Virtual Reality Experience In Long Term Care Resident Older Adults With Dementia: A Case Series

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Abstract

BACKGROUND: Behavioural and Psychological Symptoms of Dementia (BPSD) worsens as dementia progresses, intensifies caregiver distress and consequent institutionalization. We wanted to evaluate feasibility of Virtual Reality (VR) as non-pharmacologic intervention for BPSD in a long-term care home.

METHODS: A single site (Henley Place at London, Ontario) case series with a convenience sample (24 older adult residents with moderate to severe dementia). Intervention was 30 minutes of VR experience with Broomx®, five days a week for two weeks.

RESULTS: Implementing VR experience was possible at Henley Place (recruitment rate=40%, the adherence rate=21%, and the attrition=0%) and participants could tolerate it. No adverse events and one-to-one staff use were recorded during the intervention period.

CONCLUSION: VR experience can be implemented in a care home.

TRIAL REGISTRATION: The study was not registered as clinical trial. We obtained ethics approval from ADVARRA Canada Ethics Board before recruiting participants for the study.

Background

Dementia is a progressive neurocognitive condition, predominantly affecting older adults that evolves to disability and, eventually, mortality [1]. There is no cure for dementia [1]. According to the Alzheimer's Association [2], over 747,000 Canadians are living with dementia. The annual dementia incidence rate in Canada was 360 per 100,000 people in 2011 [3]. In 2016, dementia ranked the fifth leading cause of death worldwide [4]. Dementia accounted for 6.3% (95% confidence interval [CI] 5.4% to 7.5%) of disability-adjusted life in years for the people aged 70 years and over [5].

Behavioural and psychological symptoms of dementia (BPSD) is common in people with dementia that may include but are not limited to symptoms such as apathy, depression, agitation, aggression, sleep disorders, and psychosis [6, 7]. The most frequent disturbances reported were anxiety/agitation/aggression (52%; 95% CI 47% to 57%), apathy (36%; 95% CI 31% to 41%), depression (32%; 95% CI 28% to 37%), sleep disturbance (27%; 95% CI 23% to 32%) and irritability (27%; 95% CI 23% to 32%) [7]. Lyketsos and colleagues [7] reported 75% (95% CI 70% to 79%) of participants with dementia exhibited at least one BPSD from the onset of their cognitive symptoms. Depression and apathy are common in vascular dementia [8]. Frontotemporal dementia typically presents with gross decline in behaviours (BPSD) and speech/language [9] with disinhibition and eating disturbances being common [8]. In Alzheimer's dementia, delusion is common [8]. Family members of individuals with dementia reported that their loved ones' BPSD are the reason for their decision in placing them in a long-term care home [10, 11].

Apathy is characterized by a lack of emotional responsiveness [12]. On the other hand, depression symptoms include loss of energy/interest, change in appetite, impaired concentration, insomnia, sadness, anhedonia, suicidal ideation, self-blame, weight change, sexual disinterest, and hypersomnia [13]. Apathy and depression in individuals with dementia are associated with other behavioural symptoms [14]. For instance, apathy is associated with disinhibition and abnormal motor behaviour, whereas depression is associated with anxiety, agitation, irritability, and hallucinations [14].

Typically, agitation is referred to as inappropriate verbal, vocal, or motor activity that cannot be otherwise explained [15]. Agitation may include rejection of care, noncompliance, uncooperative behaviour, resistance to care, and aggression [16]. Aggression can be explained as deliberate, overt, and harmful acts toward another person, object, organism or one's self [17]. Possible causes of agitation/aggression in individuals with dementia include pain, medical illness, loneliness, boredom, medication side effects, environmental changes, and fatigue [18].

Sleep disorder in individuals with dementia includes difficulty falling asleep or staying asleep, sleep fragmentation, wandering, and excessive daytime sleepiness [19]. The causes of sleep disorder in individuals with dementia may include disturbances of their circadian rhythm, pain or discomfort, medications, anxiety, and depression [20]. Disturbances in circadian rhythm refer to early sleep onset and offset, late sleep initiation and rise time, and irregular sleep–wake rhythm [21]. The neurodegenerative changes in dementia (deposition of amyloid and tau) can impair melatonin production and release from brain that consequently may affect the circadian rhythm [22]. A five-year retrospective survey on institutionalized individuals with dementia (n=2447) reported sleep disorder as a common complaint (> 50% of cases) in later stages of the condition irrespective of types of dementia [23]. Inadequate or poor-quality night-time sleep can impact a person's daytime functioning and quality of life [24].

According to the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.) and the World Health Organization, the central concept of psychosis is impaired reality [25, 26]. Hallucinations (without insight into their pathologic nature), delusions, or both are present in psychosis [25, 26]. Psychotic symptoms are less common than depression, agitation, and sleep disorders in individuals with dementia [27]. However, psychosis can be a source of distress for both individuals with dementia and their caregivers [27].

