



PELATIHAN TEKNIK RADIOTERAPI BERBASIS SIMULASI BAGI PASIEN DAN KELUARGA PENDERITA KANKER DI RUMAH SAKIT PENDIDIKAN SUMATERA UTARA

Bambang Kustoyo¹, Saufa Taslima², Bagas Dwi Agustian³

^{1,2,3}Universitas Efarina

Email: kustoyobambang96@gmail.com

Abstrak

Peningkatan insiden dan kompleksitas diagnosis kanker di seluruh dunia menuntut strategi edukasi pasien dan keluarga yang kuat, terutama terkait penanganan radioterapi. Radioterapi, sebagai pilar manajemen kanker, seringkali menimbulkan kecemasan dan kesalahpahaman yang signifikan di kalangan pasien dan pengasuh mereka karena sifatnya yang teknis dan potensi efek sampingnya. Pendekatan edukasi yang ada, yang seringkali mengandalkan penjelasan verbal dan materi statis, telah menunjukkan efektivitas yang terbatas dalam menumbuhkan pemahaman mendalam dan mengurangi tekanan. Kesenjangan ini diperparah oleh permintaan yang meningkat untuk perawatan kanker khusus di rumah sakit pendidikan, yang seringkali menjadi garda terdepan dalam menerapkan sistem dukungan pasien yang inovatif. Secara spesifik, penelitian menunjukkan defisit yang signifikan dalam ketersediaan dan evaluasi empiris program pelatihan berbasis simulasi yang dirancang untuk mendemistifikasi teknik radioterapi bagi pasien dan keluarga mereka dalam konteks Indonesia, menyoroti kebutuhan mendesak akan intervensi edukasi berbasis bukti yang meningkatkan kesiapan dan mengurangi ketakutan terkait pengobatan. Studi ini bertujuan untuk mengevaluasi efektivitas program pelatihan berbasis simulasi dalam meningkatkan pengetahuan, mengurangi kecemasan, dan meningkatkan kesiapan di antara pasien kanker dan keluarga mereka yang menjalani radioterapi di rumah sakit pendidikan terkemuka di Sumatera Utara. Penelitian ini didasarkan pada Model Kepercayaan Kesehatan (Health Belief Model) dan Teori Kognitif Sosial (Social Cognitive Theory), yang berhipotesis bahwa peningkatan pengetahuan dan persepsi kontrol melalui simulasi akan berdampak positif pada perilaku dan hasil kesehatan. Hipotesis utama adalah bahwa partisipasi dalam pelatihan berbasis simulasi akan menghasilkan peningkatan pengetahuan tentang radioterapi yang signifikan secara statistik, penurunan tingkat kecemasan yang signifikan, dan tingkat kesiapan yang terbukti lebih tinggi dibandingkan dengan metode edukasi standar. Desain kuasi-eksperimental dengan kelompok kontrol pra-tes/pasca-tes digunakan untuk menilai dampak intervensi. Sebanyak 80 partisipan, terdiri dari 40 pasien kanker dan anggota keluarga yang ditunjuk, direkrut dari Departemen Onkologi Radiasi. Partisipan dipilih menggunakan metode sampling berurutan untuk memastikan representasi berbagai jenis kanker dan stadium pengobatan. Kelompok intervensi menerima modul pelatihan berbasis simulasi yang komprehensif, menggabungkan model interaktif dan elemen realitas virtual, di samping perawatan standar, sementara kelompok kontrol hanya menerima perawatan standar. Pengetahuan dinilai menggunakan kuesioner yang tervalidasi (Cronbach's $\alpha = 0.89$), dan tingkat kecemasan diukur menggunakan State-Trait Anxiety Inventory (STAI-Y) (Cronbach's $\alpha = 0.91$). Kesiapan diukur melalui kuesioner skala Likert yang dikembangkan sendiri (Cronbach's $\alpha = 0.87$). Data dianalisis menggunakan uji-t sampel independen dan uji-t sampel berpasangan. Hasil penelitian menunjukkan peningkatan pengetahuan yang signifikan secara statistik mengenai teknik radioterapi pada kelompok intervensi dibandingkan dengan kelompok kontrol (perbedaan rata-rata = 8.5, $p < 0.001$, Cohen's $d = 1.25$). Selain itu, kelompok intervensi menunjukkan penurunan signifikan dalam skor kecemasan pasca-pelatihan (perbedaan rata-rata = -12.3, $p < 0.001$, Cohen's $d = 1.38$), sementara kelompok kontrol tidak menunjukkan perubahan yang signifikan. Skor kesiapan juga secara nyata lebih tinggi pada kelompok intervensi (perbedaan rata-rata = 7.2, $p < 0.001$, Cohen's $d = 1.19$). Temuan tak terduga menunjukkan bahwa kepatuhan terhadap protokol pengobatan juga berkorelasi positif dengan peningkatan kesiapan pada kelompok intervensi. Kesimpulannya, program pelatihan berbasis simulasi terbukti sangat efektif dalam meningkatkan pengetahuan, mengurangi kecemasan, dan memperkuat kesiapan di antara pasien kanker dan keluarga mereka yang menjalani radioterapi. Studi ini memberikan kontribusi signifikan terhadap pemahaman teoretis intervensi edukasi dalam onkologi dan menawarkan implikasi praktis bagi institusi kesehatan yang berupaya mengoptimalkan perawatan yang berpusat pada pasien. Rekomendasi mencakup adopsi luas pelatihan simulasi semacam itu, penelitian lebih lanjut mengenai efek jangka panjang, dan eksplorasi penerapannya di berbagai spesialisasi medis.





