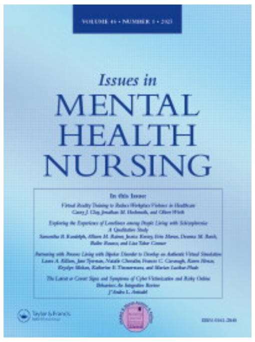

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Virtual Reality Training to Reduce Workplace Violence in Healthcare

Casey J. Clay, PhD, BCBA-D[a], Jonathan M. Hochmuth, PhD, NIOSH[b] and Oliver Wirth, PhD, NIOSH[b]

[a]Department of Special Education and Rehabilitation Counseling, Utah State University, Logan, Utah, USA; [b]Health Effects Laboratory Division, National Institute for Occupational Safety and Health, Morgantown, West Virginia, USA

ABSTRACT

Violence against nurses and other healthcare workers is a significant and escalating concern, impeding the provision of safe and effective healthcare services. A majority of nurses experience some kind of violence, including physical and nonphysical assaults during their careers. The consequences of workplace violence extend beyond individual trauma, leading to increased burnout, turnover, and significant financial costs for healthcare systems. Training programs focused on workplace violence prevention (WVP) have become ubiquitous, with elements like situational threat assessment, de-escalation techniques, and physical skills. Studies show that experiential components, such as role play, enhance the effectiveness of these trainings. Virtual Reality (VR) offers a promising solution by providing immersive, interactive training environments that enhance decision-making, physical coordination, and team dynamics. In this article we discuss how VR simulations can replicate real-world settings, allowing healthcare workers to practice and master violence prevention and management skills in a controlled, safe environment. We also describe how VR is scalable and cost-effective, enabling widespread adoption within and across organizations with minimal logistical challenges. Integrating VR into WVP training programs could significantly improve training outcomes, reduce the need for physical and chemical restraints, and ultimately enhance the overall safety and quality of healthcare services

Violence experienced by healthcare workers is a national priority for the U.S. Department of Health and Human Services and a barrier to providing safe and effective healthcare services (Agency for Healthcare Research and Quality, n.d.). According to the U.S. Bureau of Labor Statistics biennial data for 2021-2022, approximately 71% of all non-fatal lost-time injuries due to workplace violence were sustained by healthcare workers (United States Bureau of Labor Statistics, 2024a). During that same period, the lost-time incident rates related to violence were 4.3 per 10,000 full-time employees for all occupations, but 16.6 for registered nurses, 12.5 for licensed professional or vocational nurses, and 48.7 for nursing assistants (United States Bureau of Labor Statistics, 2024b). As high as the rates in nursing occupations are, psychiatric technicians and aides had rates of 288.6 and 515.7, respectively (United States Bureau of Labor Statistics, 2024b). This suggests that providing care for patients in need of behavioral and mental health services presents a particularly significant risk. Moreover, 73% of nurses believed that assault is "just part of their job" (Speroni et al., 2014). Despite this, workplace violence (WPV) likely is underreported among healthcare workers due to disconnects between informal and formal reporting systems, fear of retaliation, and the belief that nothing will be done to improve conditions (Byon et al., 2021; Pompeii et al., 2016; Sabbath et al., 2017). Furthermore, Black healthcare workers are even less likely to report WPV while simultaneously being more likely to experience violence at work (Hawkins & Ghaziri, 2022), which contributes to the documented underreporting of occupational injuries among these workers (Sabbath et al., 2017).

The impact of workplace violence is detrimental not only to the individual victim but also to the entire healthcare system. Physical and psychological trauma can lead to demotivation, compassion fatigue, burnout, and turnover (Wolotira, 2023). The direct costs associated with treatment and liability related to non-fatal workplace violence in hospital medical systems can vary but are substantial. For example, in one hospital 30 WPV injuries requiring treatment incurred $94,156 in costs during a 12-month period (Speroni et al., 2014), whereas an analysis of a large hospital system found 798 incidents in a 30-month period incurring total costs of $505,480 (Essenmacher et al., 2013). Increasing trends in workplace violence rates have led to legislative mandates and voluntary standards for cost-effective and outcomes driven training (Arnetz, 2022).