Managing BPSD is often challenging as the causal relationship of the symptoms and pathophysiology is complex [28]. For example, an individual with dementia may exhibit BPSD due to pain necessitating pain management instead of psychotherapy [29]. However, available pharmacotherapies for BPSD has limited effectiveness in terms of possible serious side-effects resulting from multi-morbidity or polypharmacy or age-related altered metabolism [30]. Consequently, BPSD management is increasingly focusing on maintaining an optimal quality of life with non- pharmacotherapies [31]. The Registered Nurses' Association of Ontario best practice guideline on dementia management recommends non-pharmacologic interventions to manage BPSD for individuals with dementia, irrespective of drug treatments received [32]. Various activities (e.g. listening to music, singing, dancing, reading, painting, drawing, cooking, knitting, talking, listening to others, playing with a pet, playing video games, and virtual reality [VR] experience) engaging individuals with mental stimulation, reminiscence, and orientation had been used as non-pharmacologic interventions in clinical setting [33-35].

VR experience is considered a computer-generated non-pharmacologic intervention focusing on sensory stimulation using a virtual environment [35, 36]. An individual using VR can look around or move around in an artificial environment [36]. This technology requires the user to either use a headset or a projector (e.g. BroomX©) to generate realistic images, sounds and other sensations that simulate an user's physical presence in a virtual or imaginary environment [36]. The technology does not need a specialist/technical person to setup the machine, to use the VR program [35] and is cost effective for people with psychotic disorders [37]. A randomized control study in hospitalized patients (n=116) with psychotic disorders found that six months' VR experience improved participants' Quality-Adjusted Life Years (effect size [ES]=0.01, 95% CI 0.03-0.07) [37]. The average cost of gained Quality-Adjusted Life Years was Euro 42,030 [37].

BroomX© provides an immersive experience with images and sound through a projection device having automatic control to conform the visuals to a 360° experience no matter the size of the room, or what furniture is in the room [38]. Individuals with dementia enjoy virtual experiences [35, 39] but its effect can be negligible on emotion (ES=0.1, 95% CI -0.07 to 0.36) and execution of daily activities (ES=0.1, 95% CI -0.3 to 0.49) when provided with a headset without music [40]. Unlike other types of VR technology, users of BroomX© can experience VR without headset, control the distance of images (bringing the image closer for better look) to get an interactive experience and can incorporate customized music with customized images [38].

To date there is no published research about the use of VR experience with BroomX© as a non-pharmacologic intervention in LTC residents with moderate to severe dementia and BPSD. Therefore, we considered the technology worth exploring and decided to conduct a feasibility pilot in a care home.

Our objective was to explore the feasibility of VR experience. We evaluated 1) the rate of recruitment, adherence and attrition; 2) participants' tolerance for VR; 3) facilitators and barriers to implementation of VR to achieve that objective.

Methods

Study design

A single site case series.

Participants

Older adults (aged ≥ 65 years) residing in a care home at London ON Canada with a Cognitive Performance Scale score between 3 to 5 and exhibiting at least one BPSD were eligible to participate in this study. Ontario long-term care homes regularly evaluate their residents' cognition with Cognitive Performance Scale score [41]. The scale includes four areas: memory, decision-making skills, communication and eating [42]. Residents experiencing no difficulties in these four areas score 0, whereas residents having severe memory problems and are unable to make daily decisions or feed themselves or are comatose score 6 on the scale [42]. A Cognitive Performance Scale score 0 indicates no dementia, whereas a score of 1-2 indicates mild, score of 3 indicates moderate, and score of 4-6 indicates severe dementia [42]. We excluded those diagnosed with epilepsy, those who were blind, at end of life, and unable to communicate in English. We also excluded those having substitute decision-makers appointed as Public Guardian and Trustee.

One care home staff member identified the possible participants using their Cognitive Performance Scale score. Once identified, the care home staff spoke with participants' substitute decision-makers face-to-face or by phone to learn if they would agree to be contacted for a possible study participation. Once agreed, we (KC, Research Assistant) contacted the substitute decision-makers from November 26, 2018 to January 04, 2019 to recruit participants.

Intervention

The intervention was VR experience using BroomX© technology, introduced in 2017 [43]. The technology uses a MK Player360© hardware and a software [43]. A MK Player360© is a projection device with light and sound control that can provide an immersive experience covering the user's field of vision (180° horizontal view x 120° vertical view) with full high definition resolution [43]. The software provides customized interactive visual and auditory experience accessed by a smartphone app (See Figure 1: Technical information on Broomx©) [43]. The family members informed us about participants' leisure activities, objects of attention, preferences for musical instruments, genres of music, images of nature, and urban scenes. One of us (ASG from Crosswater Digital Media [<https://crosswater.net/>]) customized the multimedia content of BroomX© smartphone app accordingly and created a multimedia library with pleasing images of nature, set to music (72 beats/minute) for this study.

