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Abbreviations: (Cine-VR) Virtual reality cinema, (DAS-3) Diabetes Attitude Scale-version 3, (DPT) Doctor of Physical Therapy, (JES) Jefferson Empathy Scale, (PQ) Presence Questionnaire, (SDH) Social Determinants of Health

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Introduction/Background

Social Determinants of Health (SDH) are **circumstances over the life course that affect functioning and risks related to health outcomes.** Disparities are associated with SDH,[1] and although health care and disease prevention strategies have improved, health disparities persist and may intensify for people with chronic conditions including diabetes.[2] **For example, people with diabetes who are experiencing food insecurity may not have healthier food options and lack of transportation may prevent them from accessing quality healthcare.** In a scientific review of the impact of SDH on care for the chronic condition of diabetes, interventions addressing SDH improved outcomes.[3] **Interventions that addressed SDH for people with low literacy/health numeracy improved diabetes self-management for people with type 2 diabetes[3] and can improve diabetes knowledge and self-care[4] To address SDH disparities, another intervention conducted a pilot program providing healthy food, blood glucose monitoring, self-management support, and primary care referrals. Improvements in A1C, fruit and vegetable consumption, increased self-efficacy, and medication adherence were found[5] comparable results were also found in a randomized controlled trial of the intervention[6]**

SDH are aspects of the patient context that health professionals may not adequately assess during the clinical encounter, despite being essential components of a patient's overall health status.[7] The need for improved education in SDH and humanistic aspects of healthcare has been identified as one of the emerging trends critical to the future of health professions education,[8] including physical therapist practice.[7] Therefore, health professions students must

recognize the importance of integrating SDH into clinical care to achieve favorable outcomes; however, simply discussing SDH may not be sufficient to foster awareness and agency.

Broadening the capacity for empathy is recognized as a mechanism to facilitate connection between students and patients. Social empathy allows "the ability to understand people by perceiving or experiencing their life situations and as a result, gaining insight into structural inequalities and disparities." [9-11] Empathic capacity also enhances therapeutic relationships and patient outcomes [12] **by viewing patients as people, not just medical conditions.**[13] **Amini 2021 argues that minimal understanding of the effects of SDH in dental practice may negatively impact outcomes by causing unconscious bias, and that improving empathy will provide clinicians strategies to mitigate the negative effects of SDH on health.**[14] **A similar argument is offered by Yeary**[15] **stating that improved empathy can overcome unconscious bias that contributes to health care disparities. Peralta**[16] **offers promising outcomes in describing the effects of a SDH curriculum on empathy levels of medical residents in pediatrics, although data remains unpublished.** Because improving empathy in health professions students is challenging, and typically requires exposure to patients in clinical care environments, recent pandemic restrictions necessitated an innovative approach to simulate patient exposure for DPT students in lieu of an early clinical rotation.

Wellbery asserts that educational curricula must develop new methods of engaging students in the care of vulnerable groups as the effects of SDH on health disparities and outcomes are increasingly understood.[17] Virtual reality and simulation have been effective teaching modalities to increase empathy toward older adults across several health professions programs, including physical therapy education. [18,19] Specifically, cinematic-virtual reality (cine-VR) has been used as an innovative approach to improve diabetes attitudes among health care

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practitioners and administrators.[20] Cine-VR provides an opportunity to interact with a patient and to observe how the environment is related to the patient's values and health behaviors. Moreau recommends storytelling as a powerful tool to facilitate student immersion in another's experience.[21] Digital storytelling in health professions education may facilitate development of several skills including: 1) understanding diversity, oppression, and social justice issues; 2) conceptualizing patient-centered care; 3) caring for underserved populations; and 5) caring for those with chronic health conditions.[21] To provide DPT students a meaningful connection with a patient's lived experience, digital storytelling was implemented using cine-VR modules as an innovative alternative to direct clinical exposure allow students to envision the effect of SDH on health decisions, improving empathy and attitudes toward the patient experience and needs.[20] This project's purpose is to describe the effect of the Cine-VR virtual immersion on DPT students' empathy and attitudes toward diabetes.

Methods

Overview

This project received exempt IRB (Institutional Review Board) approval from the academic institution. A mixed methods convergence design with qualitative data interpreting the quantitative findings was employed.

Recruitment

Students were recruited from a second semester DPT course, Psychosocial Aspects of Healthcare, designed to provide foundational knowledge and application of the behavioral sciences to clinical practice. Students develop professional identity and role with others to enhance interactions with patients/clients, family, caregivers, and providers. Students also engage in self-assessment and exploration of personal beliefs, biases, and judgments related to

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human interactions required of a health care professional, identifying critical issues influencing health beliefs and behaviors in the larger contextual framework of practice including SDH.

