

Original Article

Implementation of Immersive Virtual Reality Tours of Heritage for Intermediate Care with Life-Limiting Illnesses

Kannikar Intawong¹, Perasuk Worragin², Pipitton Homla³, Kitti Puritat^{3*}

¹Faculty of Public Health, Chiang Mai University, Chiang Mai, Thailand.

²College of Art Media and Technology, Chiang Mai University, Chiang Mai, Thailand.

³Faculty of Humanities, Chiang Mai University, Chiang Mai, Thailand.

*Corresponding Author : kitti.p@cmu.ac.th

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Abstract - This study presents the implementation of immersive Virtual Reality (VR) heritage tours tailored to the religious and cultural way of life for patients in intermediate care with life-limiting illnesses. The research employs a Research and Development (R&D) methodology with 12 participants drawn from a specific hospital setting. The intervention's impact on symptom management and overall well-being was assessed using the Edmonton Symptom Assessment System (ESAS). Significantly improved depression and well-being outcomes were observed, indicating the potential of VR to positively influence emotional states and overall well-being. However, certain symptoms did not exhibit statistically significant changes, necessitating further exploration of the broader effects of VR interventions. This study establishes a foundational step towards the continued exploration and optimization of immersive VR interventions within intermediate care settings.

Keywords - Palliative care, Quality of life, Virtual Reality, Intermediate care, Culture heritage.

1. Introduction

In order to ensure the high quality of the papers, with an aging population and epidemiologic transition, there is a notable rise in life-limiting diseases worldwide, consequently driving greater demand for palliative care [1]. In addition, advances in scientific and Technological advancement have resulted in an increase in the number of people diagnosed with life-limiting illnesses facing more extended periods of palliative care, which may require a year or more of health care support [2]. However, adults receiving palliative care frequently face emotional and spiritual difficulties, which can lead to depression, a desire to end their suffering, and feelings of hopelessness. All of these obstacles can significantly diminish their quality of life, making it more difficult for them to experience happiness and fulfilment on a daily basis [3]. A promising approach to improving palliative care patients' psychological well-being is to offer personalized and meaningful activities or experiences related to things that have been important to them throughout their lives [4]. Engaging in such meaningful activities and experiences can help these patients maintain their dignity and enhance their overall quality of life [5]. For instance, some patients with terminal cancer express a wish to visit a memorable place or return home [6]. However, providing these experiences poses challenges, including not having enough time or money, as

well as dealing with various symptom burdens and physical limitations [5, 7]. Therefore, fulfilling these wishes can be difficult for patients. To help overcome these barriers, Virtual Reality (VR), an immersive computer-generated 3D environment that allows users to experience the sensation of being present in a different physical place [8], can be used as an additional and non-pharmacological approach. VR allows patients to experience different situations virtually and helps manage complex symptoms like severe pain, anxiety, or difficulties with movement or memory. By utilizing VR, healthcare providers can offer patients beneficial and individualized activities without worrying too much about time, money, or physical limitations.

This can be a valuable tool for enhancing the mental health of patients receiving palliative care. Despite extensive research on VR in healthcare, particularly for managing chronic pain, anxiety, and depression, a significant gap exists in applying VR for virtual cultural heritage travel as a therapeutic intervention for elderly patients with life-limiting illnesses. Most studies have concentrated on the general emotional benefits of VR, with limited exploration of how VR can be customized to reflect culturally significant experiences that address patients' spiritual and emotional needs. This study addresses this gap by examining the impact of VR-based



cultural heritage tours on the emotional well-being of elderly patients in intermediate care.

2. Literature Review

2.1. VR in Healthcare

According to [9], Virtual Reality (VR) is an advanced technology that enables the creation of interactive, computer-generated 3D environments, primarily providing visual and auditory feedback, with occasional incorporation of haptic feedback. VR systems are generally classified into three categories: non-immersive, semi-immersive, and fully immersive. Non-immersive systems, typically utilized on desktop platforms, offer limited interaction and immersion through input devices like keyboards or joypads. Semi-immersive systems, on the other hand, employ larger displays or projectors to facilitate moderate interaction, often using tools such as Kinect or data gloves. Fully immersive systems, including Head-Mounted Displays (HMDs) or Cave Automatic Virtual Environments (CAVEs), provide extensive interaction and complete immersion in the Virtual Environment (VE) [10]. VR is increasingly recognized in healthcare as a cost-effective digital therapeutic tool, capable of simulating real environments to deliver immersive and interactive experiences that enhance users' sense of presence [11-13].