Common components of workplace violence prevention (WVP) training involve visuospatial awareness, decision-making, communication, and physical skills related to situational threat assessment, recognition of escalating behavior, de-escalation techniques, evasion and extrication skills, as well as restraints and holds (team and individual)

CONTACT Casey J. Clay Casey.clay@usu.edu Department of Special Education and Rehabilitation Counseling, Utah State University, 2865 Old Main Hill Logan, Utah 84322-2865, USA.

(Arbury et al., 2017). Training may also include information on the types of workplace violence, general risk factors, legal issues, and facility specific processes (e.g. reporting) (Arbury et al., 2017). Typically, these skills are delivered via a desktop computer and involve a combination of advancing through a series of educational slides or videos with brief quiz or participation activities, and practice of the skills being taught (i.e. live trainer role playing). A study by Glass et al. (2017) directly compared computer-based training with or without peer facilitation (i.e. role playing in different scenarios with feedback) to reduce WPV and harassment for homecare workers. They reported greater increase in confidence and a significant decrease in actual workplace violence for the group that included peer facilitation (Glass et al., 2017). This example demonstrates the benefits when training incorporates experiential components in addition to information. As another example of benefits of integrating peer role-play, Ulrich et al. (2017) evaluated role-play simulation as an active learning strategy when addressing bullying in nursing practice. Participants were senior-level nursing students across 3 universities in the Midwest. Role-play activities were designed to evoke authentic affective responses from participants and discussion on how to address bullying. Reflection worksheets were gathered from participants indicated high levels of perceived negative organizational perception. Authors concluded responses and actions can be leveraged during a critical debriefing facilitated by the nurse faculty member.

WVP training involving practice and role play may also reduce the necessity for chemical and physical restraints by identifying risk factors and equipping staff with de-escalation strategies that can be used before a patient reaches a point where more restrictive and intrusive procedures must be used. Some studies of WVP training have shown reductions in various outcomes, including lost-time staff injury, patient injury, use of restraint and seclusion, customer complaints, and harassment (Glass et al., 2017; Paccione-Dyszlewski et al., 2012). Additionally, there is evidence to suggest comprehensive training and education programs lead to a reduction in violent incidents in healthcare settings (Fricke et al. 2023; Wirth et al., 2021). However, specific training programs alone do not appear to consistently reduce rates of workplace violence and further comparisons testing specific interventions are needed (Fricke et al. 2023; Heckemann et al., 2015). Furthermore, limited public data exist on long-term effectiveness of large-scale, commercially available WVP training programs (Arbury et al., 2017). In a review of the most common WVP training programs for health care workers, Arbury et al. (2017) reported that training programs frequently included no content on facility risk assessment, pharmacology, facility procedures for reporting WPV, worker rights, and working alone. Of note, working alone often creates a high risk for the health care worker (Arbury et al., 2017). Interestingly, research on outcomes of WPV training typically only involve indirect or subjective methods for measuring improvement, such as perception surveys about workers' confidence in executing topics of the training, or behavioral intention (Bernstein et al., 2024; Calabro et al., 2002; Ferrara et al., 2017; Graber, 2019; Griffin et al., 2021).

One way to improve the consistency and effectiveness of WVP training is to incorporate principles of experiential learning, which can be defined as the process of learning through participatory, interactive and applied experience (Gentry, 1990). There are different approaches to experiential learning, such as *in-situ* training, role play, tabletop simulations, and virtual reality. *In situ* training might provide the learner with experiences in the same or similar context where the skill is to be performed (e.g. the place of employment). Role play provides the learner with highly physically interactive experiences usually involving a confederate (i.e. peer or actor) or the trainer acting out specific scenarios to which the learner practices appropriate responses (Glass et al., 2017). Table-top methods present the learner with various scenarios in interactive exercises while sitting or standing at a desk or interacting with scenarios programmed for a personal computer (Brunero et al., 2021). Advances in computing power and software have made possible *virtual reality* (VR)—another experiential educational approach that holds additional benefits and promise for skills training.