The maximum duration and frequency of the VR experience (intervention) was 30 minutes, five days a week (Monday to Friday) for two weeks. The timing of the intervention was customized for each participant to avoid their usual lunch time, visiting hours, and nap time. However, the two-week intervention schedule was fixed for the convenience of the project. If a participant missed the intervention for the day for any reason, there was no makeup session on a different day. Research Assistant selected the library items for each. If a participant preferred a particular library item, the Research Assistant selected that item several times. There was no limit to the frequency or variety of the played library items.

For safety concern, we stopped the intervention if a participant became agitated with a specific VR library item. Research Assistant was present inside the intervention area during the VR sessions in case the participant needed assistance with postural balance and thus reduced the risk of falls. The care home staff also were on call during the VR sessions in case of any unforeseen adverse events.

We provided the intervention at the care home from November 2018-January 2019. The VR experience was provided using a headset at the beginning of the intervention (November 5-9, 2018) to five participants. We noticed that all five participants felt uncomfortable using the headset as it limited their vision, was too loud, and was heavy. The pilot study was conducted during Ontario flu season. We were obliged to disinfect the headset after each use with a disinfecting liquid, challenging our time management. We did not use headset from then on.

During the second week of the intervention period (November 12-16, 2018), we carried the MK Player360© projector to the participants' own rooms. We plugged the electrical cord from the projector into a working electrical outlet, kept the projector in a vertical position, and used care home's Wi-Fi connection to pair the device with study smartphone. We covered TV with bed sheet, brought down any wall hangings, closed windows and door curtains for a clearer visualization of VR images when setting up MK Player360© projector inside a participant's room. Two participants got agitated when setting up the hardware and software in their own rooms. Our time management also was challenged when assembling/disassembling VR hardware at participant's own room. From that time forward, we assembled MK Player360© projector in a pre-determined area inside the care home before starting the VR sessions to accommodate participants' discomfort and practicality of time management.

Outcome Measures and Statistical Methods

Feasibility of VR experience. 1) The rate of recruitment (the proportion of consenting participants to eligible participants over the 6-week recruitment period), adherence (the proportion of participants attending 10 intervention sessions to the number of participants allocated to the intervention) and attrition (the proportion of participants completing the study to the number of participants allocated to intervention).

2) Participants' tolerance for the VR with measures such as the proportion of participants who were able to tolerate at least 80% of the planned sessions, the mean length of participants' VR experience in minutes per session, number of times each type of negative behaviour observed and the proportion of participants who experienced each negative behaviour, number of times each type of positive behaviour was observed and the proportion of participants who experienced each positive behaviour, number of adverse events during the intervention period, health care resources used (i.e. number of participants requiring one-to-one staff use, psychotropic drug prescription), and change in Euro-Qol 5-Dimension) to indirectly indicate their tolerance to VR experience.

According to the Need Driven Behaviour Model [44], an individual with dementia expresses his/her physical/emotional needs or exhibits his/her dementia symptoms through physical/verbal expressions/gestures. Following this model, we labelled the following behaviours as "negative" for this pilot study: agitation, wandering, hitting (including self), kicking, grabbing onto people, pushing, throwing objects, biting, scratching, spitting, hurting self or others, tearing objects or destroying property, making physical/verbal sexual advances, inappropriate dressing or disrobing, intentional falling, eating/drinking inappropriate substance, handling objects inappropriately, hiding objects, hoarding objects, performing repetitive mannerisms, screaming, cursing or verbal aggression, repetitive sentences or questions, strange noises (weird laughter or crying), complaining, constant unwarranted request for attention or help, pulling away/walking away, perseveration of word/repetitive talking, raising tone of voice, resisting, and not eating. We labeled the following behaviours as "positive" based on Henley Place staff members' experience with the participating residents for this pilot study: being seated still, being focused, sleeping better than usual during night time, being calm, smiling, and communicating verbally/non-verbally.

We defined an adverse event as any event due to being in a VR session leading to emergency transfer, hospitalization, death, a persistent or significant incapacity or substantial disruption of the participants' ability to conduct the activities of daily living following Code of Federal Regulations [45].