For instance, VR has been employed to manage chronic conditions such as chronic pain, obesity, and post-traumatic stress disorder. The finding indicates that VR interventions can help reduce chronic pain by distracting patients from their pain and providing relaxation techniques. Additionally, VR can promote physical activity and healthy eating habits in patients with obesity. Moreover, for patients with post-traumatic stress disorder, VR can simulate exposure therapy, aiding them in confronting and overcoming traumatic memories [14]. Despite the potential benefits, the adoption of VR may encounter some challenges, particularly concerning elderly populations. To illustrate, some individuals may hesitate to try newer therapeutic technologies like VR. Additionally, a study reported that two participants experienced increased pain during the VR intervention, possibly due to the weight of the headset [15]. Therefore, the use of VR in elderly populations requires careful consideration.

2.2. Emotional Well-being in Elderly Patients with Life-Limiting Illnesses

Life-Limiting Illnesses (LLIs) refer to conditions that, while manageable to some extent, cannot be cured and are likely to result in death. These illnesses encompass a broad range of chronic and progressive diseases, such as advanced cancer, heart failure, Chronic Obstructive Pulmonary Disease (COPD), dementia, frailty associated with aging, chronic liver disease, and chronic kidney disease [16][17]. These conditions pose significant challenges for elderly patients, as they not only confront the physical symptoms but also experience emotional

distress and psychological burdens. Consequently, emotional well-being plays a vital role in these patients' overall quality of life. To clarify, emotional well-being is not only related to reducing negative emotions but also related to the intensity and frequency of positive emotions [18]. In palliative care settings, individuals with life-limiting illnesses frequently encounter psychosocial and spiritual challenges, which can result in feelings of depression, hopelessness, suicidal thoughts, and a diminished quality of life [3], [19].

Virtual Reality (VR) has shown considerable effectiveness in improving psychological well-being. For instance, Baker et al. conducted research in residential aged care facilities, indicating that VR can be a powerful tool for enhancing entertainment and mood among older adults. This is especially important as older individuals often struggle to engage in activities they previously enjoyed, and VR has the potential to enrich their daily experiences in Long Term Care (LTC) settings [20]. Baños et al. investigated the feasibility and benefits of using VR as a positive psychological intervention for patients with advanced cancer. Their study found that VR interventions were not only feasible but also well-tolerated by patients, with significant positive effects on emotional well-being by reducing negative emotions and boosting positive ones [21]. Shah et al. examined a VR-based stress management program for participants with mood disorders in psychiatric wards, revealing that VR significantly reduced stress, depression, and anxiety among participants [22]. Additional studies have confirmed the positive impact of VR on the emotional well-being and overall quality of life of adults in palliative care [23, 24]. These interventions have notably improved various aspects such as pain management, depression, anxiety, overall well-being, and even shortness of breath [25]. This underscores VR's potential as a valuable tool for enhancing emotional well-being and providing psychological and physical comfort to elderly patients with life-limiting illnesses.

2.3. Therapeutic Potential of VR Travel

Virtual Reality (VR) technology presents an innovative approach to creating immersive and realistic experiences with therapeutic benefits, particularly in the context of VR travel therapy, which is gaining increasing attention. For example, Defouilloy et al. explored the therapeutic potential of VR travel by employing a rail-travel simulator aimed at reducing anxiety symptoms in elderly adults with cognitive disorders. The study found that the simulator, which used film projection to mimic the landscape flow during a train journey, was both feasible and well-received by participants, leading to reduced anxiety and high engagement [26]. Similarly, Kabir et al. developed LIFEView, a virtual travel program designed to enhance the well-being and quality of life of palliative care patients. Participants using LIFEView reported greater relaxation, reduced anxiety, and improved positivity after virtually traveling to various destinations around the world [27].