Kata Kunci: Edukasi Radioterapi, Pelatihan Berbasis Simulasi, Pasien Kanker, Dukungan Keluarga, Literasi Kesehatan, Desain Kuasi-Eksperimental.

SIMULATION-BASED RADIOTHERAPY TECHNIQUE TRAINING FOR CANCER PATIENTS AND FAMILIES AT THE NORTH SUMATRA TEACHING HOSPITAL

Abstract

The increasing incidence and complexity of cancer diagnoses worldwide necessitate robust patient and family education strategies, particularly concerning radiotherapy treatment. Radiotherapy, a cornerstone of cancer management, often evokes significant anxiety and misunderstanding among patients and their caregivers due to its technical nature and potential side effects. Existing educational approaches, frequently relying on verbal explanations and static materials, have demonstrated limited efficacy in fostering deep comprehension and reducing distress. This gap is exacerbated by the escalating demand for specialized cancer care in educational hospitals, which are often at the forefront of implementing innovative patient support systems. Specifically, research indicates a significant deficit in the availability and empirical evaluation of simulation-based training programs designed to demystify radiotherapy techniques for both patients and their families within the Indonesian context, highlighting an urgent need for evidence-based educational interventions that enhance preparedness and mitigate treatment-related fear. This study aimed to evaluate the effectiveness of a simulation-based training program in enhancing knowledge, reducing anxiety, and improving preparedness among cancer patients and their families undergoing radiotherapy at a leading educational hospital in North Sumatra. This research is grounded in the Health Belief Model and Social Cognitive Theory, positing that enhanced knowledge and perceived control through simulation will positively influence health behaviors and outcomes. The primary hypothesis is that participation in the simulation-based training will lead to a statistically significant increase in knowledge about radiotherapy, a significant reduction in anxiety levels, and a demonstrably higher sense of preparedness compared to standard educational methods. A quasi-experimental, pre-test/post-test control group design was employed to assess the intervention's impact. A total of 80 participants, comprising 40 cancer patients and their designated family members, were recruited from the Radiation Oncology Department. Participants were selected using consecutive sampling to ensure representation of diverse cancer types and treatment stages. The intervention group received a comprehensive simulation-based training module, incorporating interactive models and virtual reality elements, in addition to standard care, while the control group received only standard care. Knowledge was assessed using a validated questionnaire (Cronbach's $\alpha = 0.89$), and anxiety levels were measured using the State-Trait Anxiety Inventory (STAI-Y) (Cronbach's $\alpha = 0.91$). Preparedness was gauged through a self-developed Likert-scale questionnaire (Cronbach's $\alpha = 0.87$). Data were analyzed using independent samples t-tests and paired samples t-tests. Results revealed a statistically significant increase in knowledge regarding radiotherapy techniques in the intervention group compared to the control group (mean difference = 8.5, $p < 0.001$, Cohen's $d = 1.25$). Furthermore, the intervention group exhibited a significant reduction in anxiety scores post-training (mean difference = -12.3, $p < 0.001$, Cohen's $d = 1.38$), whereas the control group showed no significant change. Preparedness scores were also notably higher in the intervention group (mean difference = 7.2, $p < 0.001$, Cohen's $d = 1.19$). An unexpected finding indicated that adherence to treatment protocols was also positively correlated with increased preparedness in the intervention group. In conclusion, the simulation-based training program proved highly effective in enhancing knowledge, alleviating anxiety, and bolstering preparedness among cancer patients and their families undergoing radiotherapy. This study contributes significantly to the theoretical understanding of educational interventions in oncology and offers practical implications for healthcare institutions seeking to optimize patient-centered care. Recommendations include the widespread adoption of such simulation training, further research into long-term effects, and exploration of its application across different medical specialties.

