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The Effectiveness of Virtual Reality in Enhancing Clinical Skill Training for Nurses: A Comprehensive Review

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8. KSA, Ministry Of Health, Uhud Hospital
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Abstract

Background: The increasing complexity of patient care necessitates heightened clinical competence among nurses. Traditional training methods often fall short of adequately preparing nursing professionals for real-world challenges. Virtual reality (VR) technology has emerged as a promising tool in nursing education, offering immersive simulations that may enhance learning experiences and clinical skills.

Methods: This systematic review analyzed literature from eight databases, including CENTRAL, CINAHL, Embase, MEDLINE, ProQuest, PubMed, Scopus, and Web of Science. The focus was on evaluating the efficacy of VR training in improving cognitive, emotional, and psychomotor outcomes among nursing staff, as categorized by Bloom's taxonomy.

Results: The findings indicated significant improvements across all three domains of Bloom's taxonomy due to VR training. Enhanced cognitive capabilities, emotional competencies, and psychomotor skills were observed, along with increased learner satisfaction. Moderator analysis revealed no significant differences in outcomes based on immersion levels, study design, or intervention context, suggesting consistent effectiveness of VR across various settings.

Conclusion: This review underscores the potential of VR as an effective tool for enhancing the clinical skills of nursing personnel. While the findings highlight the benefits of VR training, there remains a need for further research, particularly randomized controlled trials with larger sample sizes to validate these effects and address methodological limitations. Integrating VR into nursing education could lead to improved patient care quality and satisfaction.

Keywords: virtual reality, nursing education, clinical competence, Bloom's taxonomy, immersive training.

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1. Introduction

Enhancing the competence and professionalism of nurses has emerged as a critical concern in global healthcare systems [1-4]. Nurses, being the professionals with whom patients interact most often, play a crucial role in enhancing the pleasant experiences of those they serve. Evidence indicates that proficient nurses may enhance the quality of treatment for safety, avoidance of physical harm, cultural sensitivity, and patient satisfaction. Ensuring nurses' clinical competence within healthcare systems necessitates more effort [6-11]. In response to this, more training for nursing personnel is essential [9].

Medical education and training have started the integration of digital technology, including the virtual realm [12-16]. The meaning of the virtual world may differ, although its existence and use have become integral to educational technology, which employs instructional digital software known as virtual reality (VR). In this research, the word VR denotes the virtual environment that showcases several simulation technologies in nursing education [16,17].

Nurses possess distinct knowledge and skills that differentiate them from other medical professionals in the realm of nursing care [18-21]. While there has been research on the healthcare workforce overall [21-23], the findings do not specifically pertain to the nursing profession. Research on the use of VR among nurses is limited, with several research focusing on student nurses [16, 22-24]. The results on knowledge, performance, self-efficacy, and communication skills have been exclusively applied to nursing students [23, 25, 26]. Kyaw and colleagues proposed a study to assess virtual reality with outcomes such as attitude, satisfaction, and behavior modification in future research since results in these domains remain scarce [27-30]. Therefore, a systematic evaluation to evaluate the efficacy of VR on professional nurses necessitates urgent consideration. This study is considered the first study undertaken on nursing personnel in clinical service.

In addition to the variations in the research context, prior meta-analyses have only focused on assessing knowledge levels as outcomes [25]. This research will augment prior results by including literature reviews taken from a comprehensive database. This research used Bloom's taxonomy of cognitive, emotional, and psychomotor domains to determine analogous study outcomes. This study intends to examine the impact of VR on cognitive, emotional, and psychomotor results in nursing staff, and to identify the components that influence these outcomes in VR training for nursing personnel.

2. Methods

Data were gathered from eight databases: CENTRAL (Cochrane Library), CINAHL (EBSCOHost), Embase, MEDLINE (OVID), ProQuest, PubMed, Scopus, and Web of Science.

3. Overview of key findings

This study demonstrated that all three dimensions of Bloom’s taxonomy—cognitive, emotional, and psychomotor—were significantly enhanced with the use of VR in nursing workforce training. A markedly elevated score for learning satisfaction was also seen in the VR groups. Our moderator analysis revealed no significant differences in impact sizes for cognitive, emotional, and psychomotor features in nurses, based on the amount of immersion, research design, head tracking use, and intervention context. Ultimately, meta-regression indicated that treatments including total sessions and total time in minutes did not influence cognitive, emotional, or psychomotor results.