Table 1. Literatures of VR interventions and their impact on patients with life-limiting illnesses

Studies	Population	Setting	VR Technology	Aims	Results
Niki et al., 2019 [6]	20 terminal cancer patients	Japan	HTC VIVE	Assess the effectiveness of VR travel in symptom management	Significant improvement in symptoms like pain, anxiety, and well-being.
Ferguson et al., 2020 [15]	25 dementia patients	U.S.A.	Mirage Solo	Explore VR as a therapeutic recreation for dementia patients	Secure and enjoyable experience for patients, positive feedback.
Johnson et al., 2020 [23]	12 adults with life-limiting illnesses	U.S.A.	Samsung Gear	Evaluate the utility of VR for symptom management in palliative care	The VR experience was enjoyable, beneficial, and well-tolerated, and it positively affected patients' symptoms, including pain, anxiety, and shortness of breath.
Perna et al., 2021 [29]	26 hospice patients	U.K.	Google Daydream	Feasibility of multiple VR sessions for hospice patients	High willingness to participate, positive response to VR sessions.
Lloyd & Haraldsdottir, 2021 [24]	19 patients with life-limiting conditions	U.K.	Not reported	Investigate the benefits of immersive VR for hospice patients	VR alleviated symptoms, induced positive emotions, and provided new experiences.

Additionally, Benham, Kang, and Grampurohit integrated games and virtual travel into an immersive VR intervention, which proved to be an enjoyable and engaging way to distract patients from pain [28]. Niki et al. highlighted the ability of VR to simulate real-world locations, providing terminally ill patients with the opportunity to fulfill their bucket-list experiences and potentially improve their end-of-life journey. The study demonstrated that VR travel effectively reduced symptoms in terminal cancer patients without severe side effects [6]. Moreover, Lloyd and Haraldsdottir found that VR interventions could offer hospice patients new experiences, help them reconnect with their past, and temporarily shift their focus away from their current circumstances. Participants expressed positive emotions and fulfillment from experiences that would have been otherwise unattainable due to their illness [24]. Collectively, these studies suggest that VR travel therapy holds promise as a psychosocial and spiritual intervention, supporting emotional well-being.

2.4. The Role of Spiritual Care and Religious Coping in Enhancing Quality of Life and Well-Being

Recently, the significance of spirituality and religion in the context of healthcare and overall well-being has gained considerable attention. Spiritual needs encompass the desire to discover purpose and meaning in life, establish connections with others, engage with a higher power or religion, maintain well-being, foster communication, and be treated with dignity and respect [44]. Arrey et al. [45] assert that spiritual needs are connected to one's overall health, which can affect their well-being. When these needs are unmet, it may impact their Quality of Life (QOL). Conversely, addressing spiritual needs can result in emotional balance and improved overall well-being. In non-Western countries like Thailand, where religion

assumes a central role within the culture, the concept of religious care gains particular significance. To illustrate, Thailand stands as a center of Theravada Buddhism, with a vast majority of its population, around 94%, identifying as Buddhist [46]. Recent research demonstrates the positive impact of Buddhist religious care amidst disruptions in the healthcare system.

Evidence suggests that despite these challenges, Buddhist religious care effectively contributes to individuals' well-being and health. Research conducted by Counted et al. [47], Diego-Cordero et al. [48], Domaradzki [49], Dorji and Lapierre [50], and Kwak et al. [51] emphasizes the positive impact of Buddhist religious care, especially during times of healthcare system challenges and transitions. In this study, our approach to utilizing immersive virtual reality (VR) interventions in palliative care has demonstrated notable improvements in emotional well-being, particularly in managing symptoms such as depression and anxiety.

These results surpass those reported in the current literature, primarily due to our emphasis on cultural and spiritual relevance in virtual environments. Unlike previous studies that focused on general emotional benefits or pain management through VR, our methodology involved the careful selection of a serene temple environment deeply rooted in the cultural and religious practices of the participants. This culturally tailored approach allowed for a more meaningful and personalized experience, leading to more significant emotional engagement and symptom relief. Additionally, our integration of advanced hardware, such as the Meta Quest 2 with its high-resolution displays and 3D audio capabilities, provided a more immersive and realistic experience, which

further contributed to the superior outcomes. By combining cultural sensitivity with cutting-edge technology, our study offers a novel perspective on how VR can be optimized to meet the specific emotional and spiritual needs of palliative care patients, thereby achieving better results than those reported in existing literature.