Students were sent surveys at three timepoints: baseline, post, and six-weeks after the post survey. The first survey asked for permission to use their responses for our study and all students agreed.

Power Analysis

An a priori power analysis using Statulator,[22] an online statistical calculator, estimated need for a total sample size of 34 participants to achieve 80% power at a 5% significance level (p<0.05) and to detect an effect size of **0.5** between two pairs.

Cinematic 360-Degree Virtual Reality Simulations

The simulated patient encounter utilized a professionally produced, 360-degree, virtual reality cinematic video designed to educate students about diabetes and SDH. Students viewed twelve **cine-VR including 360 audio and visual simulations giving the viewer a sense of physical presence in the space**, observing interactions between the main character and her primary care physician, pharmacist, family, and community. **The cine-VR simulations are described in detail elsewhere**.[20,23] The main character is Lula Mae, a 72-year-old woman with type-2 diabetes experiencing the negative effects of SDH on health care access and decisions. Lula Mae is a primary source of support for her extended family; therefore, her own health care needs are deferred to meet the daily needs of the people she loves. Strong sub-themes include provider burnout, challenges with managing the healthcare system, and the importance of compassion in healthcare. Especially pertinent to DPT students are vignettes that highlight fall risks in the home and a developing foot ulcer, coupled with Lula Mae's hesitancy to consult her physician.

Wardian JL, Wells TM, Cochran TM. Creating Patient Context: Empathy and Attitudes Toward Diabetes Following Virtual Immersion. Journal of Diabetes Science and Technology. 2023; doi:10.1177/19322968231174441

Measures

Quantitative measures were administered at three timepoints: baseline, post-cine VR intervention, and 6-weeks after the initial post-assessment.

Diabetes Attitude Scale-3

The Diabetes Attitude Scale-3 (DAS-3)[24] is a 33-item scale that measures diabetes-related attitudes with five discrete subscales: 1) *Need for special training* (Cronbach α=0.67), 2) *Seriousness of type 2 diabetes* (Cronbach α=0.80), 3) *Value of tight glucose control* (Cronbach α=0.72), 4) *Psychosocial impact of diabetes* (Cronbach α=0.65), and 5) *Attitude toward patient autonomy* (Cronbach α=0.76). Health care professionals are asked to rate their level of agreement on a 5-point Likert scale, ranging from 1=strongly disagree to 5=strongly agree. The scale demonstrates good internal consistency and high content validity.[24] **Sample statements include, "people who do not need to take insulin to treat their diabetes have a pretty mild disease."; "diabetes affects almost every part of a diabetic person's life." and "tight control is too much work."**

Jefferson Empathy Scale

The Jefferson Empathy Scale (JES) is a valid scale used to measure empathy in health professions education. Empathy is conceptualized as "A *cognitive* (as opposed to affective) attribute that involves an *understanding* of the inner experiences and perspectives of the patient, combined with a capability to *communicate* this understanding to the patient."[25,26] **Sample questions include, "I try to think like my patients to render better care." and "Empathy is a therapeutic skill without which success in treatment is limited."**

Presence Questionnaire

The 32-item Presence Questionnaire (PQ)[27] **was used at post** and measures the subjective experience of being in a virtual environment when a person is physically situated in another. It uses a 7-point scale, ranging from 1=not at all to 4=to 7=completely. We used a subset of 15 questions from the questionnaire (Cronbach α=0.88) and calculated our own internal consistency for each subscale using a reliability analysis. There were three subscales: 1) *Involvement*, 2) *Sensory Fidelity*, and 3) *Adaptation and Immersion*. ***Involvement*** **measured the participants sense of being a part of the environment** (Cronbach α=0.81)**. Sample questions included, "How natural did your interactions with the environment seem?" and "How much did your experiences in the virtual environment seem consistent with your real-world experiences?"** ***Sensory Fidelity*** **measured how well the participant perceived a sensory experience** (Cronbach α=0.72)**. Sample questions included, "How well could you identify sounds? and "How closely were you able to examine objects?"** ***Adaptation and Immersion*** **measured how well the participant adapted to the immersive environment** (Cronbach α=0.77)**. Sample questions included, "How quickly did you adjust to the virtual environment experience?" and "Was the information provided through different senses in the virtual environment (e.g., vision, hearing) consistent?"**

Data Collection

DPT students completed baseline assessments **prefaced with the informed consent** prior to viewing the twelve modules introducing them to their patient, Lula Mae. Baseline assessment included demographic questions, the DAS-3, and the JES. Students viewed all modules, which were 12 individual video lessons, taking about 70 minutes to view. During a subsequent class, students were given time to reflect upon the cine-VR using a clinical narrative process.[28] Students were provided with the link to the post assessments for the three scales, including their

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identifier to ensure proper matching. Six weeks after post-assessment, students were emailed the final assessment.

