Integrating Virtual Reality into Medical Education: Teaching Dermatological Aspects of HIV Through Immersive Simulation

Nicole Aust[1,], Allison Meihofer[2], Brooke Blan[3], Rachel Amsellem[4], Bijoy Shah[5], Liana Ly[6], Ashley Brudzinski[7], Luca Walborn[8]*

[1,4,8]Nova Southeastern University Dr. Kiran C. Patel College of Osteopathic Medicine, Tampa, FL, USA

[2]Nova Southeastern University Dr. Kiran C. Patel College of Osteopathic Medicine, Davie, FL, USA

[3,7]Midwestern University Arizona College of Osteopathic Medicine, Glendale, AZ, USA

[5]Albert Einstein College of Medicine, Bronx, NY, USA

[6]Touro University California College of Osteopathic Medicine, Vallejo, CA, USA

[*]Corresponding author:

Nicole Aust, MS, BS
Nova Southeastern University, Dr. Kiran C. Patel College of Osteopathic Medicine, Tampa, FL, USA,
Phone: 571-344-9310,
Email: na1102@mynsu.nova.edu

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ABSTRACT

Virtual reality (VR) is an immersive technology that allows users to engage in three-dimensional environments in real-time. This technology is rapidly gaining traction for its educational applications in the healthcare sector, especially through diagnosing dermatological manifestations particularly in HIV-positive patients. This paper aims to present a literature review highlighting how VR can be integrated into dermatological diagnoses and aid in prognostic outcomes specifically in HIV-positive patients. Detection of dermatological conditions in HIV can provide a good indication of disease progression, however, that can be difficult due to varying clinical presentations and similarity to those of other diseases. Early detection and differentiation of these lesions can lead to improved outcomes in patients suffering from this disease. VR technology can bridge this gap by providing an engaging learning platform for students - allowing for low-risk assessments of clinical cases and creating 3D visualizations of skin lesions that were previously limited to textbook pages. VR learning can enhance the education of healthcare professionals by providing a 3D experience that is standardized and reproducible where complex conditions can be explored. This development in education will lead to more accurate diagnoses and improved outcomes in patients. Overall, this literature review highlights how VR can resolve inconsistencies in medical education and can also provide more clinical exposure for students in low-income areas. Through continued development and integration of this technology in the healthcare field, students will be met with an elevated learning experience integrating improved spatial knowledge and refinement of clinical skills.

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This will then translate to enhanced quality of care for patients in the future.

Keywords: Virtual Reality, Kaposi Sarcoma, Skin Cancer, HIV Management, Dermatology

INTRODUCTION

Virtual reality (VR) is a technology that allows users to interact with computer-generated, three-dimensional environments in real time, creating a sense of immersion through various tools such as head-mounted displays or projector-based VR rooms. This immersive experience enables users to engage with virtual objects or perform actions within a simulated environment, making it particularly effective for hands-on learning in healthcare education. Because of its utility, VR is rapidly transforming how healthcare professionals learn today by providing an immersive environment to practice and refine clinical skills. By simulating realistic scenarios, VR offers a safe and controlled space for learners to gain hands-on experience, enhancing both knowledge acquisition and clinical competence. Research on this technology has consistently shown that VR-based education improves knowledge retention and skill performance among medical students and professionals [1].

This technology is particularly useful in the context of dermatological education for HIV management, given the high prevalence of skin conditions in people living with HIV. These manifestations can serve as early indicators of HIV infection and often reflect disease progression. Dermatologic presentations in HIV range from AIDS-specific eruptions, such as xerosis, pruritic papular eruptions, eosinophilic folliculitis, and acne, to opportunistic infections like herpes simplex, molluscum contagiosum, cutaneous leishmaniasis, bacillary angiomatosis, disseminated histoplasmosis, disseminated cryptococcosis, and zoster. HIV-associated skin conditions also include AIDS-related malignancies, such as Kaposi's sarcoma, lymphoma, and nonmelanoma skin cancers, as well as antiretroviral therapy (ART)-associated drug eruptions. Unfortunately, traditional teaching methods often rely on static images and lectures, which may not adequately prepare learners to recognize and manage these complex dermatologic conditions in clinical practice. Early and accurate identification of these manifestations is critical for timely intervention and better patient outcomes [2].

Given the potential of VR to enhance clinical education, this literature review aims to explore its role in advancing dermatological education for HIV-associated skin conditions. By reviewing current research, we will identify the strengths and limitations of VR-based learning and training in this context and highlight any gaps in the existing literature that require further exploration.

