Empowering Dementia Communication via Virtual Reality AI-Driven Simulations

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Abstract

The use of effective communication skills is essential for direct care workers to provide quality care for persons living with dementia (PLWD) in long-term service and support settings (LTSS). However, direct care workers often report feeling unprepared, lack competence in care, and fear inter- acting with PLWD. This proof-of-concept study proposes the Virtual reality Communication Training Optimizing Real-world Interactions (VICTORI) intervention, aiming to develop and evaluate the usability, acceptability, and preliminary effectiveness of virtual reality (VR) simulated communication training for direct care workers using artificial intelligence (AI)-generated patients with dementia. Care-related and social communication scenarios in dementia care will be developed, based on current literature, our validated communication instrument, and AI technology. Six modules consisting of pre-briefing, simulation facilitation, and de-briefing will be developed, refined, and evaluated based on an advisory board of experts and direct care workers' quantitative and qualitative feed- back.

To test the usability, acceptability, and effectiveness of the VICTORI intervention, we will use a single group pre- and post-test intervention design, integrating quantitative measures and qualitative semi-structured interviews in this mixed-methods study. Thirty direct care workers will be recruited at two LTSS in North Texas. Direct care workers will participate in six VR-AI simulation communication training sessions that include communication with AI-generated patients, real-time feedback, and detailed evaluation of communication behaviors. Each simulation will be recorded to further evaluate the participant's communication skills using the Dyadic Communication Observational coding scheme in Dementia care (DCODE). Additionally, participants' potential side effects during VR simulation will be assessed using continuous physiological data and self-reported questionnaires at each simulation session. Communication knowledge and competence in dementia care will be assessed before and after training using self-reported questionnaires. Direct care workers will also be interviewed to assess acceptability and satisfaction with the VICTORI training.

This proposal will introduce innovative training methods that leverage AI technology into communication training in dementia care. Objective assessments, including AI-based feedback, physiological data, and observational assessments, assure reliability and validity of the data to evaluate plausibility of VICTORI intervention.

Significance

Direct care workers, such as nursing assistants and home health aides, are the front-line workforce in long-term service and support (LTSS) settings. They provide direct nursing care and socialization opportunities for persons living with dementia (PLWD). Addressing complex needs of PLWD, including physical, cognitive, emotional, and behavioral symptoms, presents significant challenges (Alzheimer's Association [AA], 2023). Among these challenges, communication difficulties, such as repetition and difficulty finding the right words, are one of the earliest and most significant symptoms of dementia, affecting emotional and behavioral symptoms (AA, 2023). Direct care workers often report feeling unprepared and lack competence in care for PLWD, particularly in communication (Slater et al., 2019). Effective communication training is essential to equip direct care workers with the skills needed to build relationships and deliver high-quality, person-centered dementia care.

Virtual reality (VR) simulation in dementia care is an innovative training method for improving communication skills among direct care workers (Nye et al., 2019). VR simulations allow learners to practice essential skills, minimize mistakes, and receive immediate feedback in risk-free environment. VR simulations are cost-effective, flexible in terms of time and location, and highly accessible (Song et al., 2023). Integrating artificial intelligence (AI)-generated patients into VR simulations can further enhance the realism and effectiveness of training by providing real-time feedback on communication behaviors. Despite the potential benefits of VR simulation training in dementia care, current interventions primarily focus on empathy and disease knowledge, with a limited emphasis on communication skills (Campbell et al., 2021; Kimzey & Mastel-Smith, 2022; Saab et al., 2022; Solecki et al., 2021). Additionally, there is a lack of evidence in interventions that incorporate AI-generated patients to enhance communication training. To address these gaps, we propose a proof-of-concept study called Virtual reality Communication Training Optimizing Real-world Interactions (VICTORI). This study aims to develop and test six VR-AI generated communication simula-

tion modules tailored for direct care workers. The goal of VICTORI intervention is to enhance communication knowledge, skills, and competence among direct care workers. The VICTORI project will first develop training modules following the International Nursing Association for Clinical Simulation and Learning (INACSL) Healthcare Simulation Standards of Best Practice-Simulation Design (Watts et al., 2021). Second, we will engage 30 direct care workers in LTSS located in Dallas and Fort Worth, Texas to participate in the training.

Rationale

Our guiding theoretical framework, the Nursing Simulation Education Framework (Jeffries, 2005) will guide elements of simulation and outcomes of the VICTORI intervention. Components of this framework include teacher and student factors, simulation design characteristics, and learner outcomes, including knowledge, skill performance, satisfaction, critical thinking, and self-confidence. As a result of participating in the VICTORI intervention, direct care workers will demonstrate better knowledge on communication with PLWD, use more facilitative communication skills and less disabling communication (improved skill performance with critical thinking), and have higher levels of competence and satisfaction in providing care for PLWD.