In our judgement, one-to-one staff usage indicated acute decline or worsening of a participant's health. For instance, the care home may provide a participant one-to-one staffing if he/she causes another individual a physical incident or a sexual incident; becomes physically aggressive (non-manageable) with drug and other therapy; has history of a similar behaviour that ended up on having one-to-one staff usage in the recent past; is in risk of potential self-harm; exhibits an agitated aggressive behaviour or a wandering behaviour; and is at risk of being victimized by another individual. Psychotropic drugs refer to any drug affecting mental processes and behaviour [46]. Psychotropic drugs include, but are not limited to, antipsychotics, antidepressants, antianxiety drugs, mood stabilizers, anticonvulsants, and hypnotics [46]. The Euro-Qol 5-Dimension scale is a generic quality of life tool, insightful in identifying which dimensions of health are most affected by a given condition or treatment [47]. The tool has five domains: mobility, self-care, usual activities (e.g. work, study, housework, family or leisure activities), pain/discomfort, and anxiety/depression with five possible answers for each domain (1=no problem, 2=slight problem, 3=moderate problem, 4=severe problem, 5=unable to do/extreme problem) [47].

3) Facilitators and barriers to implementation of VR included data on the number of times a library item was selected, whether a substitute decision-maker was present during the VR sessions, and factors that were observed to be enabling or disabling during the VR experience.

Data collection. KC and Research Assistant used electronic data capture forms to record the number of participants contacted, consented, completed VR sessions; labelled participants' behaviours during the VR sessions based on direct observation; completed adverse event forms, archived the number of one-to-one staff usage, proportion of night-time sleep, and psychotropic drug prescription at baseline, at the end of first week, and at the end of second week of intervention from the participant's medical chart. The care home staff caregivers completed the Euro-Qol 5-Dimension at baseline, at the end of first week, and at the end of second week of intervention.

Sample Size

We felt that approximately 40% of participants would be eligible and have an substitute decision-maker willing to provide consent to participate in the trial from the care home (192 bed capacity). The reason for our low estimate was that attempts to contact the substitute decision-makers were to take place during Holiday season (Christmas and New Year), which did not optimize access. To maximize the recruitment, Research Assistant contacted substitute decision-makers on weekdays from 9 to 5 and kept the study phone open on evenings and weekends for them to call back. Research Assistant also went into the care home after hours to meet substitute decision-makers in the evenings and weekends. Given this estimate, to be 95% confident we needed 18-27 eligible participants (and their substitute decision-makers) in the population to provide consent [48].

Results

We presented the number of eligible participants who were approached, screened, signed/withdrew informed consent, received/not received the intervention, lost to follow up/discontinued, and analyzed, describing the reasons for each one in Figure 2 (The flow chart for participant enrollment, allocation, follow-up, and analysis).

Six participants failed the screening due to a change of their health condition (Cognitive Performance Scale score >5 [n=2], epilepsy [n=1], palliative care [n=1], blind [n=1], unable to communicate in English language [n=1]). One participant withdrew consent before the intervention started due to a conflicting family visit schedule. The demographic and clinical characteristics of the participants are shown in Table 1.

Objective 1. The recruitment rate was (31/77) 40% (95% CI, 29% to 52%), the adherence rate was (5/24) 21% (95% CI, 7% to 42%), and the attrition was (0/24) 0% (95% CI, 0% to 14%).

Objective 2. 75% of participants were able to complete at least 80% of the sessions. The maximum number of sessions attended by any participant was 10 and the minimum number of sessions attended by any participant was 2. The average

length of participants' VR experience was 22.2 (95% CI, 23.5 to 20.9) minutes per session. The shortest length of a session was 1 minute; this participant was agitated when session started and left the intervention area.

The observed negative behaviours were complaining (n=6), restlessness (n=5), agitation (n=2), calling out for help (n=2), and crying (n=1). Sixteen (66%; 95% CI, 45% to 84%) of the 24 participants experienced at least one negative behaviour and 5/24 (21%; 95% CI, 7% to 42%) participants experienced more than one negative behaviour. The observed positive behaviours were sleeping (n=24), interacting with VR images/attendant (n=19), smiling (n=12), singing/humming (n=5), dancing/ tapping feet in rhythm (n=4), and kissing attendant's hand (n=2). All (100%) participants experienced at least one positive behaviour and 23/24 (96%; 95% CI, 79% to 100%) participants experienced more than one positive behaviour.

All adverse events were observed outside the VR sessions and were not related to the intervention. We noted two adverse events (falls) during the two-week intervention period. Overall, the pilot participants were relatively stable since none of them used one-to-one staff four weeks before and during the intervention period. However, three participants used one-to-one staff service after the intervention (3/24, 13%; 95% CI, 3% to 32%). The dosage of psychotropic drugs remained either unchanged (14/24, 58%; 95% CI, 37% to 78%) or reduced (8/24, 33%; 95% CI, 16% to 55%) after the intervention. The frequencies and proportions by Euro-Qol 5-Dimension indicate no detectable change in participants' health condition from baseline to end of second week of intervention (Table 2). The Euro-Qol 5-Dimension index value using Crosswalk value set for North America (<https://euroqol.org/eq-5d-instruments/eq-5d-5l-about/valuation-standard-value-sets/crosswalk-index-value-calculator/>) based on van Hout and colleagues' [49] work also indicates no detectable change in their health condition (index value mean for Euro-Qol 5-Dimension $\pm$ Standard Deviation [SD] at baseline=0.4 $\pm$ 0.2; at week-1=0.4 $\pm$ 0.3; and at week-2=0.4 $\pm$ 0.3).