Dermatological Manifestations of HIV

HIV-associated dermatological conditions are diverse and often serve as early indicators of disease progression. Among the most prevalent cutaneous manifestations are opportunistic infections, inflammatory conditions, and neoplastic disorders, each presenting with unique diagnostic and management challenges. Understanding the interplay between these conditions is essential, as their presentation is influenced by the degree of immunosuppression, regional epidemiology, and patient demographics. For instance, while opportunistic infections are frequently observed in patients with advanced immunosuppression, the specific conditions that predominate may vary based on geographical and population-specific factors. In a study of 100 HIV-positive patients in India, Chandrasekaran and Pachamuthu demonstrated that candidiasis was the most common oral lesion and dermatophytosis was the most common fungal disease [3]. Opportunistic infections such as cryptococcosis, histoplasmosis, bacillary angiomatosis, and herpes simplex occur due to HIV-induced immunosuppression, with their severity correlating with decreased CD4 counts [2]. In addition to these infections, HIV is also associated with a range of inflammatory skin conditions. Notably, seborrheic dermatitis, pruritic papular eruptions, eosinophilic folliculitis, and psoriasis usually present more severely and are often refractory to conventional treatments, necessitating specialized therapeutic strategies [4]. Beyond opportunistic infections and inflammatory disorders, HIV patients also face an increased risk of neoplastic conditions, including Kaposi sarcoma (KS) and non-melanoma skin cancers (NMSC), which further complicate disease management [5]. Asgari MM, et al. reported that HIV-infected individuals with a history of NMSC had a 15% increased risk of developing another NMSC compared to uninfected individuals. In HIV patients with lower CD4 counts and higher viral loads, the risk for squamous cell carcinoma (SCC) was significantly higher [6]. The study highlights a strong association between immune dysfunction and SCC risk, suggesting that HIV-infected individuals, especially those with severe immunosuppression, may

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benefit from targeted skin cancer screening and monitoring. The presence of various opportunistic, inflammatory, and neoplastic conditions not only signifies immune deterioration but also complicates therapeutic decisions, as coinfections can obscure primary diagnoses.

The diagnostic challenges associated with dermatological conditions in HIV-positive individuals stem from overlapping clinical presentations and the need for meticulous visual recognition skills. HIV patients often present with atypical manifestations of common diseases, increasing the risk of misdiagnosis. For example, dermatophytosis in HIV individuals can mimic Kaposi sarcoma or present as highly inflammatory bullous lesions, making identification challenging [7]. Furthermore, the difficulty in distinguishing fungal infections from other opportunistic diseases can lead to delays in appropriate antifungal treatment or unnecessary therapies, increasing the risk of disease progression and systemic involvement. The differential diagnosis is further complicated by the broad spectrum of opportunistic infections and immune-related skin conditions, requiring thorough clinical evaluation, laboratory tests (KOH prep, fungal cultures, biopsies), and histopathological confirmation to ensure accurate diagnosis and timely treatment. Misdiagnosis or delayed diagnosis can have severe consequences, including prolonged morbidity, increased mortality, and complications like immune reconstitution inflammatory syndrome (IRIS) following antiretroviral therapy initiation [8]. Additionally, differentiating HIV-related dermatoses from those arising independently of immunosuppression requires a comprehensive understanding of cutaneous disease evolution in immunocompromised states [9]. Certain conditions, such as seborrheic dermatitis, psoriasis, and drug-induced eruptions, occur in both immunocompetent and immunocompromised individuals. However, their presentation, severity, and response to treatment may vary significantly in HIV patients. For instance, psoriasis in an HIV-positive individual may exhibit an explosive, treatment-resistant course resembling erythroderma, making it difficult to distinguish from cutaneous T-cell lymphoma or a severe drug reaction [10]. This underscores the importance of integrating pattern recognition training and differential diagnostic strategies into medical education, as reliance on textbook descriptions alone may be insufficient.

Current dermatological education methods for HIV-related skin conditions predominantly utilize textbook images, case studies, and clinical exposure to live patients. However, these traditional approaches present limitations. Textbooks and static images, while foundational, fail to capture the dynamic progression of diseases and often lack sufficient visual depth for dermatological education. Case studies provide contextual understanding but are limited by the scope of cases available. Live patient interactions depend on clinical exposure, which varies significantly based on geographic location and healthcare settings. McMahon et al. highlight the challenges of diagnosing Kaposi sarcoma (KS) in sub-Saharan Africa and the various reasons for diagnostic delays [11]. The lack of KS awareness among both patients and providers hinders diagnosis. In addition, incorrect diagnoses, referral delays, and lack of biopsy facilities complicate detection. These challenges underscore the need for more comprehensive training approaches to address knowledge gaps and improve early diagnosis and management of KS. Continuous clinical exposure is essential to ensure consistent training and preparedness in diagnosing and managing the variability of HIV presentation. The variation in clinical exposure due to geographic location and healthcare setting affects learners' ability to recognize cutaneous manifestations, often the first sign of HIV infection [12]. Furthermore, Mangion et al. demonstrate a significant lack of uniformity in dermatology education across medical schools [13]. Teaching methods rely on outdated, limited content and lack focus on real-world application. There is insufficient clinical exposure and an overall reduction in teaching time, leading to a gap between theoretical knowledge and practical clinician skills. Hussain et al. discovered that 20% of junior or resident doctors felt confident in describing a rash, and a mere 8% were comfortable initiating basic therapy for skin complaints [14]. Additionally, 33% of doctors had never taken a skin swab, and 90% had never performed a skin scraping, highlighting a clear gap in hands-on dermatological training [14]. These limitations in traditional learning methods highlight the need for innovative educational tools such as virtual reality (VR), which offers an immersive and interactive platform that enhances comprehension, allows repeated exposure to rare conditions, and improves diagnostic accuracy in dermatology education.