Approach

Participants and Setting

We will recruit 30 direct care workers at two LTSS located in Dallas and Fort Worth area, Texas. The inclusion criteria for direct care workers include: (1) attendants, certified nursing assistants, assisted living aides, home health and home care aides, nurse aides, personal care aids, and program assistants; and (2) currently providing care for PLWD at LTSS or their private homes. Individuals with the following conditions will be excluded due to non-compliance concerns with wearing wristbands and VR headset: a history or current symptoms of seizures, pre-existing binocular vision abnormalities or psychiatric disorders, or serious medical conditions; broken or damaged skin on wrists, any allergy to any metals, cardiac pacemakers, hearing aids, defibrillators, or other implanted medical device; and individuals who are pregnant. Direct care workers who are non-English speaking will also be excluded.

The simulation training modules will be developed and piloted at the Smart Hospital at the University of Texas at Arlington, launched in 2023 for advanced nursing simulation education, featuring state-of-the-art VR simulation labs equipped with headsets, touch con- trollers, and large monitoring screens. The intervention will be provided at two LTSS sites. Both sites have full time and part time direct care workers who serve PLWD in the community.

Outcome Instruments

Usability, acceptability, and satisfaction of VR simulation will be assessed using the revised Simulation Effectiveness Tool-Modified (SET-M) questionnaire, Simulator Sickness Questionnaire (SSQ), Igroup Presence Questionnaire (IPQ), physiological data, and semi-structured interviews.

- The SET-M is revised to evaluate the acceptance, usability, and participant's perception of VR simulation on pre-briefing, scenario, and de- briefing (Leighton et al., 2015).
- The SSQ will be used to assess side effects of VR simulation including cybersickness (general discomfort, stomach awareness, sweating, nausea), oculomotor problems (eye strain, headache), and disorientation (dizziness) (Kennedy et al., 1993; Knobel et al., 2021).
- The IPQ assesses fidelity of VR simulation including spatial presence, involvement, experienced real- ism and overall sense of presence (Melo et al., 2023).
- Physiological data of participants will be obtained before, during, and after each module to objectively evaluate potential side effects of VR simulation. The data includes temperature, systolic peaks, pulse rate, respiratory rate, blood volume pulse, and digital biomarkers [i.e., pulse rate variability and electrodermal activity (skin conductance level)] using a wristband. Safety and efficacy have been established in previous studies to detect non-invasive physiological data (Siirtola, 2019; Siirtola & Röning, 2020).
- Transcribed interview recordings will be analyzed using thematic analysis to enhance understanding and identify shared meaning of participating in this study (Elo & Kyngäs, 2008). Attendance and dropout rates, drop out reasons, usefulness, ease of use, content, duration, clarity, and difficulty of the intervention will be discussed.

Communication skills will be evaluated using the DCODE (Kim et al., 2022), developed by the PI, to assess communication between direct care workers and AI-patients (19-item facilitative, 13-item disabling, 11-item neutral communication for caregiver, 22-item engaging, 12-item challenging, 7- item neutral communication for AI-patient). The instrument is a coding system specifically designed to measure micro-level verbal and nonverbal communication behaviors in dementia based on Communication Accommodation Theory (CAT). Examples of the instrument items are correcting, back-channeling, head nodding, and use of humor. The instrument showed adequate evidence of reliability and validity and feasibility and ease of use in video observational analysis of dyadic communication between PLWD and caregivers (Kim et al., 2022), In addition, the AI feedback and the overall scoring within the simulations will be used to assess the changes of communication skills of direct care workers.

Competence in dementia care will be assessed at pre- and post-intervention using Sense of Competence in Dementia Care Staff scale (SCIDS). This scale consists of four subscales, professionalism, building relationships, care challenges, and sustaining personhood (Orrell et al., 2012).

Study Procedures

1st phase: Development of VICTORI modules. We will develop initial dementia communication scenarios based on the literature, DCODE, and AI technology. The simulation training modules will consist of approximately 50 minutes of pre-briefing, simulation facilitation, and debriefing by a trained simulationist, to ensure deeper learning on person-centered dementia communication (Watts et al., 2021).

- AI Patients: We will utilize AI patient models with unlimited dialogue, emotional responses, personalities, and moods. We can customize these characters to standardize scenarios with training through Large Language Models (LLMs).
- AI Pathophysiology: The AI system moderates simulations by using dynamic and responsive pathophysiology with a large database of conditions, event triggers, and physiology to simulate a realistic patient experience without an instructor required to be present.
- AI Grading System: Our automatic grading system includes AI prompts that the database will collect contextual performance evaluation based on what the student performs during the simulation.