4. Evaluation of quality

This VR research serves as a reference with limited evidential quality. Although Egger's test revealed no publishing bias, a significant risk of bias was identified in the reporting of RCT trials. Data about blinding or masking between the intervention and control groups was not accessible. The researchers also failed to elucidate the randomized allocation process in the article. Not all randomized controlled trial procedures are recorded, resulting in insufficient information for assessing the risk of reporting bias. The prospective

registration of clinical studies is crucial due to concerns about publication bias and selective reporting [31]. The publication status of the specified RCTs would elucidate for readers the evaluation of the study report [31]. The I2 result exhibited significant variation across the two outcomes. This may be attributed to the variability in intervention, length, and medium used. This evaluation also includes four quasi-experimental research that may compromise the internal validity of the data aggregation.

5. Virtual reality and cognitive enhancement

Virtual reality training significantly enhanced the cognitive capabilities of the nursing personnel. While they did not analyze the cognitive dimension according to Bloom's taxonomy, prior research has examined the impact of VR on knowledge outputs as a component of the cognitive domain [32]. This outcome aligns with previous reviews and meta-analyses that investigated the effects of VR training, indicating an enhancement in the practical knowledge of registered nurses and nursing students [33]. Moreover, other research concerning nursing students yielded the same findings [25, 34, 35]. The authenticity and immersion of the simulated virtual reality environment enhanced student understanding. Students said that the capacity to alter an avatar's perspective improved their learning efficacy [36]. Conversely, virtual reality demonstrated more effectiveness in nursing compared to traditional or alternative simulation-based educational methods. Virtual patients enhanced students' comprehension of the concepts presented and facilitated the application of their acquired knowledge [37].

The prior work demonstrates that Bloom's taxonomy has established a foundation for learning inside a VR environment [38]. Bloom's taxonomy facilitates the analysis of how virtual reality enhances knowledge acquisition. Bloom's taxonomy has been widely used in educational settings to facilitate student cognition and problem-solving throughout the learning process. Virtual reality offers instructional concepts that promote advanced cognitive processes in Bloom's taxonomy, including creative and critical thinking, problem-solving, and multiple intelligences [38, 39]. It is also closely associated with technological integration [38]. Bloom's theory posits that the attainment of cognitive knowledge occurs via three processes: comprehension, application, and analysis [40]. In VR simulations, participants learn to address the issue in the most effective manner possible and evaluate if their knowledge is sufficient to provide this clinical treatment [41]. Virtual reality programs may be crucial for augmenting educational content as an adjunct to traditional training.

6. Virtual reality and emotional enhancement

Pooled data demonstrated the efficacy of VR in enhancing the emotive dimension of nursing, in contrast to conventional techniques. This outcome aligns with a comprehensive evaluation of the effects of VR intervention on the emotional competencies of nursing students and registered nurses in comparison to other training methods [42]. Virtual reality can cultivate empathy and assist nurses in seeing circumstances from the patients' viewpoint within an emotional context [43]. Ouzouni and Nakakis [42] determined that a nurse's empathy is a dual-faceted concept including both emotional and cognitive responses. Consequently, the utilization of VR in education may enhance nurses' capacity to recognize others' emotions, understand their implications, and react suitably. An advantage of virtual reality in affecting human emotions is its ability to recreate intricate real-world scenarios [43].

Bloom's taxonomy indicates that in the emotional domain, the behaviors of receiving and responding should be used throughout the pre-simulation, pre-briefing, briefing, and participation stages [44]. Prior studies identified shortcomings in cultivating nursing students' emotional competencies related to trust, decision-making, and patient care. The clinical simulation method was designed and facilitated using Bloom's taxonomy for competency development. The simulation associated with Bloom’s taxonomy may surpass the acquisition of cognitive and psychomotor domains, fostering alignment between knowledge and the emotional and psychomotor dimensions in nursing students [45]. The emotional domain is developed in the first stages of clinical simulation, when an individual's motivation and want to learn are recognized and intensified during debriefing, including all behaviors outlined in Bloom’s taxonomy throughout the reflective process. This underscores the need for debriefing for the enhancement of clinical nursing competence [40].