Emerging Role of Virtual Reality in Medical Education

Virtual reality (VR) is reshaping medical education by shifting traditional lecture-based instruction toward immersive, experiential learning [15]. This evolution from passive to active engagement has boosted student motivation and improved

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educational outcomes. Early use of VR centered on surgical simulations and anatomical visualization, enabling learners to explore three-dimensional complex structures [16]. These capabilities support spatial reasoning and help students grasp intricate anatomical relationships that are often difficult to understand through textbooks alone. Recent advances in haptic feedback and artificial intelligence have made these simulations increasingly lifelike, enhancing the learning experience through responsive, real-time interaction [17]. In this controlled environment, students can engage in repeated practice without patient risk, an essential component in developing confidence and procedural skills.

Furthermore, VR-based anatomy education has improved spatial understanding and long-term retention compared to conventional methods [18]. These outcomes emphasize VR's value as a core educational modality, particularly in foundational subjects. Over time, VR's applications have expanded to include emergency response scenarios, procedural skill development, and patient communication exercises, broadening its impact across medical curricula [15]. This versatility allows students to build technical proficiency, critical thinking, and interpersonal skills. Looking ahead, the convergence of VR with augmented reality (AR) and artificial intelligence (AI) is poised to create adaptive learning environments tailored to individual needs, promoting more personalized and competency-based education [19]. This trajectory reflects the growing potential of immersive technologies to meet the evolving demands of modern medical training.

The earliest applications of VR in medical education centered on surgical and anatomical training, driven by these disciplines' high visual and procedural demands [16]. These initial use cases highlight VR's unique capacity to simulate spatially intricate tasks, making it particularly valuable in specialties where visual acuity and procedural accuracy are paramount. Surgical trainees, for instance, can use VR simulators to practice techniques in a risk-free environment, which has been shown to bolster both confidence and clinical competency prior to operating on actual patients [20]. This hands-on repetition without patient harm accelerates skill acquisition and shortens the learning curve for beginners. As VR continues to advance, it supports self-directed exploration of anatomical structures and allows learners to revisit content multiple times, reinforcing understanding and retention. Collectively, these innovations bridge theoretical learning with hands-on practice, preparing students more comprehensively for clinical responsibilities.

Building on its success in procedural fields, VR has gained traction in dermatology and infectious disease specialties, where diagnostic accuracy and public health readiness are paramount. In dermatology, VR can present various clinical cases for learners to assess, offering a consistent and low-risk environment for practicing diagnostic reasoning. While not a replacement for direct clinical exposure, these simulations can help address gaps in clinical availability by ensuring all students engage with a wide range of cases. Similarly, VR has proven effective in infectious disease education, particularly for outbreak preparedness and infection control [21]. By simulating high-stakes public health scenarios, VR provides a dynamic space for learners to practice critical decision-making under pressure. These simulations challenge learners to apply protocols and respond to evolving conditions in real-time, reinforcing both technical knowledge and situational awareness [22]. Such immersive experiences are essential in preparing future clinicians for evolving global health threats. The expanding use of VR across these fields highlights its versatility as a technical training tool and a platform for cultivating clinical reasoning, systems thinking, and crisis preparedness.

Beyond content delivery, VR offers structural advantages that enhance the learning process. VR's immersive, interactive nature promotes experiential learning by allowing students to practice cognitive and motor skills within realistic clinical scenarios [23]. Unlike passive instructional methods, VR fosters active participation, which has been shown to accelerate skill development and improve information recall. In comparative studies, VR-trained students have consistently outperformed peers on objective structured clinical examinations (OSCEs), demonstrating stronger procedural accuracy and decision-making skills [24]. This reinforces VR's potential to strengthen patient safety by allowing trainees to achieve readiness before entering clinical environments. Additionally, VR supports personalized learning by allowing users to revisit content at their own pace and tailor experiences to individual learning needs [25]. This flexibility is especially beneficial in mastering complex tasks that require repetition. Ethical considerations also favor VR: Learners can practice skills without risking patient harm, creating a safer, more forgiving space to develop competence [26]. Looking ahead, integrating AI-driven adaptive learning may allow simulations to adjust dynamically

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based on user performance, offering an even more targeted and efficient approach to training.