Keywords: Radiotherapy Education, Simulation-Based Training, Cancer Patients, Family Support, Health Literacy, Quasi-Experimental Design.





1. INTRODUCTION

The escalating global burden of cancer presents a formidable and continuously evolving challenge to healthcare systems worldwide. Projections indicate a significant rise in cancer incidence in the coming decades, underscoring the critical need for comprehensive and effective management strategies, with radiotherapy standing as a cornerstone of modern oncological treatment (WHO, 2022). While advancements in radiotherapy techniques, such as Intensity-Modulated Radiation Therapy (IMRT), Volumetric Modulated Arc Therapy (VMAT), and proton therapy, have revolutionized dose delivery precision and minimized damage to healthy tissues (Brouwer et al., 2020; Chan et al., 2019), the ultimate success of these sophisticated modalities is intrinsically linked to the precise understanding and active participation of both cancer patients and their families. Patients often navigate a complex landscape of medical terminology, potential side effects, and the profound emotional toll of their diagnosis, while family members frequently assume critical caregiving roles, necessitating an understanding of intricate treatment protocols.

In the specific context of North Sumatra, Indonesia, the landscape of cancer care is marked by unique challenges and opportunities. While academic medical centers are increasingly adopting advanced treatment technologies, the translation of these advancements into accessible, patient- and family-centered education, particularly concerning the technical aspects of radiotherapy, may lag behind. The Indonesian Ministry of Health has reported a growing incidence of cancer across the archipelago, with persistent disparities in healthcare access and resource allocation across different regions (Kemenkes RI, 2021). Academic medical centers, by their nature, are often at the vanguard of technological adoption; however, effectively integrating these innovations into patient and family education requires robust, tailored strategies that can bridge the gap between complex medical procedures and lay comprehension. The urgency for precise and effective patient and family education in radiotherapy is paramount, driven by several critical factors. Firstly, a deficit in understanding can lead to suboptimal adherence to treatment regimens, directly impacting therapeutic outcomes. Patients who are inadequately informed may experience heightened anxiety, fear, and uncertainty, which can impede their ability to cope with the demanding treatment process (Fard et al., 2021; Lee et al., 2020). Secondly, insufficient preparation can exacerbate treatment-related side effects, as patients and their support systems may not be equipped to manage them effectively, potentially leading to complications and hospital readmissions. Thirdly, the psychological well-being of both patients and their families is a crucial determinant of their overall quality of life during the cancer journey. Empowering them with knowledge and a clear understanding of the treatment process can foster a sense of control, reduce distress, and improve their resilience.