What is virtual reality?

VR simulates or resembles real-world settings to provide a realistic, immersive experience. In practice, virtual reality is created with computer-generated digital environments that can be experienced and interacted with as if those environments were real (Jerald, 2015). Accordingly, VR allows users to see, hear, and interact with a virtual surrounding that approximates the real environment. This requires that the VR environment represents the dimensional, visual, and interactional qualities of the corresponding real-world accurately. The degree to which VR accurately represents these real-world environments varies largely based on the methods used to present and interact with the audio-visual elements of the environment (Coban et al., 2022). For example, in desktop-based VR the environment is presented on a computer screen and the user interacts via keyboard, mouse, game controller, or touchscreen. Although desktop-based VR can be quite realistic, this method is considered non-immersive (Coban et al., 2022). More immersive types of VR include *mixed reality* (MR) and *augmented reality* (AR). In these types of VR computer-generated sensory cues are added onto the already existing real-world environment. Examples include overlaying filters on social media backgrounds or on video conferencing platforms, head-mounted displays (HMD) worn by users that present environments and associated sensory cues on screens affixed to glasses or through a headset (e.g. Meta Quest and HTC Vive). Another type of AR is Cave Automatic Virtual Environment (CAVE) which projects the auditory and visual stimuli in a space that is separated or isolated from the natural environment such as in a golf or flight simulator.

Features and benefits of virtual reality training

Immersive VR environments have shown promise in enhancing training for decision-making, visuospatial awareness, physical coordination, and team dynamics. Such environments are already being leveraged across various sports to simulate real-world scenarios and improve performance in basketball (Pagé et al., 2019), rugby (Bideau et al., 2010), soccer (Craig, 2013), and baseball (Zaal & Bootsma, 2011). Beyond sports, industries like construction and mining utilize VR to teach hazard recognition skills (Rey-Becerra et al., 2023; Scorgie et al., 2024; Zhao & Lucas, 2015) and enhance the learning and recall of safety protocols (Sacks et al., 2013). In healthcare, VR is improving surgical training by providing a platform for practitioners to hone their skills in a controlled environment (Gurusamy et al., 2008; Li et al., 2017; Seymour et al., 2002).

By leveraging VR's unique capabilities training programs can offer immersive experiences that are both effective and adaptable to learners' needs while maintaining high standards of realism and transferability to real-world applications. Perhaps among the most obvious features of VR that might benefit training objectives are (1) the realism and the interactive aspects of the technology, (2) its capacity for measurement, standardization, and repeatability, and (3) its scalability and portability.

VR is virtual and realistic

A significant advantage of VR training is its ability to provide a safe and controlled setting that closely mirrors the real-world environment—a feat difficult to achieve *in situ*. *In situ* simulation-based training, is defined as simulated encounters in the exact setting where they are expected to occur, as opposed to dedicated simulation labs or centers (Goldshtein et al., 2020). The realism of a virtual environment hinges more on interaction fidelity than visual accuracy. A simple virtual space with basic graphics but realistic interactions can be more effective than a visually realistic one lacking interactivity. It is this preservation of the perception-action loop; how we navigate and interact within an environment; and how that navigation affords new opportunities for interaction hat significantly enhances functional fidelity (Craig, 2013). Realism allows skills trained in VR to transfer to real-life settings and studies have shown that skills trained in VR can be effectively applied *in vivo* (Dobrowolski et al., 2021; Gopher et al., 1994; Kanade & Duffy, 2024; Levac et al., 2019; Munz et al., 2007; Sibert et al., 2008).

Realism is enhanced by arranging fully immersive simulations where trainees feel more completely present in the virtual environment (Radhakrishnan et al., 2021; Schwarz et al., 2020). The concept of presence, or telepresence, can be enhanced by blending virtual elements with real-world components during training making the virtual experience feel more authentic (Bideau et al., 2010). For example, Bideau et al. designed a training environment in which goalkeepers stood in a real goal in front of a screen that displayed a virtual stadium and opposing player throwing a ball. The combined virtual and physical setting improved the ability to intercept a ball when facing different throwing actions and ball trajectories.