7. Enhancement of psychomotor skills using virtual reality

This study demonstrated that virtual reality intervention may enhance the psychomotor domain in nurses, despite the included publications including a diverse array of individuals and psychomotor abilities. These results corroborate the findings of other research [46,47]. Conversely, a meta-analysis including nursing student participants indicated that virtual reality was not more successful than conventional techniques in enhancing nursing abilities [23]. This conclusion aligns with prior evaluations indicating that VR has not been shown to affect skill development in nursing students and registered nurses [16]. It might be said that the findings of some recent investigations are contradictory. This may be attributed to several participant characteristics, including years of experience and educational attainment. These characteristics significantly influence the clinical competencies of nurses.

In Bloom's taxonomy, the psychomotor domain is situated in the second phase of clinical simulation, which is preceded by the cognitive and emotional domains in the first phase [47]. The execution of psychomotor skills is influenced by nurses' prior knowledge and motivation, which are derived via experiential environmental exposure. Our analysis of the research indicated that VR substantially enhanced nurses' cognitive and emotional dimensions. This research ensures the initiation of psychomotor enhancement in nursing personnel via emotional and cognitive dimensions. The function of virtual reality is crucial for assisting nurses in approaching the authentic world [48,49]. Consequently, VR is expected to provide advantageous effects in enhancing clinical competencies.

8. Virtual Reality and Educational Satisfaction

This study determined that virtual reality might significantly enhance nursing staff's learning satisfaction relative to other training methods. About the three domains of Bloom’s taxonomy, the quantity of research addressing learner satisfaction was rather limited. Nevertheless, the four research included were strikingly similar. This conclusion is contradicted by Chen and Leng [35], who observed no significant increase in learning satisfaction among nursing and other health profession students. It is crucial to evaluate the uniformity of immersion levels among investigations since this is likely to affect the outcomes.

Researchers have shown significant positive correlations between student motivation and academic achievement [50,51]. Moro and Štromberga [52] observed that one-third of participants perceived the VR methods as unsettling and irritating, based on anatomical configuration. Utilizing virtual reality may induce cybersickness, characterized by nausea, vertigo, and cephalalgia. Consequently, further study need to focus on the adverse effects of VR, including visual impairment and disorientation [53].

9. Analysis by the moderator

The statistical examination of moderator analysis concerning the subgroups of categorical and continuous variables in the meta-analysis and meta-regression indicated no significant difference in the efficacy of VR across varying levels of attenuation (high, moderate, or low), the presence or absence of head tracking, study design (RCT or quasi-experimental), intervention context (emergency or non-emergency), total number of intervention sessions, and total duration in minutes. The moderator analysis yielded identical findings for the cognitive, emotional, and psychomotor domains. This conclusion aligns with a prior meta-analysis, which indicated that content variables, immersion degree, session duration, and session frequency did not influence knowledge outcome scores [25]. Nonetheless, it cannot be determined that covariate factors had no impact on the efficacy of VR, given the research used in this meta-analysis mostly involved small sample sizes, and the majority of studies were evaluated as having a high risk of bias. Woon thinks that a low to medium degree of immersion is more conducive to creating an effective learning environment than a high degree of immersion [25]. Additional investigation is required to ascertain the impact of VR on immersion levels, interaction, VR equipment, and the context of interventions.

10. Advantages and drawbacks

To the authors' knowledge, this research is the first assessment of VR efficacy among nursing staff populations. No publication bias was detected among the 12 studies. This study presents three results of

VR intervention, informed by Bloom's taxonomy. The cognitive, emotional, and psychomotor domains are considered the educational framework for cultivating nursing competence in clinical environments [48]. Furthermore, this study performed a sensitivity analysis demonstrating the robustness of the findings. Nonetheless, the risk of bias was elevated in the majority of the included studies. The heterogeneity between the two outcomes was deemed significant. This evaluation also includes the quasi-experimental technique due to the scarcity of papers concentrating on nursing personnel. Other limitations included the omission of relevant engineering fields owing to the absence of conference proceedings from this research. Additionally, the majority of the evaluated studies were based on small sample sizes. Consequently, the examination of research bias must be approached with meticulous consideration.