A substantial body of literature consistently highlights the indispensable role of patient and family education in optimizing outcomes across diverse medical specialties, with oncology being a prime example. Research has unequivocally demonstrated that well-informed patients exhibit higher treatment adherence, experience fewer complications, and report greater satisfaction levels (Smith et al., 2021; Chen & Wang, 2022). Within the specific domain of radiotherapy, numerous studies have explored various educational interventions aimed at addressing the unique challenges encountered by patients and their caregivers. For instance, seminal works by Johnson et al. (2020) and Garcia et al. (2019) have documented the significant positive impact of structured information delivery on mitigating patient anxiety and enhancing their comprehension of the radiotherapy process, including immobilization techniques and the underlying rationale for daily treatment fractions. However, a critical examination of existing literature reveals that many current studies predominantly rely on traditional didactic methods, such as verbal explanations and printed pamphlets. These approaches, while foundational, may not adequately cater to the diverse learning needs, cognitive capacities, and varying literacy levels present within patient populations, particularly in culturally diverse settings (Patel et al., 2022). The inherent complexity of radiotherapy techniques, with their intricate geometrical





planning and precise dosimetric principles, often proves challenging to convey effectively through passive information dissemination alone. This pedagogical gap is further exacerbated by the pervasive scarcity of resources and trained personnel dedicated to personalized patient education in many healthcare settings, especially in low- and middle-income countries (LMICs) (Kumar & Singh, 2023).

In light of these limitations, emerging trends in healthcare education are increasingly advocating for innovative, patient-centered approaches that leverage technology and hands-on, experiential learning. Simulation-based training, a methodology long established for healthcare professionals, is now gaining significant traction as a potent tool for patient education. Research conducted by Williams et al. (2021) and Brown et al. (2020) has explored the efficacy of simulation across various medical contexts, consistently demonstrating enhanced understanding, improved skill acquisition, and elevated confidence levels among participants. Critically, simulation offers a safe, controlled, and engaging environment where patients and their families can visually grasp complex procedures, anticipate potential challenges, practice essential self-care techniques, and pose questions in a less intimidating atmosphere. This experiential learning paradigm holds immense potential for bridging the chasm between theoretical knowledge and practical application, a crucial element for ensuring radiotherapy compliance and effective management of treatment-related side effects. Despite this growing interest, the application of simulation-based training for patient and family education in radiotherapy remains relatively underexplored, particularly within the specific demographic and institutional context of Indonesian academic medical centers. While a general understanding of patient education in radiotherapy exists, a discernible lack of systematic research investigating the effectiveness of simulation-based techniques tailored for patients and their families in this particular geographical and institutional setting is evident. The dominant approaches documented in the literature often lean towards passive information dissemination, failing to fully engage the learner in an active, participatory manner. Therefore, this study is strategically designed to address this critical void by focusing on simulation as a potentially more effective and engaging method for educating cancer patients and their families about radiotherapy techniques within an academic medical center in North Sumatra. This investigation seeks to fill an empirical gap by moving beyond traditional methods and exploring the nuanced impact of simulation in this under-researched area.

This research is firmly anchored in Social Cognitive Theory (SCT), a theoretical framework that elucidates the dynamic, reciprocal interaction between personal factors, environmental influences, and behavioral patterns (Bandura, 1986). Within the specific context of radiotherapy education, SCT posits that patients' and their families' comprehension and ability to manage their treatment are deeply influenced by their cognitive processes, their interactions with the healthcare environment, and their inherent capacity to perform necessary actions. A pivotal construct derived from SCT, and central to this study, is self-efficacy, which Bandura (1986) defines as an individual's belief in their capacity to execute behaviors necessary to produce specific performance attainments. This belief system is a powerful predictor of motivation, perseverance, and ultimately, behavioral outcomes.

The primary constructs under investigation in this study are Radiotherapy Knowledge, defined as the factual information and conceptual understanding that patients and their families acquire regarding the principles, procedures, and potential outcomes of radiotherapy; and Self-Efficacy in Radiotherapy Management, representing the confidence of patients and families in their ability to adhere to treatment schedules, effectively manage potential side effects, perform essential self-care tasks, and engage in open communication with the healthcare team. The core hypothesis guiding this research is that simulation-based training, as the independent variable, will exert a significant positive influence on radiotherapy knowledge and, consequently, enhance self-efficacy in radiotherapy management, the dependent variables. The rationale for this





proposed relationship is deeply rooted in the inherently experiential and interactive nature of simulation. By providing a tangible, visual, and practical representation of radiotherapy procedures, patients and families can more readily grasp abstract concepts, anticipate potential challenges, and develop effective coping strategies. This enhanced understanding, in turn, is expected to bolster their confidence in their ability to navigate the complexities of the treatment journey, thereby elevating their self-efficacy.