Another important element of the perception-action loop is perspective. VR empowers users to actively explore and discover new information from different angles unlike static media where perspectives are fixed (Craig, 2013). VR also offers unique perspectives unattainable through other training methods. For example, one project allowed users to experience age-related conditions from an elderly person's viewpoint, enhancing medical students' empathy and understanding of these health issues (Dyer et al., 2018). Similarly, police officers reported increased efficacy in de-escalation training when provided with multiple perspectives of a scenario including their own, a bird's eye view, and the suspect's (Kleygrewe et al., 2024).

VR also has the ability to emphasize features of the virtual environment or scenario to ensure that critical information is highlighted for the trainee (Levac et al., 2019). This is especially useful for teaching complex motor skills such as in rehabilitation, by highlighting errors, guiding appropriate responses with different stimuli (i.e. visual, haptic, auditory), and increasing or decreasing variation in responses as needed (for review see Levac et al., 2019).

VR is not limited to physical skills and can extend to social interactions as well virtual scenarios can provide controlled, reproducible social exposures, enabling therapists to vary contexts (e.g. shops, restaurants) without leaving their office. This not only ensures confidentiality but also maximizes learning transfer. Patients often find virtual exposure less intimidating than real-world encounters, enhancing its utility in clinical applications like exposure therapy (Bouchard et al., 2017).

VR allows measurement, standardization, and repeatability

VR technology in training also allows enhanced capabilities for measuring/monitoring important performance-related outcomes. One of the inherent challenges with complex skill acquisition is measuring the simultaneous biomechanical, physiological, and psychological responses that occur during training (Bideau et al., 2010).

VR allows for the integration of physiological metrics with performance data to offer a more comprehensive approach to skill development. For example, objective measures like galvanic skin response (GSR) and heart rate variability (HRV) as additional measures are important because of their relationship to stress and burnout—a significant concern impacting both patient care and organizational outcomes (Buckley et al., 2020; Jun et al., 2021). For instance, Chao et al. used GSR and HRV in a study with university students in Taiwan comparing VR training with traditional methods such as film-watching and manual-reading (Chao et al., 2017). They found that VR not only improved task performance but also reduced mental workload, particularly in complex tasks as evidenced by both subjective survey assessments and the objective physiological measures. Similarly, measures of physiological activity (i.e. EMG), mental workload, and task performance have been used in VR trainings for peri-care activities with nursing students (Stone et al., 2024). Moreover, techniques like eye-gaze tracking can help assess where individuals focus their attention during simulations—important data that has been gathered in medical crisis events in previous VR research (Anbro et al., 2020). This ability to measure situational awareness could be invaluable for WVP training.

Another significant advantage of VR compared to traditional training methods is standardization. Its capacity to consistently gather data across multiple sessions ensures that trainees can achieve mastery through uniform practice. For instance, VR surgical training programs provide unlimited practice opportunities, each followed by detailed statistical performance analyses (Li et al., 2017).

VR training also excels in offering immediate performance feedback. For example, studies have shown that VR training for tasks like street crossing safety can include features like session pausing and repetition, allowing multiple attempts with feedback to reinforce learning (Coban et al., 2022; Sacks et al., 2013; Thomson et al., 2005). Similar methods of pausing and repeating steps are currently used in healthcare simulation training methods, like Rapid Cycle Deliberate Practice (RCDP) for pediatric resuscitation skills (Hunt et al., 2014), and could be adapted to virtual delivery modes. VR provides the ability for nurses to refine their skills without resorting to trial-and-error methods during live patient interactions. This is especially important in high-stakes scenarios where errors can have serious consequences. For example, VR has recently been shown to significantly reduce errors in arterial blood gas (ABG) assessment compared to training as usual (Kennedy et al., 2023).

Repetition and other fluency building strategies are already being utilized in applications of VR training. For example, Clay et al. (2021) successfully used VR to train pre-service clinicians in delivering behavioral treatments under challenging conditions, such as dealing with aggressive behavior. Participants repeated scenarios until they achieved a mastery criterion of 90% or higher across all components of behavioral skills training (BST), including instruction, modeling, rehearsal, and feedback (Clay et al., 2021).