The initial VR-AI simulation scenarios will consists of care-related and social communication scenarios with PLWD, based on the PI's previous studies investigating video-recorded home-care interactions between PLWD and family caregivers (Kim et al., 2023a; Kim et al., 2023b; Kim et al., In review; Kim & Liu, 2022; Kim et al., 2024). The scenarios will have a beta test with technological support to test plausibility of the scenarios. In addition, trained simulationists will tailor the context and content of the communication with AI-generated PLWD and pre- and de-briefing. The modules will be re- viewed by an advisory board of simulationists with expertise in nursing, communication, dementia, and caregiving, and subset of direct care workers (n = 4) from the research sites to provide comprehensive feedback on the simulation scenarios. Subject matter experts will review each scenario on the relevancy and representativeness of content in measuring person-centered dementia communication (Terwee et al., 2007) and calculate a Content Validity Index [CVI]) (Polit & Beck, 2006). The feedback will also include context of communication, real-time feedback, visualization, verbalization, non- verbal communication, and pre-briefing and post-simulation de-briefing components.

2nd phase: Testing of the VICTORI intervention. Our primary contact person in each site will facilitate our research and participant recruitment at each site. The research team will follow up with all potential participants who contact the PI's directly or are referred by the primary contact person at the research sites. Pre-intervention self-report questionnaires and demo- graphic information (e.g., age, gender) will be collected.

We will provide six VR simulation training modules to participants based on the prior study (O'Rourke et al., 2023), that was determined as the most feasible and appropriate timeframe to evaluate the intervention's preliminary impact. The intervention will be scheduled and delivered at the research sites on a weekly basis during participants' work hours. All six, an hour-long, VR simulation trainings by each participant will be recorded in MP4 format for analysis of communication skills and engagement of AI-generated patient. The participants will wear the wristband five minutes before, during, and five minutes after the VR-AI simulation training to collect real-time physiological data. Qualitative interviews will be conducted pre- and post- intervention to assess participants' expectations as well as their acceptability of and satisfaction with the intervention.

Planned Data Analysis

Self-report questionnaire data will be analyzed using descriptive statistics, including mean, percentage, and standard deviation. Evaluation of communication skills and patient engagement will be conducted using the video-recorded VR-AI simulations with a behavior data analysis program, Noldus The Observer® XT 17.0 (Noldus Information Technology Inc., Leesburg, VA, USA). Continuous data such as video recordings and physiological data will be characterized using mean, percentage, standard deviation, rate, and relative frequency to describe the participants. Next, we will perform timed-window sequential analysis to assess temporal relationships between physiological data and communication skills as well as staff and AI-patient communication (Kim et al., 2023). Finally, we will perform machine learning techniques to make predictions and identify patterns of collected data: Cross-validation with the optimal tuning parameter lambda generated from the glment package in R, logistic Least Absolute Shrinkage and Selection Operator (LASSO) regression, Principal Component Analysis (PCA), Bayesian mixed-effects modeling, and pattern recognition method such as Decision Trees, Random Forests, and k-Nearest Neighbors.

Benchmarks for Success

This proposal is explicitly designed to develop and test usability and acceptability of communication training intervention using VR and AI-generated patients for direct care workers. By the conclusion of this study, VR simulation scenarios will be developed and accomplish acceptability and

usability with no or minimal refinement. Participants will report acceptability and satisfaction on the VR simulation, no to minimal side effects with VR simulation, and report improved communication knowledge, skills, and competence in care for PLWD.

Future Directions

The VICTORI intervention, if successful, will lead to a clinical trial to test efficacy, effectiveness, and cost-effectiveness of VICTORI on staff time and facility regulations and guide- lines related to person-centered care across multiple LTSS. A larger sample size and randomized control trial design will allow for more accurate estimation of the results. Higher doses of the training and follow-up assessments will be assessed in assessing long-term impact of the intervention. Analysis of actual interaction between staff and PLWD will add more robust effects of the VICTORI intervention to en- hance communication skills and PLWD satisfaction on quality of care. In addition, we will adapt the VICTORI project to family caregivers in community settings to enhance their communication skills and relationships with their loved one living with dementia to provide family members with the necessary support needed to in care for their loved one, reducing caregiver burden, and improving communication be- tween PLWD and family caregivers.

Broader Impact Statement

The VICTORI study is a proof-of concept study that tests the plausibility of the VICTORI intervention consists of the two phases: the development VR communication training for direct care workers using AI-generated dementia patients; and testing its usability, acceptability, and effectiveness through pre- and post-tests, involving 30 workers in North Texas. Training includes six VR sessions, real-time feedback, and detailed communication evaluations. The participants are the direct care workers who work with PLWD in two LTSS, including assisted living, independent living, memory care, and home care settings located in North Texas. This project is the first project that will address the communication challenges faced by direct care workers in dementia care by using VR and AI-generated patients. The VICTORI intervention aims to enhance communication skills, knowledge, and competence. This innovative training method can lead to improved care quality and better outcomes for persons living with dementia. This project will also support PLWD to stay home longer by enhancing communication skills of direct care workers. Enhanced communication leads to better understanding and management of dementia symptoms, reducing the need for institutional care. This allows PLWD to receive high-quality, person-centered care in their own homes, promoting their well-being and independence.

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