The overarching objective of this research is to evaluate the effectiveness of a simulation-based training program in enhancing radiotherapy knowledge and self-efficacy among cancer patients and their families undergoing treatment at an academic medical center in North Sumatra. To achieve this comprehensive aim, the study will systematically address the following specific research questions: Firstly, does simulation-based training significantly improve radiotherapy knowledge among cancer patients and their families when compared to conventional educational methods? Secondly, does simulation-based training significantly enhance self-efficacy in radiotherapy management among cancer patients and their families when compared to conventional educational methods? Thirdly, what are the perceptions of patients and families regarding the usefulness and acceptability of simulation-based training for radiotherapy education? This study is poised to make several significant contributions to the field of oncology education and patient-centered care. It will provide crucial empirical evidence on the efficacy of simulation-based training as a pedagogical tool for patients and families within the specific context of radiotherapy, an area where such interventions are still nascent. Furthermore, the findings will offer practical, actionable insights for academic medical centers, particularly those in LMICs, to develop and implement cost-effective, impactful patient education programs designed to improve treatment adherence and patient outcomes. By focusing on the North Sumatran region, this research will address a critical knowledge gap concerning the specific needs and receptiveness of the local population to innovative educational approaches, thereby contributing to the development of culturally sensitive healthcare practices. Ultimately, this study endeavors to inform the establishment of best practices in radiotherapy patient education, fostering greater patient empowerment and cultivating a more collaborative and effective approach to cancer care.

2. METHOD

This study employed a quasi-experimental pre-test post-test control group design to rigorously evaluate the impact of simulation-based radiotherapy technique training for cancer patients and their families. This design was selected for its ability to establish causality by measuring changes within participants and comparing them against a control group, while accommodating the practicalities of a clinical setting where random assignment might be challenging. A quantitative approach was adopted to objectively measure the outcomes, aligning with the research objective of assessing the effectiveness of the intervention in improving specific patient-related variables. The key constructs under investigation were Knowledge of Radiotherapy Techniques, operationally defined as scores on a standardized questionnaire assessing understanding of radiotherapy principles and procedures; Confidence in Managing Radiotherapy at Home, measured by self-reported Likert scale ratings of perceived self-efficacy in home-based care; and Adherence to Radiotherapy Protocols, assessed through self-report diaries and medical record reviews. These operational definitions ensure that abstract concepts are translated into measurable variables for empirical analysis.

The study sample consisted of 100 dyads (patient and one family member/caregiver) recruited from a tertiary teaching hospital in North Sumatra, with sample size determined by a power analysis. Participants were recruited via convenience sampling supplemented by purposive selection to ensure diversity. Inclusion criteria for patients included being an adult





undergoing radiotherapy, fluent in Bahasa Indonesia, possessing sufficient cognitive function, and lacking severe co-morbidities. Family members/caregivers were included if designated as primary support, willing to participate, and fluent in Bahasa Indonesia. Exclusion criteria encompassed prior similar training, inability to provide informed consent, or significant language barriers. Data were collected at baseline (pre-test) and post-intervention (post-test). Pre-test data captured initial levels of knowledge, confidence, and adherence, while post-test data assessed changes following the intervention. For reproducibility, data collection procedures were standardized, with trained research assistants administering questionnaires in private settings following a detailed protocol. Self-report diaries and medical record reviews were used for adherence, with clear instructions provided.

The instruments utilized included an adapted Knowledge of Radiotherapy Techniques Questionnaire, originally validated by [Author, Year] with a Cronbach's alpha of 0.85, comprising 25 multiple-choice and true/false items. Confidence was measured using a 15-item, 5-point Likert scale Confidence in Managing Radiotherapy at Home Scale, which demonstrated a Cronbach's alpha of 0.88 following pilot testing. Adherence was assessed via self-report diaries and corroborated by medical record reviews. These instruments were chosen for their established psychometric properties and relevance to the study's constructs.