3. Purpose of the Study

This study aims to explore the feasibility of utilizing VR travel experiences for elderly individuals with life-limiting illnesses. It also seeks to assess the potential impact of VR travel to cultural heritage sites on the emotional well-being of these patients. The insights gained from this research could offer valuable guidance for future studies, providing crucial information to healthcare professionals, researchers, and developers involved in creating virtual reality-based interventions for patients with life-limiting conditions.

4. The Development Process of Virtual Reality Tours of Heritage

The COVID-19 pandemic has created additional challenges in delivering palliative care to patients with life-threatening illnesses. While traditional methods have shown their value, they struggle to fully address the heightened emotional and psychological needs that have arisen due to the pandemic. Medical professionals must exercise caution and maintain a safe distance from patients in intermediate care settings. In this context, Virtual Reality (VR) stands out as an intriguing and feasible solution due to its ability to create immersive sensory experiences. To create VR-InterCare (Virtual Reality Platform for Intermediate Care), we have followed a methodology closely aligned with the framework proposed by [33]. This methodology consists of a four-step process: Conceptualization, Preparation, Implementation, and Evaluation. We delve into the specifics of each step in the following sections, while Figure 1 offers a comprehensive visual representation of the entire process.

4.1. Conceptualization Step

The conceptualization step serves as a foundational stage, delineating crucial aspects such as target participants,

objectives, and appropriate virtual environments for the patients. Specifically, the focal beneficiaries of this system are patients in Intermediate Care (IMC) settings within hospitals, with the overarching aim of augmenting accessibility to post-acute rehabilitation services within the initial six-month period subsequent to the manifestation of various symptoms. It is important to note that although inpatients receive quality rehabilitation services, these provisions are often associated with high operational costs and limited accessibility [34].

The core purpose of the virtual reality application encompasses the pursuit of two primary objectives: firstly, to bolster the emotional well-being of patients confronted with life-limiting conditions, secondly, to alleviate the burdens borne by medical personnel engaged in the dispensation of post-acute rehabilitation services. The selection of the virtual environment has converged upon a temple scenario, a choice rooted deeply within Thailand's cultural heritage. Within this cultural context, temples are imbued with the profound capacity to offer mental solace and comfort [35].

This selection is supported by the cultural significance of engaging in activities such as merit-making at temples or participating in sermons, both of which are integral to fostering individual well-being. Additionally, the conceptualization phase is enriched by the inclusion of a concise storyboard, as illustrated in Figure 2, which effectively captures the fundamental aspects of the proposed approach.

4.2. Preparation Steps

Ensure the seamless execution of the virtual reality-enhanced palliative care project. This phase involves the aggregation of indispensable resources, the establishment of a collaborative framework, and the refinement of the project's scope. Initially, a multidisciplinary team is carefully curated, encompassing medical professionals, technologists, virtual reality experts, and design specialists from Doi Saket Hospital, the Faculty of Public Health, the College of Art and Media Technology, and the Faculty of Humanities at Chiang Mai University.