VR can also promote transfer of skills beyond the training context to real-world environments and novel situations. For example, basketball players who trained decision-making skills within a VR simulation translated those improvements in game-time performances more effectively than those who trained using only video playback (Pagé et al., 2019). In surgical skills training, intracorporeal knot-tying was trained using VR, and not only showed improvements in quality and efficiency but also transferred effectively to video-trainer exercise that are an accepted proxy for real surgical procedures (Kanade & Duffy, 2024; Munz et al., 2007).

Finally, VR allows for repeated practice without risk. For example, VR simulations could allow staff to safely practice managing various mental health crises repeatedly without direct contact with patients or trainers. VR has already been used to effectively train healthcare workers in client communication skills (Moser et al., 2024), the assessment of mental health disorders (Cieslowski et al., 2023) and delivering behavioral treatments to patients with aggressive behavior (Clay et al., 2021).

VR is scalable and portable

A key advantage of VR training is its portability and scalability. Portability allows for the use of VR devices in various locations, enhancing scalability by facilitating widespread adoption across an organization or industry. This means VR can be deployed across extensive networks and organizations. For instance, VR training for Walmart resulted in employees scoring higher on knowledge tests, demonstrating better knowledge retention, and providing higher satisfaction scores. Walmart expanded this success by distributing 18,000 Oculus Go headsets to its academies and expanding to over 30 active VR training modules (Gale, 2021).

One of the key advantages of virtual learning is its accessibility; trainees only need the relevant hardware, such as headsets or monitors, available on-site. This eliminates the costs associated with transporting trainers and trainees. Moreover, VR's asynchronous delivery model allows training to occur on-demand without waiting for an instructor or group sessions—training can be tailored to individual needs and schedules. In fact, the flexibility of this delivery method has already been used to effectively facilitate Just-in-Time, Just-in-Place trainings for clinical assessments in emergency departments (Shah et al., 2023).

VR is cost-effective and efficient

Another feature of VR that follows from its scalability is its cost-effectiveness. Technological advancements have made gyroscopes, motion sensors, high-definition screens, and processors more affordable and effective for training purposes (Institute of Medicine, 2013; Zendejas et al., 2013), driving down hardware costs while improving user experiences. Cost savings for hospitals are another significant outcome. Farra et al. (2019) conducted a cost-benefit analysis comparing virtual reality with live disaster exercises for neonatal intensive care unit evacuation training. While initial costs were higher for VR ($327.78 per participant) compared to live drills ($229.79 per participant), over three years of repeated trainings, VR became more economical ($115.43 per participant) due to scalable development costs versus fixed costs associated with live exercises (Farra et al., 2019). Simulation training exercises typically aim to replicate a hands-on environment outside the actual workplace. In medical education, role-playing with professional actors or using costly medical mannequins (sometimes exceeding $10,000) are common methods for teaching and assessing clinical competence. However, these approaches come with challenges such as actor availability, transportation logistics, and potential risks like confidentiality breaches and exposure to pathogens. For example, a comparison of VR to simulation-based training in nursing students across four modules (i.e. verbal aggression, deteriorating patient, cognitive impairment, and palliative care) found no difference in knowledge, motivation, or self-efficacy post clinical placement, but the VR cost $3,350 per semester as opposed to $18,670 for the simulation training (Kiegaldie & Shaw, 2023). Moreover, the VR training allowed for more than 95% of students to actively engage in the training, whereas only 15% were able to participate in the simulation while most only observed.

Research indicates that technology-assisted simulations can improve patient outcomes—including discomfort levels, survival rates, complication rates, and procedural success (Cook et al., 2011). Similarly, de-escalation trainings have shown reductions in physical and clinical restraints (Krull et al., 2019), suggesting that VR technology could further benefit patients by potentially decreasing the need for restraint and seclusion, reducing injuries, and enhancing customer service and quality of care.