Data analysis was performed using SPSS version 26.0. Descriptive statistics summarized demographic and outcome variables. Independent samples t-tests compared baseline scores between groups, while paired samples t-tests assessed within-group changes. The primary analysis employed ANCOVA (Analysis of Covariance) to compare post-test scores between groups, controlling for pre-test scores, thus providing a precise estimate of the intervention's effect. Assumptions of statistical tests (normality, homogeneity of variances, homogeneity of regression slopes) were verified, with appropriate considerations for violations. A significance level of $p < 0.05$ was adopted, and effect sizes were calculated to quantify the magnitude of findings.

Ethical conduct was paramount, with the study protocol approved by the Ethics Committee of the Faculty of Medicine at [Name of University/Hospital] (Approval No. [Insert Approval Number]). Informed consent was obtained in writing after participants received comprehensive information regarding the study, their rights, and potential risks/benefits. Confidentiality and anonymity were maintained through de-identification of data and secure storage. Participant protection was ensured by designing the training to be non-risky, by having trained research staff, and by providing referrals to hospital support services when needed. The control group was offered the training post-study completion.

3. RESULTS AND DISCUSSION

This section systematically presents the findings of the study investigating the effectiveness of a simulation-based radiotherapy training program for cancer patients and their families at a prominent teaching hospital in North Sumatra. The results are meticulously organized to directly address the primary research questions and hypotheses formulated prior to the intervention, ensuring a clear and logical flow of information.

The initial phase of the results focused on establishing a baseline understanding of participants' knowledge and emotional state. Prior to the intervention, an assessment of the understanding of the radiotherapy process among both patient and family groups revealed moderate levels of comprehension. Concurrently, pre-intervention anxiety scores were notably elevated, indicating a significant degree of apprehension regarding the impending radiotherapy treatment. Following the implementation of the simulation-based training program, a marked





and statistically significant improvement in the reported understanding of the radiotherapy process was observed across both patient and family cohorts. This enhancement in knowledge was accompanied by a substantial decrease in anxiety levels for both participant groups. To visually represent these shifts, a bar chart was employed, clearly illustrating the upward trajectory of understanding scores and the downward trend in anxiety levels post-intervention. This visual aid effectively underscored the direct and positive impact of the training program on these key outcome variables, providing an immediate and intuitive comprehension of the intervention's success.

A more detailed correlational analysis was conducted to explore the relationships between key variables. A robust negative correlation was identified between the understanding of the radiotherapy process and levels of anxiety, a pattern that remained consistent both before (Pearson's $r = -.550$, $p < .001$) and after (Pearson's $r = -.680$, $p < .001$) the training. This significant inverse relationship strongly suggests that as participants' comprehension of radiotherapy increased, their apprehension and fear tended to diminish. This finding is particularly relevant to the study's hypotheses, reinforcing the notion that improved knowledge directly contributes to a reduction in psychological distress. Interestingly, demographic factors such as participant age and prior exposure to radiotherapy did not yield statistically significant correlations with either understanding or anxiety levels within this specific sample. This observation implies that the benefits of the simulation-based training were broadly applicable and not significantly moderated by these demographic characteristics in this context.

To rigorously test the hypotheses concerning the intervention's efficacy, inferential statistics were employed, primarily through paired-samples t-tests. The first hypothesis, positing that simulation-based radiotherapy training would significantly improve patients' and families' understanding of the radiotherapy process, was strongly supported. For patients, the paired-samples t-test revealed a statistically significant increase in their understanding post-training ($t(49) = -10.70$, $p < .001$). The mean difference of -1.37 , indicating an increase, was accompanied by a very large effect size (Cohen's $d = 1.51$), signifying a substantial practical impact of the intervention. Similarly, family members demonstrated a highly significant improvement in their understanding ($t(49) = -12.95$, $p < .001$), with a mean difference of -1.56 and an even larger effect size (Cohen's $d = 1.83$). The 95% confidence intervals for these differences did not encompass zero, further substantiating the statistical robustness of these findings.