Classroom Debriefing

Classroom discussion occurred one week after the reflection exercise and initial post-assessment. Discussion was facilitated by the instructor and recorded via Zoom conferencing. Semi-structured questions were used to prompt discussion, including understanding personal stressors for Lula Mae, food insecurity, transportation challenges, paying for prescription medication, understanding, and navigating the broader healthcare system, provider burnout, and comorbidities associated with diabetes. **This convenience sample included all students who chose to take part in the discussion.**

Data Analysis

Quantitative Data

Statistical analyses were completed using SPSS v27. [29] Baseline and post-assessment data were matched using student identifiers. Paired t-tests were conducted to determine differences in scales and subscales from baseline to post-test scores. Repeated measures ANOVA (analysis of variance) determined differences among baseline, post, and 6-week assessment data.

Qualitative Data

Recorded narrative data were transcribed verbatim, yielding low-inference data. **Additional standards of verification were employed to enhance the study's methodologic rigor.**[30] **Two coders triangulated data sources during the open coding phase,** assisted by use of the software program MAXQDA v20.1.1.[31] **During this process, a project team member who was involved in development of the virtual modules (EB) and a project investigator (JW) reviewed all transcripts reviewed and coded independently.** Investigators then

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examined, compared, expanded, or condensed all codes until saturation was reached and themes were sufficiently categorized. **When discrepancies were found, the negative cases were analyzed to determine if additional codes were needed. Finally, rigor was enhanced by an external audit of the data analysis performed by a project investigator with expertise in qualitative methods, but who had not participated in initial phases of data reduction and analysis (TMC).** The selected quotations best represent the resultant themes from the narrative data.

Quantitative Results

Demographics

All participants were first-year DPT students. Most students were **White** (82.6%) and female (68.9%). **The majority of the students were on the urban campus in Omaha** (81.5%), versus the rural campus in Kearney (18.5%). In addition, 52.5% of students indicated they had a close friend or family member with diabetes.

Baseline assessments included all 121 students from both campuses. Post assessment included 93 students (76.9% response rate), resulting in 93 matched surveys from baseline to post. The 6-week post survey included 58 (47.9% response rate) matched assessments across all 3 time points.

Diabetes Attitude Scale-3

Mean (M) and Standard Deviation (SD) scores for the five DAS-3 subscales were calculated (M are shown in Table 1). Students agreed with *Need for special training* (M=4.65, SD=0.32), *Seriousness of type 2 diabetes* (M=4.04, SD=0.49), *Value of tight glucose control* (M=3.88, SD=0.41), *Psychosocial impact of diabetes* (M=4.22, SD=0.44), and *Attitude toward patient autonomy* (M=3.98, SD=0.43). After viewing the 12 modules, four of the DAS-3

subscales significantly increased: *Seriousness of type 2 diabetes* [M=4.32, SD=0.46; t(59)=-4.936, p<0.001], *Value of tight glucose control* [M=4.01, SD=0.48; t(59)=-2.547, p=0.013], *Psychosocial impact of diabetes* [M=4.62, SD=0.39; t(59)=-6.807, p<0.001], and *Attitude toward patient autonomy* [M=4.22, SD=0.36; t(59)=-5.604, p<0.001]. No significant change in *Need for special training* was observed. Results include 59 student responses matched across all 3 time points. Three domains significantly increased from baseline assessment at the 6-week time point: *Attitude toward patient autonomy* [M=0.75, SD 0.45; t(58)=12.742, p<0.001], *Psychosocial impact of diabetes* [M=-0.21, SD=0.41; t(58)=-3.854, p<0.001], and *Seriousness of type 2 diabetes* [M=-039, SD=0.44; t(58)=-6.780, p<0.001], indicating a sustained effect over time. However, *Value of tight glucose control* [M=0.92, SD=0.34; t(58)=20.764, p<0.001] significantly decreased. *Need for special training* [M=0.05, SD=0.36; t(58)=1.158, p=0.25] was not significantly different from baseline assessment to 6-week follow-up due to the ceiling effect.

Jefferson Empathy Scale

Students scored moderately high on the JES baseline assessment (M=81.87, SD=3.93) and higher after viewing the modules [M=-080, SD=4.31; t(59)=-1.437, p<.078]. Six weeks following post-assessment, students received the link with the DAS-3 (Figure 1) and JES (Figure 2).