As training demands grow, VR's potential to scale up to meet these needs becomes increasingly significant, especially in light of the bottleneck of supervisory resources. Traditionally, junior doctors have learned technical skills in the operating room under the guidance of senior surgeons. However, with the rise in trainee numbers, opportunities for hands-on experience have dwindled due to higher costs, ethical concerns, and reduced resident work hours. These policies have led to a decline in independent surgical experience for trainees. Moreover, as surgical techniques become more advanced, mere observation is no longer sufficient for mastering certain skills. In this context, VR training has emerged as an indispensable tool for junior doctors, providing them with essential practice before participating in actual surgeries (Li et al., 2017).

VR technology is also efficient. For instance, in an industrial ozone generator isolation training that compared VR to traditional lecture training, there was no difference in knowledge gain or retention (Stefan et al., 2023). However, VR training required approximately half as long (Stefan et al., 2023). Similarly, a recent study compared nursing students trained in VR (4 h per week, for 4 wk) to traditional inpatient clinical practice (9-10 h per week, for 4 wk) on a pediatric asthma simulation scenario. There were no differences in focused assessment, medication administration and evaluation, but the VR group performed significantly better infection control, initial assessment, and oxygen therapy (Cieslowski et al., 2023).

VR for violence prevention in healthcare

Although VR has been used to influence perpetrator behaviors in bullying (Ingram et al., 2019), aggression (Dellazizzo et al., 2019; Klein Tuente et al., 2018; 2020), and interpersonal violence (Bowman et al., 2020; Seinfeld et al., 2018; Xue et al., 2021), its application in teaching de-escalation and safety skills for violent situations is scarce, mainly focusing on law enforcement (Kleygrewe et al., 2024). To our knowledge, no VR programs have been designed specifically to equip healthcare workers with strategies to handle violence or aggression. However, preliminary efforts have been made to use VR for training some clinical skills in potentially violent scenarios (see Figure 1; Clay et al., 2021), laying the groundwork for future developments.

Healthcare workplace violence prevention training typically involves complex physical, social, communication, and decision-making skills for high-risk situations. Effective training should enable learners to master these skills through practice, apply them in real-world settings, and adapt them to new scenarios. Coordinated team responses are essential; however, the increasing reliance on temporary contract workers—who may have varying levels of training—can complicate team responses during violent incidents.

VR offers a potential solution by simulating high-risk scenarios safely, allowing for a range of responses and providing immediate feedback. It ensures skill mastery without waiting for large groups to form for traditional sessions. Trainees can learn organization-specific procedures during onboarding with VR, ensuring they are equipped with the necessary skills to respond with their team from the start. This tailored approach using VR could enhance response effectiveness and adaptability in actual incidents.

Discussion

In this paper, we highlighted several advantages of incorporating VR technology into a skills training program, such as in an experiential-based violence prevention training programs for healthcare workers. The virtual realism and experiential aspects of the technology, combined with enhanced capabilities for measuring and monitoring important performance improvements, are perhaps the most salient benefits of VR training. But, because the technology is programmable and customizable, the training can be standardized to present the most common, most relevant, and even the most dangerous training scenarios to maximize the transfer and generalization of trained skills to real-work experiences. VR training also is scalable and portable in terms of implementation across or within organizations. All these advantages contribute to improved outcomes for the patient, healthcare worker, and organization.

One challenge in developing and implementing any effective training program involves first selecting the most appropriate and effective training method. Although VR is a promising technology that provides many benefits for skills training, VR does not replace important educational and informational components of common WVP training programs. Current VR technology is not yet able to adequately simulate complex social interactions involved in teamwork or collaboration. Training and practicing skills involved in these social interactions are better handled through other types of simulations (e.g. live drills). Nevertheless, and despite the various reported benefits and advantages of VR training, properly evaluating the effectiveness of VR-enhanced training remains a challenge. Although reviews of simulation training in health professions, including VR training, have reported increases in student knowledge, skills, and self-confidence (Alanazi et al., 2017; Martin et al., 2020), evaluations of these trainings are limited by the frequent use of self-report survey measures (Alanazi et al., 2017). For example, VR video training methods for surgical procedures with medical students (Omlor et al., 2022) were assessed only with satisfaction ratings and a pre-post quiz assessment of basic rules and components of the surgical procedure. Other studies of VR-enhanced surgical training programs measured user performance around the simulation itself (e.g. duration of surgery and number of mistakes made) as well as questions regarding user perceptions (e.g. satisfaction ratings) (Li et al., 2017). There has been little to no focus on measuring the