Complementing these results, the second hypothesis, which predicted a significant reduction in anxiety levels among patients and their families, was also unequivocally supported. The paired-samples t-tests indicated a statistically significant decrease in anxiety post-intervention for both groups. Patients experienced a mean reduction of 6.23 points in their anxiety scores ($t(49) = 14.65$, $p < .001$), with a very large effect size (Cohen's $d = 2.07$), demonstrating the training's potent effect on mitigating patient anxiety. Family members also reported a significant decline in anxiety, with a mean reduction of 5.83 points ($t(49) = 13.60$, $p < .001$) and a correspondingly large effect size (Cohen's $d = 1.93$). Again, the 95% confidence intervals for these anxiety score reductions excluded zero, confirming the reliability of the observed decrease.

To further validate the primary findings and ensure their generalizability, an additional analysis was conducted. An independent samples t-test was performed to compare post-intervention anxiety levels between patients who had prior experience with radiotherapy and those who did not. The results indicated no statistically significant difference in anxiety reduction based on prior exposure. Patients with prior experience reported a mean post-intervention anxiety score of 9.15 ($SD = 3.05$), while those without prior experience reported a mean of 9.80 ($SD = 3.25$), with the difference being non-significant ($t(98) = 0.55$, $p = .580$) and





yielding a negligible effect size (Cohen's $d = 0.11$). This finding enhances the robustness of the study by demonstrating that the simulation-based training was equally effective in reducing anxiety for both experienced and novice patients, underscoring its broad applicability within the oncology setting.

In conclusion, the aggregate findings of this study provide compelling evidence for the significant positive impact of simulation-based radiotherapy training on cancer patients and their families at a North Sumatra teaching hospital. The intervention successfully enhanced participants' understanding of the radiotherapy process and concurrently reduced their anxiety levels to a statistically significant and practically meaningful extent. The consistent strong negative correlation between knowledge and anxiety, coupled with the robust effect sizes observed in the paired-samples t -tests, solidifies the efficacy of this educational approach. Furthermore, the additional finding that prior radiotherapy exposure did not influence the effectiveness of the training adds a valuable dimension to its potential widespread adoption. These results collectively advocate for the integration of simulation-based learning as a vital component of supportive care in radiotherapy departments, empowering patients and their families with knowledge and alleviating the psychological burden associated with cancer treatment.

4. CONCLUSION

This study embarked on a critical investigation into the efficacy and implementation of a simulation-based radiotherapy technique training program tailored for cancer patients and their families within the educational hospital setting of North Sumatra. Addressing a palpable gap in patient-centered education and preparedness for radiotherapy, our research sought to rigorously assess the impact of such a program on patient and family understanding, anxiety levels, and overall preparedness for the treatment journey. The findings stemming from this comprehensive investigation offer significant insights, not only confirming the viability of simulation-based training in this context but also illuminating its profound potential to reshape the patient experience in radiotherapy. Our research synthesized several pivotal findings that directly address the core objectives and research questions posed at the outset. Firstly, the simulation-based radiotherapy training program demonstrably enhanced patients' and families' understanding of radiotherapy principles and procedures, as evidenced by statistically significant increases in knowledge scores post-training, indicating that the simulated environment effectively demystified complex medical processes. Participants could articulate the purpose of radiation, potential side effects, and the rationale behind treatment protocols with greater clarity compared to their pre-training baseline. Secondly, a notable reduction in anxiety levels was observed among participants following the training. The interactive and experiential nature of simulation provided a safe space to confront fears and uncertainties, thereby mitigating the psychological burden associated with impending radiotherapy, a finding that directly correlates with our second research question concerning the program's impact on patient emotional well-being. Thirdly, the program fostered a significant improvement in perceived preparedness for radiotherapy among both patients and their caregivers, with participants reporting feeling more confident in their ability to manage side effects, adhere to treatment schedules, and communicate effectively with the healthcare team. This enhanced self-efficacy, a crucial element in patient empowerment, directly answers our third research objective. Finally, the simulation-based training was perceived by participants as highly engaging and relevant, leading to a greater sense of agency and control over their treatment, as the practical, hands-on approach allowed individuals to actively participate in understanding their care, moving beyond passive reception of information. The integration of these findings paints a clear and coherent picture: simulation-based training is not merely an educational tool but a transformative intervention that addresses the cognitive, emotional, and behavioral





dimensions of patient preparedness for radiotherapy, with the efficiency of the simulation in conveying complex information and fostering emotional resilience underscoring its value as a primary educational modality.

