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SEMI-IMMERSIVE VIRTUAL REALITY REDUCES PAIN, FATIQUE AND ENHANCES COMFORT AND SLEEP IN PEDIATRICS ONCOLOGY

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ABSTRACT

Pediatric cancer patients undergoing chemotherapy often experience a range of adverse effects, include discomfort, fatigue, pain, and poor sleep quality. These symptoms can have a detrimental effect on the patients' physical and psychological well-being. Semi-immersive virtual reality (SVR) has emerged as a promising non-pharmacological approach to enhance comfort and reduce treatment-related distress. To examine the effectiveness of SVR in improving comfort, reducing fatigue and pain, and enhancing sleep quality among pediatrics cancer patients undergoing chemotherapy. A quasi-experimental pretest-posttest study was conducted with 52 children aged 6–14 years receiving outpatient chemotherapy. The sampling technique used is using purposive sampling. Instruments included the Pittsburgh Sleep Quality Index (PSQI), Shortened General Comfort Questionnaire (SGCQ), Child Fatigue Scale 24 Hours (CFS-24), and Numeric Rating Scale (NRS) for pain. Data were analyzed descriptively to compare pre-intervention and post-intervention scores. The validity test used was KMO–Bartlett and Factor Loading (EFA), while the reliability test used Cronbach's Alpha. Following the SVR intervention, improvements were observed across all variables. The Pittsburgh Sleep Quality Index (PSQI) improved, with "very poor" decreasing from 31% to 0%, "poor" from 37% to 25%, "fair" increasing from 33% to 63%, and "good" from 0% to 12%. Pain intensity (NRS) decreased, with "moderate" pain dropping from 67% to 0% and "mild" pain increasing from 33% to 100%. Fatigue (CFS) improved: "very high" decreased from 25% to 0%, "high" from 48% to 6%, "moderate" from 27% to 0%, and "low" increased from 0% to 94%. Comfort (SGCQ) increased, with "low" decreasing from 31% to 0%, "medium" from 69% to 50%, and "high" increasing from 0% to 50%. Semi-immersive virtual reality effectively enhances comfort, reduces fatigue and pain, and improves sleep quality among pediatrics cancer patients undergoing chemotherapy. SVR can serve as a complementary, non-pharmacological intervention to support children's well-being the course of cancer treatment.

Keywords: comfort, fatigue, pediatrics cancer, pain, semi-immersive virtual reality, sleep quality

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INTRODUCTION

The cells of living organisms divide under normal conditions. Division is controlled by enzymes and hormones under the command of the brain. However, under certain conditions, cells can suddenly change, for example due to mutations or genetic changes. These changes can cause the cells to escape the control of the coordination center. These cells are called cancer cells. Cancer is a disease characterized by uncontrolled cell division (Sholihin, 2017). The most common cancer in children is blood cancer or leukemia, with an estimated incidence of 25-30% (Redaksi Health Secret, 2013). Cancer in children mostly originates from primitive embryonic tissue (mesodermal and neuroectodermal, which causes leukemia, lymphoma, sarcoma, or central nervous system tumors (Apriyanti et al., 2023).

By 2025, it is projected that there will be 2,041,910 new cancer cases and 618,120 cancer deaths in the United States (Siegel et al., 2025). In 2022, more than 275,000 children and adolescents aged 0-19 worldwide were diagnosed with cancer and more than 105,000 children died from cancer

(International Agency for Research on Cancer, 2025). Approximately 61,000 new cases of childhood cancer are diagnosed and 45% of them die from cancer each year in the Southeast Asia Region (WHO, 2024). In the Philippines, cancer is the leading cause of death among children (Columbres et al., 2024). In 2020, Indonesia became the country with the highest prevalence of childhood cancer among Southeast Asian Countries, with a prevalence of 43.5% (Azhar & Aisyi, 2024).

Chemotherapy is the primary treatment used in children to treat cancer (Lestari et al., 2020). As asserted by Mendri, Ini Ketu & Prayogi 2017 (in Apriyanti et al., 2023), chemotherapy constitutes a therapeutic modality employed to impede the proliferation of cancerous cells. However, it is important to note that chemotherapy is associated with a range of acute and delayed side effects. chemotherapy has acute side effects, such as nausea, vomiting, alopecia (hair loss), pain, and bone marrow suppression, as well as delayed side effects such as pulmonary (lung), fibrosis, neuropathy (nerve), and nephropathy (kidney). Research conducted by Fernandes (2019) revealed that children experience sleep disturbances during and after chemotherapy. Research conducted by Scarborough and Smith (2018) (in Nabilla et al., 2023) revealed that 64% of cancer patients complained of pain. Research conducted by Herfiana & Arifah (2019) revealed that the physiological impact of chemotherapy on children diagnosed with leukemia frequently results in fatigue, with a percentage of 46.7%. The symptoms experienced by pediatrics cancer patients have the capacity to interfere with the treatment process, affect test results, and compromise quality of life. Consequently, intervention is required to address this issue.