Objective 3. The order of instances a library item was selected, from most selected to least selected were Cherry Blossom (an afternoon stroll in the park with blooming cherry flowers set to soft classical music) (127 times), Farm (morning walk in a farmyard with cows and chicken set to animal and bird sound) (61 times), Truck driving (day time simulated driving in the country roads) (34 times), Symphony (a concert playing classical music) (32 times), London, UK (aerial view of city streets and iconic building in London, UK set to soft classical music) (30 times), Bavarian Alps (a morning stroll in the alpine meadow set to bird sound) (15 times), Fishing (simulated fishing in the river set to water sound) (13 times), Dolphin Swim club (simulated under water diving set to water sound) (8 times), Ireland (aerial view of city streets and iconic building in Ireland set to soft classical music) (4 times).

Substitute decision-makers were present in only 2 out of 192 sessions (0.01%, 95% CI, 0.00 to 0.04). The factors enabling participants' VR experience included: 1) use of Broomx® projector instead of headset, 2) the physical proximity of an individual during VR sessions (researchers sitting beside the participant, holding his/her hand), 3) a sound proof room with no visual distractions (e.g. windows, furniture, wall decorations), 4) having the VR set up and running prior to introducing the resident into the intervention area, and 5) knowledge of participants' preferences/dislikes on VR library items. For instance, the library item, Bavarian Alps, brought back traumatic World War 2 memories in a participant; the water themed library items (Dolphin Swim club, Fishing, and Boat ride) frightened a participant; and the Sun and Clouds library item reminded a participant of her departed husband. Avoiding these themes improved their attendance at VR sessions. Library items such as Farm and Truck Driving improved five participants' attendance as they felt a personal connection (used to be farmers/ grew up on a farm or used to drive Harley Davidson motorcycle).

The factors that negatively affected the participants' VR experience included: 1) interrupted internet (Wi-Fi) connection, 2) VR volume too high, 3) auditory distractions like the sound of closing doors and conversations among the staffs and other residents in the hallway, 4) participants' conflicting schedule, and 5) a negative emotional state of the participant (a participant missed five sessions as his ex-wife accompanied him to the intervention area against his will. Once, the ex-wife stopped accompanying him, he continued VR sessions).

Discussion

Overall, this pilot shows feasibility and tolerability of VR experience with BroomX® in a long-term care home. The study recruited typical Ontario care home population. The researchers did not require specialization for setting up and conducting VR sessions. The participants tolerated VR experience without having a substitute decision-maker accompanying them. The intervention was implemented with a projector allowing participants experience VR avoiding headset related challenges. Therefore, this study was pragmatic in nature and likely to be applicable in Ontario care homes.

The intervention period was only two weeks (10 sessions). Five participants missed VR sessions during the first week due to their conflicting schedule and health condition. A longer (four weeks) and flexible (seven days a week) intervention period might have improved the adherence rate. Furthermore, use of headset, intermittent Wi-Fi network and absence of a suitable intervention area also affected the adherence rate.

Individuals with a visual impairment and non-English speakers were not eligible for this pilot. However, after observing our pilot participants, we felt that individuals with a visual impairment might also appreciate the advantages of VR experience through auditory sensation. Further, having music/image-based VR experience, participants need not be capable of communicating in English to appreciate the effects.

A literature search on several databases (ClinicalTrials.gov, Cochrane libraries, EMBASE, ProQuest [Medline, PsycINFO, and Dissertations & Theses Global], PubMed, and Scopus) on August 2020 revealed no efficacy trials comparing VR with other psychosocial interventions in reducing BPSD. Therefore, we cannot comment on possible advantages of VR over other psychosocial interventions. Given the small sample size and study design (case series), we are unable to comment whether VR with BroomX® is better/worse than other VR interventions. However, a literature review on potential benefits of VR experience concluded that such experience may provide an opportunity to enjoy leisurely activities that may promote quality of life, psychological well-being, and social interaction in people with dementia without leaving their home [35]. They located nine studies of varying study designs and durations [35]. The common barriers in VR use across the studies were confusion (n=3), discomfort associated with headset (n=2), sadness (n=1), tiredness (n=1), and difficulty with the technology (n=1). We encountered similar barriers in our pilot study, however we were able to propose and test solutions including using projector instead of a headset, consulting with substitute decision-makers to help identify content most likely to be appealing, paying particular attention to immediate reaction to VR content and making changes as necessary, setting up the VR machine early, and using a dedicated intervention area.