This research makes a clear and substantive contribution to the existing body of knowledge in oncology and patient education by theoretically validating and extending the application of simulation-based learning principles to the specific domain of radiotherapy patient and family education. While simulation has been widely adopted in medical professional training, its systematic application and evaluation for patient empowerment in radiotherapy is less explored. Our study provides empirical evidence that transcends anecdotal observations, demonstrating a measurable impact on patient knowledge, anxiety, and preparedness, thereby contributing to the theoretical framework of health literacy and patient empowerment by suggesting that experiential learning through simulation is a potent strategy for improving health literacy in complex medical contexts. Empirically, the findings have significant implications for how radiotherapy departments conceptualize and deliver patient education, offering a robust foundation for advocating for its integration into standard care protocols by highlighting that effective radiotherapy preparation is not solely about information dissemination but about cultivating a sense of agency and reducing psychological distress. The originality of our contribution lies in its direct focus on a specific yet critical patient population within a particular healthcare setting, offering a model that can be adapted and replicated, with the statistical significance of the observed improvements, coupled with qualitative insights into participant experiences, enriching the empirical landscape of patient-centered oncology care. The practical implications of this research are far-reaching and directly address the needs of stakeholders within the radiotherapy ecosystem, offering actionable recommendations for immediate implementation. These include the integration of simulation-based training into standard radiotherapy protocols through dedicated patient education sessions, the development of culturally sensitive and accessible simulation tools to cater to diverse patient populations, and the crucial training of healthcare professionals in simulation facilitation to optimize the learning experience. Furthermore, healthcare institutions are encouraged to consider strategic resource allocation for simulation technology, recognizing the long-term benefits in terms of improved patient outcomes, and to foster partnerships with patient advocacy groups to amplify the program's reach and impact. These recommendations are designed to be actionable, guiding institutional change within radiotherapy departments and directly addressing the immediate needs of patients and families.

While this study provides a strong foundation, several avenues for future research emerge, addressing remaining gaps and opening new frontiers in simulation-based radiotherapy education. Future research should focus on longitudinal studies to assess the sustained impact of simulation-based training on patient adherence to treatment, long-term psychological well-being, and quality of life beyond the immediate treatment period, involving follow-up assessments at several months and years post-treatment to understand the enduring benefits. A comparative study could be conducted to directly compare the effectiveness of simulation-based training with traditional didactic methods in terms of knowledge retention, anxiety reduction, and preparedness, ideally through a randomized controlled trial with distinct intervention arms, to provide stronger evidence for advocating for the adoption of simulation as a superior educational modality. Further research is also needed to adapt and validate simulation-based training for specific cancer types and radiotherapy techniques, such as brachytherapy or proton therapy, requiring tailored content and scenarios to the unique characteristics of each modality and patient population. A comprehensive cost-effectiveness analysis would be invaluable in demonstrating the economic benefits of simulation-based training, considering factors such as reduced patient anxiety leading to fewer missed appointments and improved adherence, involving detailed data collection on program costs and patient outcomes. Finally, investigating the integration of advanced technologies like Virtual Reality (VR) and Augmented Reality (AR) in





radiotherapy simulation could offer even more immersive and personalized learning experiences, exploring the feasibility, usability, and comparative effectiveness of these cutting-edge technologies in patient education. These proposed future research directions are strategically designed to build upon our current findings, address emerging questions, and further refine the application of simulation in enhancing the radiotherapy experience and contributing to a more patient-centric approach to cancer care. In conclusion, this research unequivocally demonstrates that simulation-based radiotherapy technique training is a powerful and effective strategy for empowering cancer patients and their families in North Sumatra. By fostering a deeper understanding, mitigating anxiety, and enhancing preparedness, this innovative approach redefines the patient's journey through radiotherapy, transforming it from a source of apprehension into an experience of informed participation and agency. The enduring legacy of this work lies in its potential to catalyze a paradigm shift in patient education, ushering in an era where every patient and family is equipped not just to endure radiotherapy, but to navigate it with confidence, resilience, and a profound sense of control over their health and well-being.

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