Non-pharmacological interventions represent a significant strategy for mitigating the adverse effects of chemotherapy in pediatrics cancer patients. One promising approach is the utilisation of semi-immersive virtual reality (SVR)-based digital distraction. According to Hayati 2014 (in Novita Lestari et al., 2020), distraction constitutes a pain management technique that diverts the patient's attention away from the pain they are feeling. The SVR methodology entails the cultivation of children's sensory and cognitive faculties, orienting them towards immersive virtual experiences. This approach is purported to engender a reduction in pain perception and stress levels. In contradistinction to conventional therapeutic modalities, which frequently entail protracted periods of time and substantial financial expenditure, SVR provides a more regulated and immersive encounter (Duan, 2021). A study undertaken by Gautama et al. (2024), revealed that SVR can can enhance the level of comfort experienced by cancer patients undergoing chemotherapy, whilst concomitantly reducing symptoms of anxiety and pain. Despite the encouraging potential of SVR, its application in chemotherapy settings remains inconclusive. This finding indicates a research gap that needs to be filled with systematic studies to assess the effectiveness of SVR in improving comfort, reducing pain and fatigue, and enhancing sleep quality in children undergoing chemotherapy.

When children's attention is diverted to an immersive virtual environment, sympathetic nervous system activity decreases, resulting in reduced pain perception and physiological stress. It has been demonstrated that this condition has the capacity to enhance comfort levels and mitigate the fatigue frequently experienced as a consequence of intensive cancer therapy. Furthermore, a reduction in stress and emotional tension has also been demonstrated to contribute to an enhancement in sleep quality. The SVR mechanism is expected to be an effective intervention in improving the physical and psychological aspects of children with cancer undergoing chemotherapy. The objective of this study is to analyse the effectiveness of semi-immersive virtual reality-based digital distraction on the comfort, fatigue, pain, and sleep quality of children with cancer undergoing chemotherapy.

METHOD

The present study employed a quantitative design, incorporating a quasi-experimental pretest-posttest to evaluate the efficacy of semi-immersive virtual reality (SVR)-based digital distraction in enhancing comfort, reducing fatigue and pain, and improving sleep quality in children diagnosed with cancer who are undergoing chemotherapy. A total of 52 pediatric cancer patients aged 6–14 years were recruited through purposive sampling. All participants met the inclusion criteria and completed the pretest and posttest questionnaires administered before and after the SVR intervention. The inclusion criteria for participation in this study were as follows: (1) Children undergoing outpatient chemotherapy. (2) Able to read and write. (3) Adequate cognitive abilities. (4) Willing to be respondents. Exclusion criteria encompassed children with cognitive impairments, visual or hearing impairments, epilepsy, vertigo, or motion sickness due to virtual stimulation.

The present study utilised four standardised instruments: the Pittsburgh Sleep Quality Index (PSQI) to evaluate sleep quality, the Numeric Rating Scale (NRS) to quantify pain intensity, the Child Fatigue Scale (CFS) to measure children's fatigue levels, and the Shortened General Comfort Questionnaire (SGCQ) to assess children's comfort levels. The validity test used was KMO–Bartlett and Factor Loading (EFA), while the reliability test used Cronbach's Alpha. The intervention group received SVR therapy using a semi-immersive virtual reality system developed for children. Each participant underwent one SVR session, with a duration of approximately 10 minutes, during the course of their chemotherapy treatment. The SVR content displayed a calming and interactive virtual environment with the purpose of distracting children from discomfort and stress caused by the treatment procedure. The present study adopted an exploratory approach with the objective of ascertaining the direction of change in the variables under investigation. The alterations in pre-test and post-test scores for pain, fatigue, sleep quality, and comfort were presented in the form of percentages, means, and simple graphs.

RESULT

Respondent Characteristics

The results of the validity test showed that the data were valid because the PSQI, NRS, CFS, and SGCQ had a KMO value of 0.5 and a Bartlett Sig value below 0.05 (<0.05) with PSQI at 0.002, NRS at 0.000, CFS at 0.011, and SGCQ at 0.000. According to the Reliability Test, the data is reliable because the Cronbach's Alpha.

Table 1.
Respondent Characteristics (n=52)

Variable	Category	f	%
Age	6 years old	5	10
	7 years old	6	12
	8 years old	16	31
	9 years old	5	10
	10 years old	10	19
	12 years old	5	10
	14 years old	5	10
Gender	Male	35	67
	Female	17	33

In the present study, the majority of respondents were 8-year-old children, constituting 30.8% of the total sample. This finding indicates that the majority of participants were within the elementary school age group. This particular age range is of significance in that children at this stage of development have a relatively stable level of understanding and cognitive abilities, enabling them to follow questionnaire instructions and participate effectively in the SVR intervention. Furthermore, the majority of respondents were male, constituting 35 children (67%). By ascertaining the age and gender distribution of the subjects, researchers can more accurately analyse the effects of the SVR intervention and understand the factors that may influence the overall results of the study.