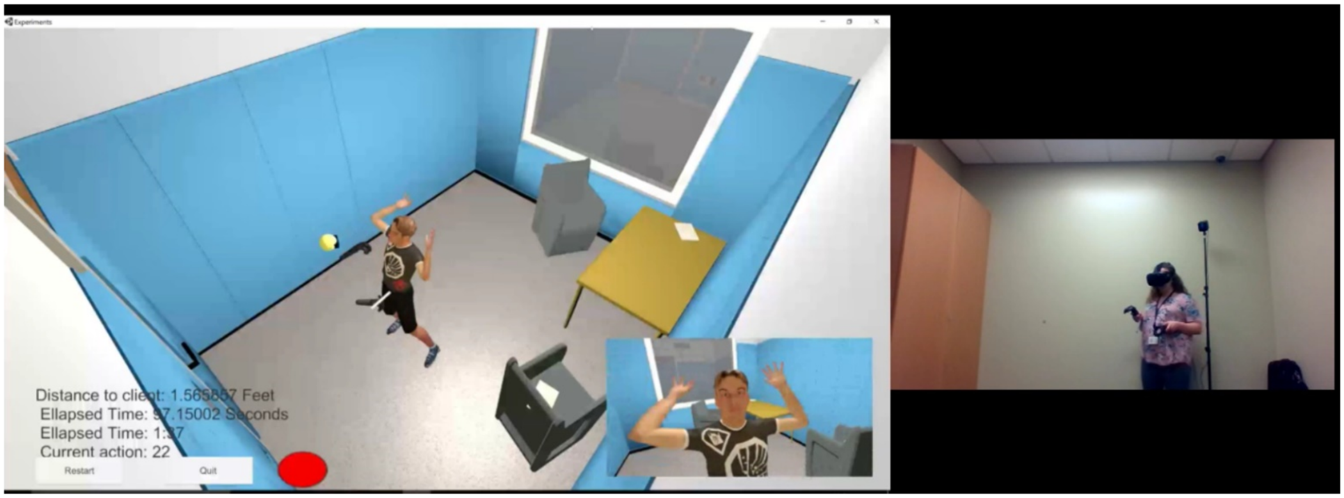

Figure 1. a) Trainee in real-time interacting with child displaying aggression, b) trainee view of virtual simulation, c) experimenter's bird's eye view of the scenario. The visible yellow ball is the trainee's head and the two black controllers are the trainee's hands.

effects of VR-enhanced training on participants' performances in real-world surgeries. Future studies of VR should include more objective measures of both skill development and transfer of knowledge to real-work practices.

A possible framework for maximizing training effectiveness is a 4-level model of training evaluation proposed by Kirkpatrick (Kirkpatrick, 1998). Kirkpatrick's model focuses on four important levels: (1) *reaction*, (2) *learning*, (3) *behavior*, and (4) *results*. *Reaction* typically involves trainees completing a post-course evaluation reporting their perspectives, interest, motivation, and researchers' assessment of attention levels. *Learning* involves measuring what participants have learned referring to knowledge and skills. *Evaluation* at this level can include trainees participating in written assessments or role-plays to demonstrate their skills. This level of evaluation allows participants to demonstrate specific skills and knowledge post-training. *Behavior* involves assessment of the trainees' ability to use their newly learned knowledge or skills in the workplace. This level of evaluation attempts to determine how well participants use their new skills when they return to the workplace or *in vivo* setting. *Results* involves a measure of the impact that the training has had overall on organizational goals. This might include improvement in staff–resident interaction, decreased incidents of workplace violence, and hospital cost savings. For example, Finan et al. (2012) demonstrated the usefulness of this approach evaluating a simulation training for neonatal intubation with first-year pediatric residents. The researchers found significant improvement in intubation skills immediately post intervention, but this did not translate into improved clinical performance in the subsequent 8-week rotation (Finan et al., 2012). In applying the Kirkpatrick model, they reported no improvement at behavior and results levels, highlighting the importance of assessment at all four levels post-training.