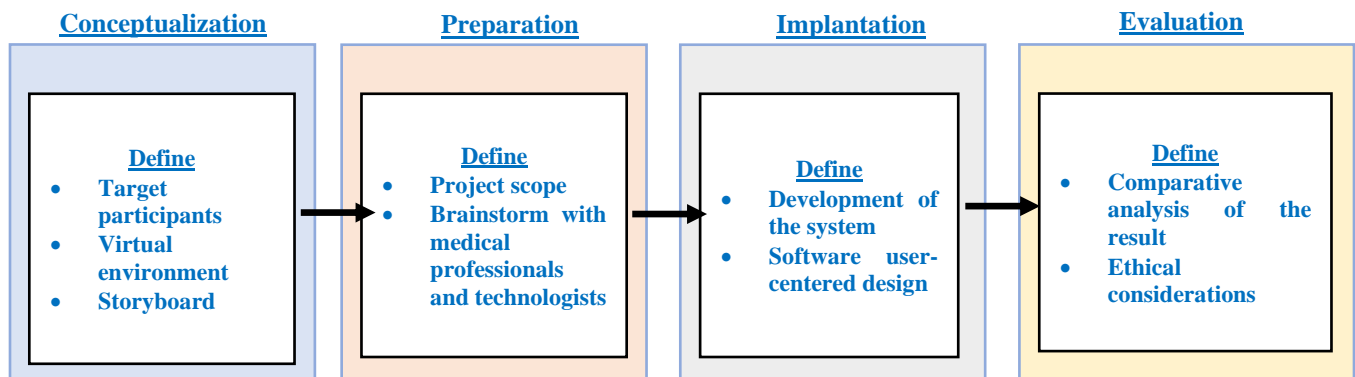


Fig. 1 Development process of virtual reality tours of heritage



Fig. 2 Concept for the storyboard of virtual reality tours of heritage

The amalgamation of their collective expertise facilitates a holistic approach, addressing both the medical and technological intricacies inherent in the project. Furthermore, a rigorous assessment of available resources is undertaken. This comprehensive evaluation encompasses an appraisal of the requisite hardware and software indispensable for the successful deployment of the virtual reality application.

Furthermore, the process includes a deliberate assessment of the necessary licenses or permissions, as well as a thorough evaluation of potential challenges that may surface during the implementation phase. In our specific context, we have chosen the Unity game engine version 2022.3.6 as the software to visualize the virtual reality system. At the same time, Meta Quest 2 has been selected as the requisite hardware for the project.

4.3. Implementation Step

The implementation phase brings the virtual reality-enhanced palliative care system to life. Guided by the objectives outlined earlier, we meticulously craft a virtual reality application that immerses users in a serene temple environment. This experience includes engaging with intricately carved Buddhist statues (Figure 3), soothing chimes, virtual exploration of the temple surroundings, and the symbolic act of ringing the temple bell (Figure 4). The software's user-centered design ensures patients can navigate these virtual scenarios effortlessly, addressing any concerns.

Ethical considerations remain paramount as suitable participants are introduced through comprehensive in-formed consent processes. This phase bridges conceptualization with reality, creating a functional and user-friendly virtual reality solution. This solution aims to enhance patients' emotional well-being while supporting medical personnel in their caregiving roles.



Fig. 3 Simulating a temple environment for engagement with Buddhist statue engravings



Fig. 4 Patients interact by ringing the bell in the simulated temple environment

4.4. Evaluation Step

The evaluation phase assesses the effectiveness and impact of the virtual reality-enhanced palliative care system (Figure 5). Comparative analysis is conducted to benchmark the results against pre-implementation data and traditional palliative care methods. This comparison highlights the system's contributions and provides insights into areas for improvement. Ethical considerations are revisited during the evaluation phase to ensure patient privacy and data security have been upheld throughout the project.



Fig. 5 Evaluate the effectiveness and impact of Patients in Doi Saket Hospital

5. Research Methodology

This study employed the research methodology of the Research and Development (R&D) method, which refers to the systematic process of creating new knowledge, technologies, products, or processes through a combination of research, experimentation, and innovation [30]. The study was conducted with the approval of the Fullboard Research Ethics Committee, Faculty of Public Health, Chiang Mai University (Document No. ET016/2022).

6. Participants

The dataset utilized in this study consisted of information gathered from a cohort of 12 participants, all of whom provided informed consent. These participants were intentionally selected from the palliative care patient population at Doi Saket Hospital. The inclusion criteria required participants to be at least 20 years old. In contrast, exclusion criteria included visual or hearing impairments, severe cognitive impairments that would hinder the ability to respond to questionnaires, and the inability to maintain a seated position.

The primary aim of this study was to assess the functional status and performance levels of individuals diagnosed with cancer and other severe conditions. For this purpose, the Eastern Cooperative Oncology Group Performance Status (ECOG PS) scale [30] was employed to evaluate participants' daily activities and overall well-being.

The ECOG PS scale ranges from 0 to 5, where 0 represents full activity, 1 indicates limitations in physically strenuous activities, 2 denotes the ability to be ambulatory and perform self-care, 3 reflects a capacity for only limited self-care, and 4 signifies a complete disability. A comprehensive overview of the participant's demographic characteristics is presented in Table 2.