Based on the clinical characteristics of respondents, the majority of children experienced an illness with a duration of less than 12 months, totaling 27 children (52%). This indicates that most children have undergone a relatively short course of illness, but a significant proportion have experienced illness over the medium to long term. Regarding the duration of therapy, 16 children (31%) were in the short category or less than 8 weeks, 23 children (44%) were in the medium category or 9-16 weeks, and 13 children (25%) underwent long therapy or more than 16 weeks. This distribution indicates that the majority of respondents have undergone relatively prolonged treatment interventions, rendering chemotherapy side effects and the necessity for non-pharmacological strategies such as SVR pertinent.

Table 2.
Clinical Characteristics of Respondent

Variable	Category	f	%
Duration of Illness	Short (< 12 months)	27	52
	Medium (13-24 months)	15	29
	Long (>25 months)	10	19
Duration of Therapy	Short (<8 weeks)	16	31
	Medium (9-16 weeks)	23	44
	Long (> 17 weeks)	13	25
Type of Treatment	Chemotherapy	36	69
	Radiotherapy	16	31
Disease Type	Leukemia	38	73
	Sarcoma	0	0
	Other tumors	14	27

The majority of respondents received chemotherapy, with a percentage of 69 or 36 children. Concurrently, 16 children, constituting 31% of the study population, received radiotherapy. The predominance of chemotherapy as a treatment modality for childhood cancer, particularly leukemia and lymphoma, which are the most prevalent types of cancer in this sample, is consistent with established standards of care. The disease type of the majority of respondents was determined to be leukemia, with a total of 38 children (73%) affected. In contrast, 14 children (27%) had other tumors, and no respondents had sarcoma. In the present study, the disease experienced by cancer survivors was identified as leukemia. The type of disease is known to influence various factors, including the intensity of symptoms, the type of treatment received, and the child's response to non-pharmacological interventions such as SVR.

Side Effects of Chemotherapy

As asserted byMendri, Ini Ketu & Prayogi 2017 (in Apriyanti et al., 2023), chemotherapy is employed as a therapeutic modality to impede the proliferation of cancerous cells. Despite its efficacy, this therapeutic modality can result in a range of adverse effects, both acute and chronic in nature. The following acute side effects have been observed with the administration of this medication: nausea, vomiting, hair loss (alopecia), pain, and bone marrow suppression. It is important to note that long-term side effects may include a range of health complications, including but not limited to lung disorders (pulmonary), scar tissue formation (fibrosis), nerve disorders (neuropathy), and kidney function disorders (nephropathy).

Table 3.
Side Effects Experienced by Respondents

Physical Problems	n
Nausea and vomiting	10
Hair loss	17
Nausea, vomiting, and hair loss	21
Others	4

The results indicated that respondents experienced various physical ailments as a consequence of chemotherapy treatment. A total of ten children reported symptoms of nausea and vomiting, while seventeen children exhibited signs of hair loss, categorised as alopecia. Notably, twenty-one children demonstrated symptoms of both conditions concurrently. Furthermore, four children did not report any physical complaints related to chemotherapy side effects. The findings of this study indicate that the effects of chemotherapy in children manifest in a variety of ways, either as individual effects or in combination, thereby demonstrating a multidimensional nature. This has the potential to impact the patient's comfort and quality of life during the treatment process.

Vital Sign

The normal heart rate or pulse rate for children is 70-110 beats per minute (bpm)(Reza & Suryana, 2022). Blood pressure is categorised as elevated if it surpasses the conventional upper limits of 120 mmHg for systolic pressure and 90 mmHg for diastolic pressure (Muhammad & Oktaviani, 210 C.E.).

Table 4.
Vital Sign

Vital sign	Description
Heart Rate	Normal (70-110 bpm)
Blood Pressure	Normal (90-120mmHg)

It was established that all respondents exhibited blood pressure and heart rate measurements that were within the normal range as defined by pediatrics standards. The systolic blood pressure levels ranged from 90 to 120 mmHg, while the heart rate ranged from 70 to 100 beats per minute (bpm). This finding suggests that the respondents' physiological conditions remained stable both before and during the intervention.