A recent pilot randomized control trial in older adults (71.8 ± 6.6) without dementia (n=24) used VR games with headset (30 min/day, two days/week for three months) to explore its feasibility [50]. Similar to us, they declared that VR experience is feasible for older adults (adherence rate was $91.55\% \pm 6.41\%$) in the VR group [50]. Unlike us, they reported adverse events such as dizziness and fatigue during the intervention in the VR group [50]. They also measured participants' depression symptoms with 15-item Korean version of Geriatric Depression Scale [51] and reported an improvement (week 12 score-baseline score=1.1, 95% CI, -0.87 to 3.07) [50].

Another recent feasibility study in older adults (80.5 ± 10.5) attending hospitals/day care centers (4 centers) used one session (maximum duration was 20 minutes) of 360° VR video footage with headset [39]. Similar to us, the participants (n=66) were diagnosed with dementia [39]. They declared VR intervention is safe (no adverse events) and feasible (adherence rate was 100%, attrition rate was 0%) [39]. They measured participants' anxiety status with a modified version of the State-Trait Anxiety Inventory [52] pre-and post-intervention [39]. Overall, the State-Trait Anxiety Inventory questionnaire revealed lesser anxiety in 12 out of 16 domains (calm, relaxed, content, adventurous, energetic, happy, sad, tense, upset/angry, worried, stressed, and anxious) [39] confirming our findings.

A mixed-method pilot study (n=10) evaluated the effects of VR experience on the level of engagement, apathy, and mood states of people with dementia from two care homes [53]. The VR session was 15 minutes in length and was experienced

once [53]. The sensitivity to change of Person–Environment Apathy Rating (apathy) was trivial [53]. The study reported environmental distractions (noise, cluttered space) as a potential barrier in implementing VR intervention [53] confirming our findings.

A feasibility study on VR intervention for people with dementia (n=57) visiting a memory clinic asked the participants rate their VR experience [54]. The participants reported that they felt secure, comfortable, less anxious, and less fatigued in VR environment [54], which is similar to our experience.

Limitations

The participant recruitment depended on communication with their SDM. The recruitment phase was short (around six weeks) during holiday season and required us to reach the SDM during their occasional visit to the Henley Place or over the phone only during weekdays from 9 to 5pm. In a fully funded study, with greater resources to allocate to recruitment efforts, we expect recruitments rates to improve.

Overall, our study was biased inherent to the study design. For example, absence of a control group impaired our ability to report whether changes in outcome reflected the intervention or simply the ups and downs associated with dementia progression. However, a systematic review on 118 studies targeting psychosocial treatments of behavior symptoms in dementia suggested that interventions tailored to individuals' preferences reporting small to moderate change in a short duration of action might work best in specific, time-limited situations [55].

Conclusion

VR intervention was feasible in an Ontario LTC home and the residents of that home with moderate to severe dementia tolerated such experience. The study recruited typical Ontario care home population and the researchers did not require specialization for setting up and conducting VR intervention. Therefore, we can conclude that VR intervention is likely to be applicable in Ontario care homes. Considering the burden of BPSD on older adults with dementia and their caregivers, VR experience is a possible non-pharmacologic intervention in managing BPSD in care homes.

List Of Abbreviations

BPSD=Behavioural and Psychological Symptoms of Dementia

CI=Confidence Interval

ES=Effect Size

SD=Standard Deviation

VR=Virtual Reality

Declarations

Ethics approval and consent to participate: The study was ethically approved by ADVARRA Canada Ethics board. The protocol number of this study is Pro00030688. The protocol can be accessed on <https://www.cirbi.net> with permission from the sponsor (primacare Living Solutions Inc. TM).

Consent for publication: All authors consent for publication and declare no conflict of interest.

Availability of data and material: Data and materials can be accessed on <http://www.empowerhealthresearch.ca/> with permission from the sponsor (primacare Living Solutions Inc. TM) but restrictions apply to the availability of these data,

which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of primacare Living Solutions Inc. TM.

Competing interests: Coauthor Dr. Manuel Montero-Odasso is an Editorial Board Member.