Another key advantage of VR is its ability to provide a repeatable, standardized learning environment. Unlike traditional methods that rely on limited patient interactions or cadaveric resources, VR enables unlimited practice without logistical barriers [27]. This is particularly impactful in specialties requiring frequent repetition, such as emergency medicine and critical care, where real-life exposure may be unpredictable. Moreover, VR helps level the playing field across institutions by offering uniform training modules, which can mitigate disparities in access to high-quality clinical experiences [28]. Standardization through VR ensures that all students receive consistent educational opportunities regardless of geography or resources. These platforms also promote interprofessional collaboration by enabling learners from different disciplines to engage in shared scenarios emphasizing teamwork, communication, and role clarity [28]. Exposure to rare or complex clinical presentations within a controlled virtual setting further strengthens preparedness, allowing trainees to approach unfamiliar scenarios confidently. In this way, VR not only reinforces procedural knowledge but also builds essential skills for effective collaboration and crisis response.

Despite these advantages, widespread integration of VR into medical education still faces notable challenges. High hardware, software, and infrastructure costs remain a barrier, particularly for resource-constrained institutions [29]. These financial demands can perpetuate educational inequities by limiting access to immersive tools in underserved settings. Additionally, the rapid evolution of VR platforms requires regular updates, technical support, and ongoing investment. From a usability standpoint, issues such as motion sickness, system latency, and insufficient haptic feedback can detract from the realism and immersive quality of simulations [29]. These factors affect user comfort and may reduce learner engagement and compromise training efficacy. Successful implementation further depends on faculty development and curricular redesign, which may face resistance from educators less familiar with digital instruction [30]. Without proper support and training, the full educational potential of VR may not be realized. Moving forward, efforts to reduce costs, improve user experience, and provide structured faculty development will be critical in ensuring VR becomes a sustainable and accessible tool across diverse training environments.

Integration of VR in Dermatology Education

Advancements in technology have played a crucial role in the evolution of medical training and patient care. The integration of virtual reality (VR) into the healthcare setting has aided in addressing current deficits, such as the limited capacity to educate and train medical professionals at medical schools, residency programs, or out in practice and the lack of real-life exposure to less common conditions. Providing the ability to simulate a digital representation of any imaginable three-dimensional (3D) artificial environment that generates user feedback, VR offers a unique approach to dermatologic training. The initial concept of VR was proposed to the entertainment industry as early as the mid-to-late 1900s [31]. Despite the delayed introduction of VR into the medical community after its development, it has continued to gain traction in various aspects of medicine, including dermatology, to the present day. Current applications of VR in healthcare include VR in nursing, VR in dentistry, VR in medicine, human simulation software, VR diagnostics, virtual robotic surgery/surgery simulation, and the use of VR in the care plan for numerous conditions: phobias, autism, PTSD, disability, etc. [32]. With such tremendous progress over a relatively short timeline, the limitations of the role of VR in medical education and training appear to be minimal.

Despite evidence supporting VR-based dermatologic training and a successful surge of VR implementation into various medical specialties, Gençoğlu et al. outlines an assessment of dermatologic education, diagnostics, and surgery through an extensive database review of recent literature that yielded results outlining a significant discrepancy between the current limited status of VR and its proposed benefits [33]. Existing VR modules for skin disease recognition and diagnosis currently exist in forms such as games and apps. “Virtual Derm” is one example of a dermatological VR app that promotes virtual practice to students throughout medical training and education; however, it is limited to an intended audience of students and to 100 patient vignettes available to be solved [33]. As the skin is the largest organ, the opportunities to create vignettes for the abundance of skin conditions and their variants, the multitude of presentations of each unique condition, and the comprehensive ways they may appear on different bodies and skin types are endless. Vignettes could be catered to a broader target audience and in a manner that engages intrinsic motivation factors, such as the use of VR as

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a dermatological education tool in the form of a game that ties in preventative skin care messages to youth and young adults in Australia [33]. In addition to VR, there has been an outpouring of interest and research geared toward AI-powered simulations for diagnosing skin conditions. To illustrate this, a single database search of "AI-powered simulations for diagnosing skin conditions" yielded 5,290 results published to Google Scholar since 2021, 3,430 of those results published since 2024, and 1,030 published within the past 4 months. The coalescence of AI as a tool in dermatology has shown impressive potential in improving the early detection of skin diseases. A revolutionary method of dermatologic training and clinical practice adopts the use of both VR and AI.