A recent review of health and safety trainings in high-risk industries found that more than 70% of VR trainings failed to assess beyond the second level of Kirkpatrick's model (Toyoda et al., 2022). We believe that VR-enhanced WVP training can facilitate achievement at all four levels of training evaluation. For example, at the reaction level, VR can provide an immersive experience in which the trainee can see, hear, and respond to realistic scenarios. Incorporating qualitative feedback from participants can further enhance the realism of virtual scenarios (McCleery et al., 2020; Moser et al., 2024), ensuring that VR training remains an effective tool for skill acquisition across various domains. At the learning level, VR serves as a pedagogical tool that teaches skills through visual examples in a three-dimensional space that can be repeated as needed until skills are mastered. At the behavior level, VR provides more accurate ways of measuring what a trainee has learned by arranging opportunities to perform and practice skills in a digital environment where performance measurement can be "built in." These performance measurements can be used to monitor performance improvements in real-work crisis situations to assess the effectiveness of training at the results level, as evidenced by improved outcomes for patients (e.g. reductions in restraint, seclusion, and injury), nursing staff (e.g. reductions in stress and injuries), and the healthcare organization (e.g. reductions in complaints, turnover, injuries, and costs).

Future considerations

As VR technology continues to advance there are important future considerations. For instance, as VR training becomes more immersive and realistic, ethical concerns may arise, such as the potential for desensitization to violence or the unintended reinforcement of biases (Rovira, 2016; Rovira et al., 2021). Furthermore, there is the risk of emotional traumatization as technology becomes more lifelike. Researchers must address these ethical challenges and develop guidelines for responsible use of VR training. Researchers, consumers, and creators of VR should consider the risks and follow ethical recommendations from experts (Madary & Metzinger, 2016; Spiegel, 2018). Specifically, consumer input into training should be considered for quality and trauma-informed care as one of the bases for effective intervention and de-escalation of aggressive situations (e.g. Hall et al., 2018). Additionally, there should be actions taken to decrease risk such as the potential for motion sickness (Madary & Metzinger, 2016).

WVP efforts also will benefit from cross-disciplinary collaboration among experts in VR technology, healthcare professionals, safety professionals, security experts, organizational leadership including quality assurance/performance management personnel, and other fields. These collaborative efforts can lead to the development of realistic training scenarios of different types of workplace violence in which various healthcare personnel can practice their specific roles and responsibilities, such as in active-threat drills that are now commonplace in healthcare settings (Brown et al., 2018; Feinstein, 2014; Feinstein & Yager, 2018).

Additionally, expanding the capabilities of remote and distributed VR training is important, especially in scenarios where physical presence is challenging or dangerous. This includes improving network infrastructure, reducing latency, and developing collaborative training platforms. Providing remote access to effective training technologies, including VR, is particularly important as rates of workplace violence have been seen to be higher in rural areas (Pompeii et al., 2016), and healthcare workers in rural settings may not have access to or be in close proximity to state-of-art simulation training centers found usually in large urban university-based healthcare centers. Furthermore, it may be useful to incorporate VR more widely in prelicensure nursing curricula (Moyer, 2023; Wilson & Hungerford, 2015). This could help to ensure that nursing students have experience with this technology and proficiency in the necessary skills as they move into a range of care settings and specialty areas throughout their careers, while supplementing the limited pool of educational and supervisory resources.

Lastly, incorporating dynamic social interactions into VR training environments is an important future direction to be explored. Multiplayer roles and social dynamics are particularly relevant in settings where teamwork is critical, such as in healthcare, emergency response, and military exercises. Rapid advances in artificial intelligence technology are likely to make this possible in the near future.

Disclaimer

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