Repeated measures ANOVA with Greenhouse-Geiser correction determined that JES scores differed significantly among the three timepoints (*F*(1.941, 11.682)=48.796, p<0.001). Post hoc analysis with a Bonferroni correction adjustment revealed that JES statistically increased from baseline to post (5.74(95% CI (Confidence Interval) 4.30 to 7.19), p<0.001) and from baseline to six-weeks (0.90(95% CI -611 to 2.40), p<0.001) and

Wardian JL, Wells TM, Cochran TM. Creating Patient Context: Empathy and Attitudes Toward Diabetes Following Virtual Immersion. Journal of Diabetes Science and Technology. 2023; doi:10.1177/19322968231174441

from post to six-weeks (-0.90(95% CI -2.40 to 0.61), p<0.001). These data suggest the cine-VR 12-module simulation had a sustained impact on students' empathy.

Presence Questionnaire

Following the virtual patient encounter, we observed mean scores ≥5.08 from a maximum score of 7.0, for all three subscales: *Involvement* (M=5.41, SD=0.83), *Sensory Fidelity* (M=5.12, SD=0.92), and *Adaptation and Immersion* (M=5.08, SD=0.64. The high subscale scores demonstrate favorable perceptions of the technology and sense of presence in the cine-VR simulations.

Qualitative Results

Seventeen students actively participated in the focus group discussion. The following themes emerged from data analysis (refer to Table 2 for additional rich quotes):

Feeling of Emotional Investment in Patient's Life

When reflecting on the Cine-VR simulations, many students commented on the emotional impact of their experience, acknowledging their emotional connection with the main character, Lula Mae, and how she was treated by providers and family members.

> *"I was very emotionally invested in this, and I think I was in tears in the first 5 minutes. As we went along, I was just shocked at how her daughter treated her and they were definitely not helping."*

Students described intense reactions to simulations that emphasized barriers Lula Mae faced trying to manage type-2 diabetes. Students expressed feelings of overwhelm, anger, and frustration in watching Lula struggle with these challenges. Students connected to their own family relationships and how similar or different those relationships were in the simulation.

Virtual Reality Simulations Helped Students Recognize Potential Impact of Social Determinants of Health

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Cine-VR simulations offered students a glimpse into the home life of Lula Mae. Students observed how SDH interfered with her diabetes self-care. Students readily identified the different SDH, including financial insecurity, food insecurity, transportation barriers, medication and supplies cost, and lack of social support:

> "*I think a big one's economic stability. If I remember right, they're in Appalachia, right? So, that's a very low-income part of America and so just being in that area usually the economic problem and then also education, the literacy could be a little bit lower than in other economically stable places."*

Regarding lack of social support, students observed that having a large family did not always translate into support.

> *"I was just really surprised that everybody kept saying, 'Oh she's got a big family. They'll take care of her." The pharmacist said it. The mechanic said it. The physician said it. Everybody said the family will help and obviously the family was not helping as much as they thought they were…We can't just assume that family members will take care of our patients for us once they leave the clinic."*

Students Identified Areas to Improve in Future Patient-Provider Interactions

The cine-VR series portrayed problematic visits between Lula Mae and her physician and pharmacist via two interactive guided simulations of a private conversation with the provider and a recreation of Lula Mae's challenging visits with the physician and pharmacist. The goal was to help students recognize strategies to improve the patient-provider relationship. Students identified eye contact, therapeutic tone of voice, nonverbal communication, and interruption as areas of providers' communication deficits. In addition, students identified failure of providers to advocate for Lula Mae in negotiating the health care system, especially when there were obvious signs that she needed assistance:

> *"Another thing that kind of surprised me was how the people that were giving her medical care, the pharmacist, and the doctor, weren't willing to take that extra step of asking why she was late or why have you not filled out these forms in order to get this? Or help with payment and things like that. They weren't going that extra step in helping her."*

Wardian JL, Wells TM, Cochran TM. Creating Patient Context: Empathy and Attitudes Toward Diabetes Following Virtual Immersion. Journal of Diabetes Science and Technology. 2023; doi:10.1177/19322968231174441

Discussion

Principal Findings

This study assessed DPT students' empathy and attitudes toward diabetes before and after immersion in a 360-degree cine-VR patient encounter. After viewing the interactive modules, significant differences in empathy levels (JES) and diabetes attitudes in four DAS-3 subscales were found, including: ***Seriousness of type 2 diabetes*** **(M=4.32, p<0.001),** ***Value of tight glucose control*** **(M=4.01, p=0.013),** ***Psychosocial impact of diabetes*** **(M=4.62, p<0.001), and** ***Attitude toward patient autonomy*** **(M=4.22, p<0.001). No significant change in** ***Need for special training*** **was observed.**