Table 2. The participants' demographic characteristics

Participant ID	Sex	Age	ECOS PS
1	Male	52	3
2	Male	60	3
3	Male	62	3
4	Male	55	3
5	Male	58	3
6	Male	54	3
7	Male	61	2
8	Male	65	2
9	Female	50	3
10	Female	51	3
11	Female	64	3
12	Female	56	2

Note: ECOG PS stands for Eastern Cooperative Oncology Group Performance Status; SD denotes standard deviation.

7. Instruments

7.1. Edmonton Symptom Assessment System

According to [31, 32], the Edmonton Symptom Assessment System (ESAS) is a quantitative instrument specifically designed for data collection in palliative care and oncology contexts. This tool is systematically used to measure and quantify the severity of a broad range of symptoms experienced by patients. The ESAS was developed to provide healthcare professionals with a standardized framework for assessing the intensity of symptoms in individuals dealing with serious illnesses. The system typically encompasses symptoms such as pain, fatigue, nausea, depression, anxiety, and shortness of breath, with patients rating the severity of each symptom on a numerical scale from 0 (no pain) to 10 (most intense pain).

7.2. Virtual Reality Tours of Heritage

As mentioned earlier, the instruments within the VR-InterCare (Virtual Reality Platform for Intermediate Care) framework were employed to evaluate Elderly Patients utilizing a virtual reality application set within a serene temple environment. This immersive virtual reality experience aims to facilitate a comprehensive assessment of patients' responses and experiences, thereby contributing to the ongoing refinement and optimization of the palliative care intervention.

7.3. Immersive VR Apparatus

The immersive VR apparatus employed in this study was meticulously designed to provide participants with a highly engaging and realistic experience, crucial for fostering a sense of presence and emotional engagement, particularly in palliative care settings. The hardware components included the Meta Quest 2 Head-Mounted Display (HMD), selected for its high-resolution displays, 90 Hz refresh rate, and wide field of view, all contributing to a seamless and immersive experience. Its lightweight design minimized physical discomfort during extended use.

To enhance the realism of the virtual environment, integrated spatial audio provided 3D audio cues, which were essential for creating an immersive auditory experience, particularly in environments with significant sound elements like temple bells. The six Degrees of Freedom (6DoF) motion tracking system inherent in the Meta Quest 2 allowed participants to move freely within the virtual space, enabling natural interaction with the environment.

On the software side, the VR experience was developed using Unity game engine version 2022.3.6, known for its robust development tools and compatibility with a wide range of VR hardware. The application was tailored to simulate a serene temple environment, complete with interactive elements such as ringing temple bells and engaging with Buddhist statues, providing a meaningful and immersive experience for the participants.

8. Data Analysis and Result

The analysis of symptom data, quantified using the ESAS, has unveiled significant trends in symptom severity before and after engagement with the Virtual Reality tours of heritage intervention. The results of the VR tours of heritage are presented in Table 3. Participants in the experiment exhibited an ECOG performance status greater than 2.

The dataset was thoroughly analyzed using IBM SPSS version 27, with a paired-sample t-test employed to evaluate changes within the same group across two different time points. The analysis yielded notable findings across various symptoms, with statistically significant improvements observed in both depression and well-being following the VR intervention, evidenced by p-values of less than 0.001.

These improvements are further emphasized by p-values measuring less than 0.001, underscoring the intervention's effectiveness. Moreover, effect size estimates (Cohen's d) indicate moderate to substantial effect sizes for depression and well-being, further underscoring the clinical relevance of the observed changes. Beyond evaluating symptom improvement, this study also examined the impact of the VR intervention on potential side effects, as well as participant's expectations and satisfaction levels before and after engaging with the VR experience. The mean scores, standard deviations, and ranges for each aspect are presented in Table 4. Furthermore, participants' expectations and satisfaction levels before and after the VR intervention were also evaluated. The analysis of other side effects did not reveal statistically significant changes after the VR intervention. However, participants' expectations and satisfaction levels exhibited a statistically

significant increase after engaging with the VR experience, with a p-value <0.001. The substantial effect size (Cohen's d = 0.887) emphasizes the substantial impact of the VR intervention on participants' overall satisfaction and positive outlook.