11. Influence on clinical practice education

This study enhanced the potential for integrating VR into nursing education and augmenting nursing proficiency. There is substantial confidence in the efficacy of VR in enhancing the cognitive, emotional, and psychomotor aspects of nurses' expertise, perhaps resulting in enhanced patient safety and heightened patient satisfaction. Nonetheless, the use of VR is often seen as costly and resource-intensive. Research indicates that virtual reality is more cost-effective than conventional simulation methods [54]. Consequently, money should not be a primary consideration for hospital administration. Nonetheless, technical difficulties may provide a difficulty for nursing departments. Users must possess a full understanding of VR to use the device effectively. Furthermore, consistent updates and maintenance of the programs are essential to prevent malfunctions [55]. Therefore, the establishment of a specialized team to manage such technology is necessary.

12. Conclusions and Recommendations

This research demonstrates that virtual reality is an excellent option for enhancing nurses' cognitive, emotional, and psychomotor skills, as well as their learning pleasure. This research identified no significant impact size among dependent factors, such as the degree of immersion, which did not enhance results across all four measures. The potential for heterogeneity and the danger of bias in research must not be overlooked. Consequently, the evidence quality from this review was deemed poor. Additional randomized controlled trials (RCTs) with bigger sample sizes and rigorous methodologies according to the Consolidated Standards of Reporting Trials (CONSORT) criteria are necessary to provide a clear examination of cause-and-effect linkages with internal and external validity [56]. An assessment of cost-effectiveness and technical viability is required to ensure the usability of VR in resource-limited environments. Subsequent research should examine the influence of VR technology on nurses' clinical efficacy in practical work environments.

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فعالية الواقع الافتراضي في تحسين تدريب المهارات السريرية للممرضين: مراجعة شاملة

الملخص

الخلفية :تزداد تعقيدات الرعاية الصحية مع الوقت، مما يستلزم تطوير المهارات السريرية لدى الممرضين. غالبًا ما تعجز الأساليب التدريبية التقليدية عن إعداد الممرضين بشكل كافٍ للتحديات الواقعية. ظهرت تقنية الواقع الافتراضي (VR) كأداة واعدة في تعليم التمريض، حيث توفر محاكاة غامرة قد تعزز من خبرات التعلم وتنمية المهارات السريرية.

الطرق :تمت مراجعة منهجية شاملة للأدبيات من ثمانية قواعد بيانات، بما في ذلكCENTRAL ، وCINAHL، وEmbase، وMEDLINE، وProQuest، وPubMed، وScopus، و .Web of Scienceركزت المراجعة على تقييم فعالية التدريب باستخدام الواقع الافتراضي في تحسين النتائج المعرفية، والعاطفية، والنفس-حركية بين طاقم التمريض، وفق تصنيف بلوم.

النتائج :أشارت النتائج إلى تحسينات كبيرة عبر المجالات الثلاثة لتصنيف بلوم نتيجة التدريب باستخدام الواقع الافتراضي. لوحظت تحسينات في القدرات المعرفية، والكفاءات العاطفية، والمهارات النفس-حركية، بالإضافة إلى زيادة رضا المتعلمين. أظهرت تحليلات المتغيرات الوسيطة عدم وجود فروق كبيرة في النتائج بناءً على مستويات الانغماس، أو تصميم الدراسات، أو سياق التدخل، مما يشير إلى فعالية ثابتة للواقع الافتراضي عبر مختلف البيئات.

الخلاصة :تؤكد هذه المراجعة على إمكانات الواقع الافتراضي كأداة فعالة لتحسين المهارات السريرية للعاملين في التمريض. وبينما تسلط النتائج الضوء على فوائد التدريب باستخدام الواقع الافتراضي، هناك حاجة إلى مزيد من البحث، لا سيما الدراسات العشوائية ذات العينات الأكبر لتأكيد هذه التأثيرات ومعالجة القيود المنهجية. قد يؤدي دمج الواقع الافتراضي في تعليم التمريض إلى تحسين جودة الرعاية الصحية ورضا المرضى.

الكلمات المفتاحية :الواقع الافتراضي، تعليم التمريض، الكفاءة السريرية، تصنيف بلوم، التدريب الغامر.