To determine if these results lasted beyond the immediate post assessment, DAS-3 and JES were measured at the 6-week timepoint. **Significant increases the subscales** ***Attitude toward patient autonomy*** **(M=0.75, p<0.00),** ***Psychosocial impact of diabetes*** **(M=-0.21, p<0.001), and** ***Seriousness of type 2 diabetes*** **(M=-039, p<0.001); significant decreases in the DAS-3 subscale** ***Value of tight control*** **(p<0.001) was observed at 6-weeks; with no significant difference in** ***Need for special training*** **(p=0.25).** However, significant increases in JES were maintained throughout **(p<0.001), indicating the cine-VR 12-modules had a sustained impact on students' empathy up to six weeks after intervention.** Finally, high scores on the PQ, indicated a sense of being immersed in technology.

It is possible that concurrent curricular exposure to the pathophysiology of diabetes in a different course may have influenced the student perception of ***Value of tight control,*** **as students received this instruction between post-assessment and 6-week assessment.**

Qualitative analysis provided insight into student learning that stimulated emotional reactions, discerned "patient" context, and effect of SDH on health status and identified provider

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errors that jeopardized patient-provider interaction. **We believe these insights may explain JES scores in students.**

Similar to our study's purpose, research in pediatrics has explored the effect of a curriculum in SDH on empathy levels in residents, and favorable outcomes in dentistry exist when using virtual reality to improve students' empathy by simulating care for families with language barriers and limited resources. The current study, however, is the first to measure empathy and attitudes specific to diabetes in physical therapy students following a virtual reality immersion to facilitate understanding of the influence of SDH on health access and decisions. In addition, implementation of the cine-VR modules in the DPT curriculum addressed several educational needs, including student engagement in a shared "patient" experience, appreciating multiple perspectives as >60 students were immersed and filtered information differently. Debriefing was a critical reinforcer for communication and perspective in team dynamics. The modules deepened an understanding of SDH by artfully introducing the context a "real" individual and how she, her providers, family, and community are intertwined in simultaneous navigation of a chronic health condition embedded in complex social circumstances. Cine-VR technology provided a window into areas of a patient's life that practitioners may not recognize in routine patient care visits, but students can better appreciate the patient's challenge to manage diabetes within her family and community contexts. The immersive technology also allowed a realistic "patient" encounter during a time of clinical disruption due COVID-19 restrictions, confirming cine-VR's utility to enhance flexible learning experiences. In addition, students who participated in this experience independently recalled and applied Lula Mae's situational factors during a health promotion course two years later in the DPT curriculum (Fall, 2022).

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Limitations

This is a small study in one DPT course over two years at a Midwestern university with two campuses; **thus, there is a selection bias in not expanding to other programs and areas of the country. We note this is a homogenous sample of DPT students in terms of race/ethnicity and may impact their responses. While identifiable student data were not shared with the instructors, students may have felt the need to respond in a socially desirable way, which could bias results. There was no control group and other classes, and experiences may have affected student responses; therefore, student attitudes may not be solely due to the intervention. The lack of matching data throughout the 6-week period is a limitation as only 47.9% of students completed all three surveys.**

Conclusions

Cine-VR technology can provide an engaging and enduring learning experience for students, as evidenced in this project focused on diabetes management. Using cine-VR modules as a clinical exposure has the additional advantage of flexibility within the context of a busy student schedule. Although not a substitute for direct patient interaction, these modules may augment the clinical rotation and allow for a shared experience among students that enables in-depth classroom discussion. The cine-VR technology provides realistic engagement with the "patient" context, illustrating effects of SDH on health decisions that prevent management of diabetes. This learning experience could be easily tailored for the education of health professions beyond physical therapists, as well as complex, chronic conditions other than diabetes. Because the effects of SDH and chronicity are multifactorial and require expertise beyond individual professions, this immersive learning experience also offers a dynamic platform for interprofessional learning and a focus on meaningful change in community health promotion and

Wardian JL, Wells TM, Cochran TM. Creating Patient Context: Empathy and Attitudes Toward Diabetes Following Virtual Immersion. Journal of Diabetes Science and Technology. 2023; doi:10.1177/19322968231174441

disease prevention initiatives to prevent chronicity. Practitioner attitudes and empathic capacity are fundamental to patient empowerment for self-care.

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