Traditional methods of dermatologic training include exposure to 2D images throughout literature resources and skin conditions evaluated and treated in the clinic throughout training. The expectation that every health care professional will be proficient in diagnosis and treatment within the extensive scope of dermatology is unrealistic, as many variables affect the skin conditions one may physically see: clinic geographical location, patient population, patient load, time of year, number of training sites, etc. Although up-to-date literature containing 2D photos may be accessible, there are imperfections within the strategy of relying on supplemental learning. VR offers a solution to the heterogeneous experiences in education and training. Compared to traditional training methods in dermatology, VR-based training has demonstrated tremendous promise in efficacy. A study conducted by Garg et al. outlines the advantages that physical 3D learning has over traditional learning in enhancing and retaining dermatologic knowledge and diagnostic and management skills [34]. Constituent with true VR studies, favorable feedback was received from the students who participated in the 3D learning method, reported as "enjoyable, effective, authentic, and advantageous over 2D learning" [34]. The results were determined by comparing the variance between mean scores earned by the 2D and 3D learner groups over three periods: baseline, immediately after completion of an assessment, and three months status-post assessment. Educational outcomes were measured as the primary endpoints between groups, including overall performance, morphology, lesion and rash recognition, and lesion and rash management. This study yielded clinically and statistically significant results, with statistical significance appreciated by a P value < 0.05 in a variation of overall performance immediately post-assessment, lesion recognition post-assessment, three months post-assessment, and rash management immediately post-assessment. It is well established that there are multiple learning styles - VR learning encompasses a design that may cater to more than one learning style attributable to its interactive nature, increasing appeal, interest, and perhaps motivation as opposed to traditional 2D learning.

Additionally, VR allows for the construction of an inexhaustible assortment of clinically significant topics, including unique case studies in the form of realistic 3D patient scenarios. This opportunity to engage in hands-on learning through virtual consultation is advantageous in the way that it increases experience and exposure while allowing room for error, decreasing potential risk and harm to actual patients. VR has proven to provide a myriad of advantages, demanding its assimilation into dermatology as its applications are comprehensively suitable across the entire scope.

Potential of VR in Teaching HIV-Related Dermatology

One challenge of dermatology education is maintaining visual memory without constant, repeated exposure. Virtual reality-based learning has serious potential to improve dermatology knowledge retention and strengthen diagnostic skills through practices of immersive visualization and interactive learning techniques. Dermatology requires students to translate 2D images into 3D concepts on various skin tones, which is a known cognitive challenge for students who have difficulty with visual and imaginative transformation [35]. VR modules can aid students who have difficulty picturing a realistic 3D view of various dermatologic manifestations. In addition, while VR has no palpation capabilities when evaluating various raised lesions, VR does allow students to examine the 3D depth and examine lesions from multiple angles [36]. This provides the unique experience of mimicking a realistic physical exam in the clinical setting. Through immersive learning, VR-based modules can be very advantageous for dermatological education and ultimately improve future HIV identification.

Virtual reality modules for dermatologic training have proven to positively impact objective learning outcomes and overall student engagement in educational practices. Ryan et al. systematically reviewed the learning outcomes of immersive technologies in healthcare student education. They reported that VR is equally effective in teaching and increases learner satisfaction, self-confidence, and engagement [35]. It is reasonable to assume that since learners are more interested

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and eager to learn with VR modules, their knowledge will only improve with continued use. Another study reported that following VR scenarios, students considered their time invested to be well spent, had fun while doing it, and rated the experience as suitable and valuable for the future [37]. Students are able to learn by active engagement versus passively receiving information and hoping it will be retained. Individuals who were forced to utilize VR modules during the COVID-19 pandemic highly recommend this training modality as a supplement to traditional educational methods, even in the absence of any potential obstacle to traditional training [38]. This further proves that students find VR training beneficial to their education. Overall, increased student engagement can only lead to more positive outcomes in knowledge retention with learners' eagerness to participate in repeat VR scenarios.

One significant advantage of virtual reality-based learning is expanding access to dermatological manifestations. VR scenarios guarantee the same learning conditions for all students, regardless of patient availability, patient population, or practice location [37]. Eventually, VR scenarios will allow students interested in dermatology to gain early exposure to the learning environment and educational experiences that are typically delayed until clinical clerkships and residency. Rare and sometimes severe conditions, including HIV, are more prevalent in some geographic regions. Suppose the location where a student conducts their training does not treat a lot of HIV patients. In that case, the learner's education will be limited, potentially resulting in poor future diagnostic accuracy. As the technology continues to develop, there is potential for the modules to incorporate synthetic clinical images, reduce data scarcity, and poor training for rare dermatological conditions and underrepresented Fitzpatrick skin types such as the HIV population [39]. Most dermatologic conditions of HIV are not easy to identify, and students do not gain adequate exposure during training. Therefore, they may be unable to confidently identify the manifestations once they are in clinical practice and may delay the diagnosis and treatment of the disease.

A virtual patient encounter with visualization of dermatologic conditions allows trainees to interact with the lesions without any clinical limitations, such as time constraints and privacy invasion [40] Students must be cognizant of the sensitivities that may come with certain dermatologic conditions. Patient encounters can be uncomfortable or even pose a risk in the setting of severely immunocompromised patients [37]. This can limit the amount of time spent in patient rooms examining their skin. VR-based learning allows all students to receive adequate, comprehensive training and improve diagnostic accuracy regardless of patient population or clinical limitations by providing opportunities for consistent exposure to a diverse range of dermatologic conditions in a risk-free and low-stakes environment. The ability to follow up the simulation with continued practice will ultimately lead to a continuous increase in knowledge over time. In addition, the engaged and repetitive exposure to various dermatological conditions will only add to the confidence of students, which can improve their educational experience once they are faced with actual patients in the clinical setting.