This multifaceted analysis highlights the broader effects of VR interventions in palliative care contexts, encompassing both symptom management and participants' overall well-being. Several participants demonstrated an escalation in their ESAS scores subsequent to their engagement with the VR intervention. The particulars of score elevation instances, along with participants' explanations and the duration of their VR sessions, are detailed in Table 5.

This data affords an understanding of scenarios wherein participants encountered an uptick in symptoms subsequent to the VR intervention. For instance, in the context of headaches, participants conveyed that prolonged VR usage, possibly due to the extended duration of engagement with the VR application, resulted in a minor increase in headache symptoms.

Similarly, some participants noted an augmentation in nausea, which they attributed to the extended duration of their VR sessions. In the case of eyestrain, participants reported heightened symptoms, with some ascribing the increase to the overall luminosity of the VR experience. These insights underscore the necessity of striking a balance between immersive engagement and the potential manifestation of side effects during the design and implementation of VR interventions for palliative care.

Table 3. The result of the pair-samples T-Test of ESAS

Symptom Category (ESAS)	Pre-VR Intervention mean (SD, range)	Post-VR Intervention mean (SD, range)	P-value	Cohen's D
Pain	1.83(1.33,0-4)	1.66(1.30,0-4)	.166	.389
Tiredness	4.08(2.06,0-6)	3.50(1.78,0-6)	.002	.514
Drowsiness	2.50(1.78,0-5)	2.25(1.71,0-5)	.082	.452
Nausea	0.25(0.45,0-1)	0.41(0.51,0-1)	.166	.389
Lack of appetite	2.83(1.40,0-4)	2.58(1.24,0-4)	.082	.452
Shortness of breath	1.66(1.15,0-4)	1.25(1.05,0-3)	.017	.514
Depression	4.08(1.97,0-6)	2.83(1.33,0-4)	<.001*	.753
Anxiety	2.58(1.54,0-4)	2.16(0.93,0-3)	.054	.668
Well-being	4.16(2.24,1-6)	3.16(1.89,1-5)	<.001*	.738

Table 4. The result of pair-samples T-Test of other side effect and expectation/satisfaction

	Before VR mean (SD, range)	After VR mean (SD, range)	P	Cohen's D
Other Side effect				
Dizziness	0.25(0.45,0-1)	0.16(0.38,0-1)	.339	.288
Headache	0.08(0.28,0-1)	0.25(0.45,0-1)	.166	.389
Eyestrain	0.00(0.00,0-1)	0.25(0.62,0-1)	.191	.621
Pre/Post VR expectation/satisfaction				
Expectation/satisfaction	4.33(2.05,1-6)	5.66(2.01,2-8)	<.001*	.887

Table 5. Detail of participants whose ESAS Increased after using VR

Other side effect	score increase	Reason for score increase	Session time (minutes)	N (%)
Headache	0 -> 1	Length of using	45	2 (16.66)
	0 -> 1	Unknown	30	
Nausea	0 -> 1	Length of using	45	2 (16.66)
	0 -> 1	Equipment is not comfortable	15	
Eyestrain	0 -> 1	Unknown	30	2 (16.66)

9. Finding and Discussion

9.1. The Effects of Immersive Virtual Reality Tours of Heritage

This study marks the first attempt to implement immersive virtual reality tours of heritage tailored to the religious and cultural way of life in Thailand for patients in intermediate care. The incorporation of immersive virtual reality (VR) heritage tours as a palliative care intervention for patients in intermediate care grappling with life-limiting illnesses has yielded captivating insights. Our study seeks to dissect the implications of this innovative approach on symptom management and overall well-being.

An analysis of symptom data using the Edmonton Symptom Assessment System (ESAS) revealed significant trends in symptom severity observed both before and after the VR intervention. Statistically significant improvements in depression and well-being were observed following the VR intervention, as indicated by p-values of less than 0.001, highlighting a high level of statistical significance. The effect size estimates (Cohen’s d) further emphasize the clinical relevance of these changes. The moderate to large effect sizes for both depression and well-being suggest that the intervention had a meaningful impact on participants' emotional states and overall well-being. Although certain symptoms did not exhibit statistically significant changes, the observed trends toward improvement suggest the latent benefits of the VR intervention in mitigating various symptoms often experienced by patients facing life-limiting illnesses.