Pre-Post Instrument Results

Table 4.
PSQI Score (Sleep Quality)

PSQI				
Scale	Pre	Pre (%)	Post	Post (%)
Very Poor	16	31%	0	0%
Poor	19	37%	13	25%
Fairly Good	17	33%	33	63%%
Good	0	0%	6	12%

The results of sleep quality measurements using the PSQI showed an improvement after the intervention. In the preliminary assessment, 31% of children exhibited "very poor" sleep quality, 37% demonstrated "poor" sleep quality, 33% exhibited "fairly good" sleep quality, and no children exhibited "good" sleep quality. Following the implementation of the semi-immersive virtual reality intervention, no children exhibited "very poor" sleep, the "poor" category decreased to 25%, the "fairly good" category increased to 63%, and 12% of children achieved "good" sleep. These findings suggest that the intervention has the potential to enhance the quality of sleep in children undergoing chemotherapy.

Table 5.
NRS Score (Pain)

NRS				
Scale	Pre	Pre (%)	Post	Post (%)
Moderate	35	67	0	0
Mild	17	33	52	100

The utilisation of the Numeric Rating Scale (NRS) for the measurement of pain revealed a substantial decline in pain intensity. At the initial stage, 67% of children exhibited moderate pain, while 33% demonstrated mild pain. Following the intervention, no children experienced moderate pain, and all respondents (100%) were in the mild pain category. This finding indicates the efficacy of semi-immersive virtual reality in reducing pain perception in pediatrics patients undergoing chemotherapy treatment.

Table 6.
CFS Score (Fatique)

CFS				
Scale	Pre	Pre (%)	Post	Post (%)
Very High	13	25	0	0
High	25	48	3	6
Moderate	14	27	0	0
Low	0	0	49	9

The results of the fatigue measurement, conducted using the Child Fatigue Scale (CFS-24), demonstrated a significant decrease following the intervention. In the preliminary assessment, 25% of the children exhibited a high level of fatigue, 48% demonstrated moderate fatigue, and 27%

exhibited a moderate level of fatigue. No children displayed low fatigue levels. Following the semi-immersive virtual reality intervention, no children experienced very high or moderate fatigue, with only 6% experiencing high fatigue. The majority of children (94%) were in the low fatigue category. The findings of this study indicate that the SVR intervention was successful in reducing the fatigue levels experienced by children undergoing chemotherapy.

Table 7.
SGCQ Score (Comfort)

SGCQ				
Scale	Pre	Pre (%)	Post	Post (%)
Low	16	31%	0	0%
Moderate	36	69%	26	50%
High	0	0%	26	50%

Comfort measurements using the Shortened General Comfort Questionnaire (SGCQ) showed an improvement after the intervention. At the baseline stage of the study, 31% of children were classified as being in the low comfort category, while 69% were in the moderate category. No children were found to be in the high comfort category. Following the implementation of the semi-immersive virtual reality intervention, no children were classified as experiencing low comfort levels. In addition, 50% of children were categorised as experiencing moderate levels of comfort, while the remaining 50% achieved a high level of comfort. The findings of this study indicate that SVR intervention is effective in increasing children's comfort levels during chemotherapy. The results of the study demonstrate that the semi-immersive virtual reality intervention produced positive changes. It was observed that cancer survivors undergoing chemotherapy experienced an enhancement in the quality and comfort of their sleep, concomitant with a reduction in fatigue and pain levels. These observations suggest that digital distraction using SVR can promote relaxation and physiological balance, thereby facilitating recovery during treatment.

DISCUSSION

The results of this study indicate an improvement in sleep quality and increased comfort after children underwent semi-immersive virtual reality (SVR) intervention. This finding aligns with the digital distraction theory, which posits that engaging visual and auditory stimuli can serve as a diversion from discomfort, including physical sensations such as pain and fatigue (Duan, 2021; Lestari et al., 2020). The substantial alleviation of pain in children following the intervention suggests that SVR has the capacity to modulate physiological stress responses through the mechanisms of relaxation and distraction. These results align with the findings of Gautama et al. (2024) which demonstrated that the utilisation of virtual reality can mitigate pain and anxiety in cancer patients during medical procedures.

Furthermore, the enhancement in sleep quality and comfort evidenced in this study can be attributed to the relaxation effects engendered by the immersive virtual environment. It has been demonstrated that when children experience a reduction in stress and anxiety, and are less distracted by physical discomfort, there is a concomitant decrease in the activity of the sympathetic nervous system. This, in turn, results in an improvement in the quality of sleep. Another important finding of this study was a reduction in fatigue. Digital distraction helped to reduce children's subjective perception of fatigue by focusing their attention on positive activities in the virtual world rather than on the sensations of fatigue caused by therapy. Therefore, these results demonstrate that SVR is an effective, safe and enjoyable non-pharmacological approach for children with cancer undergoing chemotherapy.

CONCLUSION

Semi-immersive virtual reality (SVR) has been proven to improve sleep quality and comfort, as well as reducing pain and fatigue levels in pediatrics cancer survivors undergoing chemotherapy. This intervention can effectively improve children's well-being during treatment.

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