Challenges and Future Directions of VR in Dermatology and HIV Management

While the future of VR in dermatological training remains promising, there are still many significant barriers to further incorporation. Financial challenges associated with implementing and maintaining VR technologies pose a potential block to widespread adaptation, particularly at resource-limited institutions. High costs are attributed to the need for advanced software development, hardware requirements, and specialized training [29,41,42]. Further analysis and discovery of low-cost strategies are vital, and additional research is required to determine the long-term costs of VR when compared to alternative educational methods. Regulatory and ethical concerns are additional major obstacles to VR adoption, as patient-specific models may be involved in specialized training [41,43]. Guidelines protecting patient information must be clearly outlined. Ethical concerns may contribute towards resistance to incorporation among educators and institutions. Furthermore, users unfamiliar with new technologies may be increasingly reluctant to engage in VR simulations [29]. Hesitancy towards new technology should be addressed through user-friendly applications and teaching modules. Financial barriers, ethical regulations, and technological resistance must be overcome to effectively integrate VR into dermatology education, particularly in underserved and resource-limited areas.

Technological advances within dermatology will leverage AI, AR, and VR to revolutionize both medical training and patient care. Specialized VR programming will allow trainees to encounter situations difficult to reproduce with live training, allowing standardization of learning objectives for all students [37]. The potential for VR and AR within dermatology extends beyond medical education, as dermatologists may implement new technologies to monitor skin lesions, perform

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measurements, plan and assist in procedures, and promote patient education [44]. Portillo et al. have discussed the utility of virtual avatars in the promotion of sexual health education and HIV prevention [45]; these technological advances hold the potential to inform and educate communities at risk for communicable diseases. As innovations surface, VR and AR are key to improving clinical education and dermatologic care.

CONCLUSION

Virtual reality (VR) is a relatively new technology that has been emerging for video games and, more recently, has been thought to be a valuable tool in the field of medicine. The realistic scenarios help to create a safe environment for the practice of clinical skills- particularly for identifying dermatological skin conditions found in complex diseases such as HIV. While the early detection of HIV is necessary for better patient outcomes, diagnosis proves to be challenging due to the atypical presentation of symptoms. For example, Belmokhtar Z, et al. mentioned that dermatophytosis in HIV-affected patients can often be misdiagnosed as Kaposi sarcoma. VR has proven to be a valuable asset to hone in on important skills needed for a timely intervention of HIV. By providing a controlled, interactive environment, VR enhances the accuracy and confidence of healthcare professionals in diagnosing complex conditions, ultimately contributing to improved patient care and outcomes.

In recent times, VR has been able to improve the medical curriculum for future physicians. Virtual reality enhances medical students' spatial awareness, particularly for surgeons, where three-dimensional visualization of the human body is crucial for successful procedures [16]. This new form of learning has provided a risk-free way for students to have repeated practice. This reinforcement of the curriculum helps to build confidence and leads to fewer errors in diagnosis. In the dermatology specialty, VR could help bridge the gap in clinical exposure for students in low-income areas [12]. Additionally, this training would help prepare students for different healthcare emergencies and outbreak responses that they would not usually be exposed to [21]. Overall, VR provides a powerful tool to enhance medical training, ensuring students are better prepared for clinical challenges and improving healthcare outcomes.

Future studies should explore all the benefits a virtual reality education offers, particularly in the dermatology specialty. In addition to assessing how well VR improves spatial knowledge, it is important to look at other factors, such as how VR impacts students' attitudes toward learning and its cost-effectiveness compared to traditional medical school education. Additionally, researchers should examine how VR training may influence clinical practice and whether it leads to significant changes in behavior during real-world situations. A more comprehensive understanding of VR will help determine its potential to not only enhance the learning process of medical students but also positively affect patient care and efficiency in medical practice, all while ensuring the long-term viability and accessibility of these technologies in medical institutions.

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CONFLICTS OF INTEREST

The author declares that there are no conflicts of interest.

REFERENCES

1. Kyaw BM, Saxena N, Posadzki P, Vseteckova J, Nikolaou CK, George PP, et al. (2019). Virtual Reality for Health Professions Education: Systematic Review and Meta-Analysis by the Digital Health Education Collaboration. J Med Internet Res. 21(1):e12959.

2. Mohseni Afshar Z, Goodarzi A, Emadi SN, Miladi R, Shakoei S, Janbakhsh A, et al. (2023). A Comprehensive Review on HIV-Associated Dermatologic Manifestations: From Epidemiology to Clinical Management. Int J Microbiol. 2023:6203193.

3. Chandrasekaran M, Pachamuthu A. (2017). Dermatological Manifestations of HIV - Study of 100 Cases. IOSR Journal of Dental and Medical Sciences. 16(8):22-25.