This observation aligns with prior research that has highlighted the potential of VR interventions in ameliorating physical and emotional distress among individuals confronting grave illnesses [6][36][24]. However, our findings differ from those of some studies that have examined the use of virtual reality for pain reduction in patients [37-41]. The identification of participants who encountered an escalation in symptoms post-VR intervention offers valuable insights into the nuanced intricacies of the virtual reality experience. The documented side effects, such as heightened headaches and eyestrain, underscore the necessity of achieving equilibrium between immersive engagement and the potential for discomfort, echoing similar observations found in [42][43]. This underscores the need for scrupulous monitoring and tailoring of VR experiences to ensure a positive and secure encounter for patients.

9.2. Momentary Affect and Cybersickness

In this study, participants' momentary affect was closely monitored throughout the VR sessions to assess both positive and negative emotional responses. Positive emotional outcomes, such as increased relaxation and reduced anxiety, were frequently observed, particularly in culturally and spiritually meaningful environments. However, a minority of participants did report instances of cybersickness. These occurrences were mainly linked to the duration of VR exposure and the intensity of visual stimuli within the virtual environment. To mitigate these effects, the VR sessions were designed to be brief, with breaks included to minimize discomfort. The VR application was also optimized for smooth, stable frame rates to reduce visual disturbances that could trigger cybersickness. Participants were informed about the potential for cybersickness and encouraged to report any discomfort immediately, allowing for prompt adjustments to the experience. While most participants experienced positive emotional states during the sessions, the occurrence of cybersickness in some cases underscores the importance of considering individual tolerance levels and the need for adaptive VR design to ensure a comfortable and beneficial experience for all users.

10. Conclusion, Limitation and Future Work

This study marks the first implementation of immersive Virtual Reality (VR) heritage tours tailored to the religious and cultural way of life for patients in intermediate care with life-limiting illnesses. The intervention has demonstrated significant improvements in depression and well-being, showcasing the potential of VR to positively impact emotional states and overall well-being. The research employed the Research and Development (R&D) methodology with a sample of 12 participants from a specific hospital setting, utilizing the Edmonton Symptom Assessment System to quantify symptom changes. However, certain symptoms did not exhibit statistically significant changes, suggesting the need for further investigation into the broader effects of VR interventions on symptom management. Despite its contributions, this study does have limitations. The relatively small sample size and the confined setting might restrict the generalizability of findings to wider populations. To enhance the intervention's effectiveness, future research could involve larger and more diverse samples encompassing various cultural contexts. Additionally, customization of VR experiences to accommodate individual sensitivities and preferences could be explored. In essence, this study provides

a foundational step towards the ongoing exploration and refinement of immersive VR interventions in the context of palliative care settings.

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Appendix 1

Please circle the number that best describes:

No pain	10	9	8	7	6	5	4	3	2	1	0	Worst Possible Pain
No Tiredness (Tiredness = lack of energy)	10	9	8	7	6	5	4	3	2	1	0	Worst Possible Tiredness
No Nausea	10	9	8	7	6	5	4	3	2	1	0	Worst Possible Nausea
No Lack of Appetite	10	9	8	7	6	5	4	3	2	1	0	Worst Possible Lack of Appetite
No shortness of breath	10	9	8	7	6	5	4	3	2	1	0	Worst Possible Shortness of Breath
No Depression (Depression = feeling bad)	10	9	8	7	6	5	4	3	2	1	0	Worst Possible Depression
No Anxiety (Anxiety = feeling nervous)	10	9	8	7	6	5	4	3	2	1	0	Worst Possible Anxiety
Best Wellbeing (Wellbeing = how you feel overall)	10	9	8	7	6	5	4	3	2	1	0	Worst Possible Wellbeing
No _____ Other Problems (For example, constipation)	10	9	8	7	6	5	4	3	2	1	0	Worst Possible _____