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Authors' contributions: MS analyzed and interpreted data, written the manuscript, and revised it critically for important intellectual content; KC designed and conducted the pilot study, and contributed in revising the manuscript; MJ contributed in analysis, interpretation of data, and critical revision for the work. MMO and JBO contributed in interpretation of data and revision of the manuscript; JK contributed in conception, design, and critical revision for the work; ASG created VR library for this project; and DB contributed in design, analysis, interpretation, and critical revision for important intellectual content. All authors are in agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Tables

Table 1

The demographic and clinical characteristics of the participants

Characteristics of participants	
Age (mean, standard deviation [SD])	85.8 ±8.6
Sex (n, %)	Female (18, 75%)
CPS score (mean, SD)	3.4 ± 0.6
Dementia types:	
Alzheimer's disease (n, %)	3, 12.5%
Unspecified dementia (n, %)	21, 87.5%
Comorbidities:	
Depression (n, %)	21, 87.5%
Diabetes mellitus (n, %)	3, 12.5%
Stroke (n, %)	2, 8.3%
Concussion (n, %)	1, 4.2%

Table 2

Distribution of EQ-5D dimension responses at baseline, week 1 and week 2 with index value

EQ-5D Baseline profile	EQ-5D Baseline index value	EQ-5D Week-1 profile	EQ-5D Week-1 index value	EQ-5D Week-2 profile	EQ-5D Week-2 index value
22432	0.6	12332	0.7	12232	0.7
55355	-0.1	55555	-0.1	54334	0.2
55435	0.1	55511	0.2	55532	0.1
35322	0.4	53453	0.1	53432	0.3
35543	0.3	44542	0.3	44453	0.3
15411	0.5	23333	0.6	13222	0.7
11121	0.7	11211	0.9	11112	0.9
44532	0.4	45533	0.3	54221	0.3
23423	0.6	22121	0.8	22322	0.7
55511	0.2	55521	0.2	55522	0.1
55513	0.2	55524	0.1	55332	0.2
15521	0.4	15534	0.3	15121	0.5
14411	0.7	35531	0.4	25421	0.4
55543	0.1	55523	0.1	55544	0.0
24532	0.4	23321	0.7	24332	0.6
34433	0.5	15523	0.4	24423	0.5
12421	0.7	12312	0.7	12121	0.8
25534	0.3	34332	0.6	24433	0.5
45523	0.3	45454	0.1	55544	0.0
54333	0.2	55544	0.0	55432	0.2
23311	0.8	12321	0.8	12124	0.6
23244	0.4	13355	0.2	24332	0.6
24222	0.6	13232	0.7	14322	0.7
25431	0.4	13221	0.8	23332	0.6

Table 3

Mean scores with standard deviation and pre-post score difference of the outcome measures

Scales	Baseline (mean, SD)	Week 1 (mean, SD)	Week 2 (mean, SD)	Change (Week 1-Baseline) (mean, SD)	Change (Week 2-Baseline) (mean, SD)
CSDD	9.7 ± 5.3	7.5 ± 4.6	7.5 ± 4.1	2.2±6.1	2.1±4.9
Mood	3.0 ± 1.8	2.4 ± 1.9	2.5 ± 1.8	0.5±2.1	0.5±1.8
Behaviour	2.4 ± 1.6	1.8 ± 1.5	1.7 ± 1.2	0.6±2.1	0.7±1.9
Physical signs	1.8 ± 1.3	1.4 ± 1.0	1.4 ± 1.2	0.4±1.3	0.5±1.4
Cyclic function	1.8 ± 1.7	1.5 ± 1.6	1.3 ± 1.3	0.4±2.2	0.5±1.7
Ideation	0.6 ± 0.8	0.3 ± 0.9	0.7 ± 1.0	0.3±1.1	0.1±1.1
CMAI	53.3 ± 19.1	51.3 ± 21.7	48.8 ± 17.2	2.3±13.4	4.8±15.2
Physical aggressive	18.8 ± 10.7	17.8 ± 9.2	16.4 ± 6.7	1.0±4.3	2.3±7.7
Physical non-aggressive	18.3 ± 6.3	16.5 ± 6.5	16 ± 5.8	1.8±7.1	2.3±6.5
Verbal aggressive	6.4 ± 4.3	6.5 ± 4.6	5.9 ± 3.1	0.1±2.8	0.5±3.2
Verbal non-aggressive	10.2 ± 6.3	10.6 ± 8.2	10.7 ± 7.1	0.4±5.9	0.5±5.7
Sleep	94.3 ± 9.1	88.3 ± 17.5	89.3 ± 16	5.9±13.3	5.1±10.2

CSDD= Cornell Scale for Depression in Dementia, CMAI= Cohen-Mansfield Agitation Inventory, SD=Standard Deviation

Table 4

Pre-post sensitivity to change of the outcome measures size of response, and clinical importance

Scales	ES (Week 1-Baseline)	ES (Week 2-Baseline)	Clinically meaningful (at 2 weeks only)
CSDD	0.4	0.4	Yes (small)
Mood	0.3	0.3	Yes (small)
Behaviour	0.4	0.4	Yes (small)
Physical signs	0.3	0.4	Yes (small)
Cyclic function	0.2	0.3	Yes (small)
Ideation	0.3	0.1	Yes (trivial)
CMAI	0.1	0.2	Yes (small), Clinically meaningful
Physical aggressive	0.1	0.2	Yes (small)
Physical non-aggressive	0.3	0.4	Yes (small)
Verbal aggressive	0.02	0.1	Yes (trivial)
Verbal non-aggressive	0.01	0.1	Yes (trivial)
Sleep	0.7	0.6	Yes (small to moderate), Clinically meaningful

CSDD= Cornell Scale for Depression in Dementia, CMAI= Cohen-Mansfield Agitation Inventory, ES=Effect Size.