4. Chimbetete T, Buck C, Choshi P, Selim R, Pedretti S, Divito SJ, et al. (2023). HIV-Associated Immune Dysregulation in the Skin: A Crucible for Exaggerated Inflammation and Hypersensitivity. J Invest Dermatol. 143(3):362-373.

5. Coates SJ, Leslie KS. (2019). What's new in HIV dermatology? F1000Res. 8:F1000 Faculty Rev-980.

DOI: https://doi.org/10.35702/Derm.10042

6. Asgari MM, Ray GT, Quesenberry CP Jr, Katz KA, Silverberg MJ. (2017). Association of Multiple Primary Skin Cancers With Human Immunodeficiency Virus Infection, CD4 Count, and Viral Load. JAMA Dermatol. 153(9):892-896.

7. Belmokhtar Z, Djaroud S, Matmour D, Merad Y. (2024). Atypical and Unpredictable Superficial Mycosis Presentations: A Narrative Review. J Fungi (Basel). 10(4):295.

8. Chelidze K, Thomas C, Chang AY, Freeman EE. (2019). HIV-Related Skin Disease in the Era of Antiretroviral Therapy: Recognition and Management. Am J Clin Dermatol. 20(3):423-442.

9. Altman K, Vanness E, Westergaard RP. (2015). Cutaneous manifestations of human immunodeficiency virus: a clinical update. Curr Infect Dis Rep. 17(3):464.

10. Harper-Kirksey K. (2018). Erythroderma. In: Rose E, editor. Life-Threatening Rashes: An Illustrated, Practical Guide. Cham: Springer International Publishing. pp. 265-277.

11. McMahon DE, Chemtai L, Grant M, Singh R, Semeere A, Byakwaga H, et al. (2022). Understanding Diagnostic Delays for Kaposi Sarcoma in Kenya: A Qualitative Study. J Acquir Immune Defic Syndr. 90(5):494-503.

12. Huang XJ, Li HY, Chen DX, Wang XC, Li ZC, Wu YS, et al. (2011). Clinical analysis of skin lesions in 796 Chinese HIV-positive patients. Acta Derm Venereol. 91(5):552-556.

13. Mangion SE, Phan TA, Zagarella S, Cook D, Ganda K, Maibach HI. (2023). Medical school dermatology education: a scoping review. Clin Exp Dermatol. 48(6):648-659.

14. Hussain W, Hafiji J, Stanley AG, Khan KM. (2008). Dermatology and junior doctors: an evaluation of education, perceptions and self-assessed competencies. Br J Dermatol. 159(2):505-506.

15. Pottle J. (2019). Virtual reality and the transformation of medical education. Future Healthc J. 6(3):181-185.

16. Jiang H, Vimalesvaran S, Wang JK, Lim KB, Mogali SR, Car LT. (2022). Virtual Reality in Medical Students' Education: Scoping Review. JMIR Med Educ. 8(1):e34860.

17. Al-Ansi AM, Jaboob M, Garad A, Al-Ansi A. (2023). Analyzing augmented reality (AR) and virtual reality (VR) recent development in education. Social Sciences & Humanities Open. 8(1):100532.

18. da Cruz Torquato M, Menezes JM, Belchior G, Mazzotti FP, Bittar JS, Dos Santos GGR, et al. (2023). Virtual Reality as a Complementary Learning Tool in Anatomy Education for Medical Students. Med Sci Educ. 33(2):507-516.

19. Lastrucci A, Wandael Y, Barra A, Ricci R, Maccioni G, Pirrera A, et al. (2024). Exploring Augmented Reality Integration in Diagnostic Imaging: Myth or Reality? Diagnostics (Basel). 14(13):1333.

20. Khan R, Plahouras J, Johnston BC, Scaffidi MA, Grover SC, Walsh CM. (2018). Virtual reality simulation training for health professions trainees in gastrointestinal endoscopy. Cochrane Database Syst Rev. 8(8):CD008237.

21. Asadzadeh A, Samad-Soltani T, Rezaei-Hachesu P. (2021). Applications of virtual and augmented reality in infectious disease epidemics with a focus on the COVID-19 outbreak. Inform Med Unlocked. 24:100579.

22. Malaekah HM, Assaf WA, Alsofyani MA, Muna Aljahany, Boker A. (2022). Role of Health Simulation Training in Response to Pandemic Crises in General and COVID-19 Specifically. Archives of Clinical and Biomedical Research 6(1):184-195.

23. Liu JYW, Mak PY, Chan K, Cheung DSK, Cheung K, Fong KNK, et al. (2024). The Effects of Immersive Virtual Reality–Assisted Experiential Learning on Enhancing Empathy in Undergraduate Health Care Students Toward Older Adults With Cognitive Impairment: Multiple-Methods Study. JMIR Med Educ. 10:e48566.

24. Mühling T, Schreiner V, Appel M, Leutritz T, König S. (2025). Comparing Virtual Reality–Based and Traditional Physical Objective Structured Clinical Examination (OSCE) Stations for Clinical Competency Assessments: Randomized Controlled Trial. J Med Internet Res. 27:e55066.

