while still fostering sufficient engagement (Erdős, 2023).

2. Integration with Theoretical and Clinical Contexts

The observed outcomes support the theoretical integration of biopsychosocial and behavioral distraction models in pediatric oncology care. The emotional and attentional shifts induced by VR align with Lazarus' Cognitive Appraisal Theory, which emphasizes re-interpretation of stressful stimuli through altered perception and emotional engagement. Semi-immersive VR systems—especially those with interactive or nature-based content—capitalize on this by enabling children to reinterpret treatment environments as less threatening, fostering agency and emotional resilience (Hélie, 2025) (Tennant, 2020).

Furthermore, this research reinforces self-efficacy and empowerment theories in pediatric health psychology. The interactive and participatory nature of semi-immersive VR not only distracts from discomfort but also provides children with a sense of control during invasive or distressing medical procedures. Such empowerment has been linked to improved treatment adherence and post-therapy emotional stability (Birnie, 2018) (Wong, 2022).

3. Factors Influencing Variability in Results

Variability across studies may be attributed to multiple contextual and methodological factors. Firstly, differences in VR content and session duration (e.g., passive observation versus interactive gaming) significantly influence outcomes (Tsitsi, 2024). Secondly, patient characteristics—including age, baseline anxiety levels, and previous treatment experiences—affect receptiveness to immersive stimuli (Chiu, 2023). Thirdly, clinical implementation factors such as staff training and the timing of interventions (pre-, intra-, or post-chemotherapy) may moderate effectiveness. For instance, Wong et al. (2021) found higher anxiety reduction when VR was introduced before chemotherapy initiation rather than during infusion.

Despite these differences, most trials converge on the conclusion that the psychological benefits of VR are robust, replicable, and clinically significant, particularly in procedural pain management. The minor adverse effects reported (e.g., mild dizziness, nausea) were transient and did not hinder intervention continuation (Erdős, 2023) (Tsitsi, 2024).

4. Implications for Clinical and Research Practice

The implications of these findings are multifaceted. Clinically, the results advocate for integrating semi-immersive VR as a complementary supportive therapy in pediatric oncology wards. Its practicality—requiring minimal setup, staff training, and hardware costs—positions it as a scalable, patient-centered solution for managing chemotherapy distress (Comparcini, 2023). In the post-chemotherapy phase, semi-immersive VR could extend its use into home-based rehabilitation, supporting emotional recovery and reducing anticipatory anxiety for future treatments (Wong, 2024).

From a theoretical standpoint, these findings expand the understanding of immersive cognitive interventions by demonstrating that partial immersion can achieve therapeutic engagement without total sensory isolation. This has implications for the

development of hybrid therapeutic technologies that merge clinical monitoring with engaging digital environments (Czech, 2023).

5. Limitations and Future Directions

Despite encouraging outcomes, the reviewed studies collectively highlight several limitations. Most notably, the lack of standardized protocols regarding VR duration, frequency, and content type constrains cross-study comparability (Alvarado-Omenat, 2024) (Tsitsi, 2024). Sample sizes in pediatric oncology VR research remain relatively small, often underpowered to detect subtle differences between immersion levels. Moreover, there is an evident research gap in post-chemotherapy applications, with current literature focusing predominantly on procedural or intra-treatment phases (Comparcini, 2023) (Wong, 2024).

Future research should prioritize longitudinal and multi-center trials to assess the sustained psychosocial effects of semi-immersive VR beyond hospital settings. Integration of physiological metrics (e.g., heart rate variability, cortisol levels) could further validate the psychophysiological mechanisms underlying VR's therapeutic benefits. Additionally, participatory design approaches involving children and families, as suggested by Hélie et al. (2025), may enhance content relevance and user acceptance.

6. Overall Contribution

This body of work contributes significantly to pediatric psycho-oncology by positioning semi-immersive VR as a feasible, safe, and effective adjunct to traditional care. It bridges theoretical gaps between immersive cognitive therapy and practical clinical implementation, reinforcing the view that meaningful therapeutic presence can be achieved without full sensory isolation. As technology continues to evolve, semi-immersive VR stands poised to redefine how emotional comfort and treatment engagement are fostered in pediatric cancer care.

Conclusion

This qualitative study concludes that semi-immersive virtual reality (VR) is an effective, safe, and feasible non-pharmacological distraction intervention for managing post-chemotherapy side effects in children with cancer. The synthesis of findings indicates that semi-immersive VR significantly reduces anxiety, procedural pain, nausea, and emotional distress by enhancing sensory engagement, redirecting attention, and fostering a sense of control and enjoyment during treatment. Compared to fully immersive systems, semi-immersive VR maintains therapeutic efficacy with fewer risks of cybersickness, making it more suitable for extended or hospital-based applications. The study advances theoretical understanding in pediatric psycho-oncology by reinforcing the relevance of the Gate Control Theory of Pain and Cognitive-Behavioral Distraction Models, demonstrating how sensory modulation and presence can positively shape emotional and physiological responses. Moreover, the findings emphasize the cultural importance of integrating child-centered, interactive digital interventions into healthcare settings where emotional well-being is often overlooked. Academically, this research bridges technological innovation and psychosocial care, enriching discourse on hybrid therapeutic modalities for pediatric

oncology. Recognizing limitations such as small sample sizes, heterogeneous VR content, and limited longitudinal evidence, the study recommends that healthcare practitioners incorporate semi-immersive VR into pediatric oncology care to alleviate psychological and physical discomfort during and after chemotherapy. Hospitals and treatment centers are encouraged to design structured VR programs suited to patient age and emotional needs, supported by interdisciplinary collaboration among healthcare professionals. Future research should employ multi-site and participatory designs, combining qualitative, quantitative, and physiological approaches to validate mechanisms of VR's therapeutic effects while exploring cross-cultural applications and the integration of adaptive artificial intelligence to optimize long-term outcomes in pediatric oncology care.

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