25. Marougkas A, Troussas C, Krouska A, Sgouropoulou C. (2024). How personalized and effective is immersive virtual reality in education? A systematic literature review for the last decade. Multimedia Tools and Applications. 83(6):18185-18233.

DOI: https://doi.org/10.35702/Derm.10042

26. Riddle EW, Kewalramani D, Narayan M, Jones DB. (2024). Surgical Simulation: Virtual Reality to Artificial Intelligence. Curr Probl Surg. 61(11):101625.

27. Nicholson DT, Chalk C, Funnell WR, Daniel SJ. (2006). Can virtual reality improve anatomy education? A randomised controlled study of a computer-generated three-dimensional anatomical ear model. Med Educ. 40(11):1081-1087.

28. Elendu C, Amaechi DC, Okatta AU, Amaechi EC, Elendu TC, Ezeh CP, et al. (2024). The impact of simulation-based training in medical education: A review. Medicine (Baltimore). 103(27):e38813.

29. Baniasadi T, Ayyoubzadeh SM, Mohammadzadeh N. (2020). Challenges and Practical Considerations in Applying Virtual Reality in Medical Education and Treatment. Oman Med J. 35(3):e125.

30. Lie SS, Helle N, Sletteland NV, Vikman MD, Bonsaksen T. (2023). Implementation of Virtual Reality in Health Professions Education: Scoping Review. JMIR Med Educ. 9:e41589.

31. Iqbal AI, Aamir A, Hammad A, Hafsa H, Basit A, Oduoye MO, et al. (2024). Immersive Technologies in Healthcare: An In-Depth Exploration of Virtual Reality and Augmented Reality in Enhancing Patient Care, Medical Education, and Training Paradigms. J Prim Care Community Health. 15:21501319241293311.

32. Vradmin. (2018). Virtual reality in Healthcare Virtual Reality Society. Available at: https://www.vrs.org.uk/virtual-reality-healthcare/

33. Gençoğlu Ş. (2024). Enhancing dermatology: the current landscape and future prospects of augmented and virtual reality technologies. J Health Sci Med. 7(1):132-136.

34. Garg A, Haley HL, Hatem D. (2010). Modern moulage: evaluating the use of 3-dimensional prosthetic mimics in a dermatology teaching program for second-year medical students. Arch Dermatol. 146(2):143-146.

35. Ryan GV, Callaghan S, Rafferty A, Higgins MF, Mangina E, McAuliffe F. (2022). Learning Outcomes of Immersive Technologies in Health Care Student Education: Systematic Review of the Literature. J Med Internet Res. 24(2):e30082.

36. Aldridge RB, Li X, Ballerini L, Fisher RB, Rees JL. (2010). Teaching dermatology using 3-dimensional virtual reality. Arch Dermatol. 146(10):1184-1185.

37. Junga A, Schmidle P, Pielage L, Schulze H, Hätscher O, Ständer S, et al. (2024). New horizons in dermatological education: Skin cancer screening with virtual reality. J Eur Acad Dermatol Venereol. 38(12):2259-2267.

38. De Ponti R, Marazzato J, Maresca AM, Rovera F, Carcano G, Ferrario MM. (2020). Pre-graduation medical training including virtual reality during COVID-19 pandemic: a report on students' perception. BMC Med Educ. 20(1):332.

39. Bonmarin M, Läuchli S, Navarini A. (2022). Augmented and Virtual Reality in Dermatology—Where Do We Stand and What Comes Next? Dermato. 2(1):1-7.

40. Obagi ZA, Rundle CW, Dellavalle RP. (2020). Widening the scope of virtual reality and augmented reality in dermatology. Dermatol Online J. 26(1):13030/qt6mz1s20x.

41. Landau M, Tsoukas M, Goldust M. (2025). Augmented and Virtual Reality in Cosmetic Dermatology. J Cosmet Dermatol. 24(2):e16698.

42. Muralidharan V, Pathmarajah P. (2024). Virtual reality-driven skin checks may be a promising tool in dermatology digital education. J Eur Acad Dermatol Venereol. 38(12):2205-2206.

43. Kircik L, Goldust M. (2025). The Role of Virtual and Augmented Reality in Advancing Drug Discovery in Dermatology. J Cosmet Dermatol. 24(2):e70071.

44. Meghe SR, Ramapure R, Quazee S, Singh A, Jawade S. (2024). Augmented/Virtual Reality in Dermatology: A Digital Arsenal in Modern Era. J Pharm Bioallied Sci. 16(Suppl 5):S4572-S4574.

45. Orta Portillo GA, Fletcher JB, Young LE, Klausner JD. (2023). Virtual avatars as a new tool for human immunodeficiency virus prevention among men who have sex with men: a narrative review. Mhealth. 9:29.

DOI: https://doi.org/10.35702/Derm.10042