According to Cohen an ES is trivial if it is less than 0.20, small if it is between 0.21 – 0.49, moderate if it is between 0.51-0.79, and large if it is greater than 0.80 (Cohen, 1988). We considered the change to be clinically meaningful when ES of CMAI score was ≥ 0.2 (Rapp et al., 2013), and ES of sleep percentage was ≥ 0.4 (Perlis et al., 2000).

Table 5

Longitudinal validity of Cornell Scale for Depression in Dementia domains at the end of week 1 and week 2

CSDD domain	GRC-depression			
N=24	Week 1			
	Pearson correlation	Moderately better (4, 5) (n=5) (mean $\pm$ SD)	Minimally better (1, 2, 3) (n=2) (mean $\pm$ SD)	Stable (0) (n=16) (mean $\pm$ SD)
Total score	-0.23	6.6 $\pm$ 5.5	6 $\pm$ 1.4	7.5 $\pm$ 4.6
Mood-related signs	-0.15	2.4 $\pm$ 2	2 $\pm$ 1.4	2.3 $\pm$ 1.9
Behavioural disturbance	-0.28	1.2 $\pm$ 1.1	1 $\pm$ 1	2 $\pm$ 1.6
Physical signs	-0.05	4.2 $\pm$ 0.5	2.5 $\pm$ 0.7	1.4 $\pm$ 1
Cyclic functions	-0.22	1.2 $\pm$ 1.1	1 $\pm$ 0.0	1.4 $\pm$ 1.8
Ideational disturbance	0.02	0.4 $\pm$ 0.9	0.0 $\pm$ 0.0	0.4 $\pm$ 1.0
	Week 2			
	Pearson correlation	Moderately better (4, 5) (n=5) (mean $\pm$ SD)	Minimally better (1, 2, 3) (n=4) (mean $\pm$ SD)	Stable (0) (n=14) (mean $\pm$ SD)
Total score	-0.16	5.2 $\pm$ 3.3	9 $\pm$ 3.6	7.9 $\pm$ 4.5
Mood-related signs	-0.09	1.8 $\pm$ 1.6	2.8 $\pm$ 1.7	2.6 $\pm$ 2
Behavioural disturbance	-0.25	1 $\pm$ 0.7	1.5 $\pm$ 1.3	2 $\pm$ 1.4
Physical signs	-0.08	1 $\pm$ 1	2 $\pm$ 1.2	1.4 $\pm$ 1.3
Cyclic functions	0.07	1 $\pm$ 1	2 $\pm$ 1.2	1.2 $\pm$ 1.4
Ideational disturbance	-0.18	0.4 $\pm$ 0.9	0.8 $\pm$ 1	0.8 $\pm$ 1.1

CSDD= Cornell Scale for Depression in Dementia, GRC= Global Rating of Change, SD=Standard Deviation

Table 6

Longitudinal validity of Cohen-Mansfield Agitation Inventory domains at the end of week 1 and week 2

CMAI domain		GRC-agitation			
N=24	Week 1				
	Pearson correlation	Moderately better (4, 5) (n=2) (mean $\pm$ SD)	Minimally better (1, 2, 3) (n=8) (mean $\pm$ SD)	Stable (0) (n=10) (mean $\pm$ SD)	Minimally worse (-1, -2, -3) (n=3) (mean $\pm$ SD)
Total score	-0.16	53.5 $\pm$ 7.8	48.9 $\pm$ 19.6	42.5 $\pm$ 19.4	80 $\pm$ 13.5
Physical aggressive	-0.15	16 $\pm$ 7.1	17.5 $\pm$ 10.0	16.7 $\pm$ 10.4	24.3 $\pm$ 4.3
Physical non-aggressive	0.05	21 $\pm$ 4.2	17 $\pm$ 7.1	14.2 $\pm$ 6.6	20 $\pm$ 6.3
Verbal aggressive	-0.43*	5 $\pm$ 2.8	5.8 $\pm$ 3.4	4.7 $\pm$ 3.5	13 $\pm$ 5.3
Verbal non-aggressive	-0.43*	11.5 $\pm$ 6.4	8.6 $\pm$ 7.9	6.9 $\pm$ 2.4	22.7 $\pm$ 9.1
	Week 2				
	Pearson correlation	Moderately better (4, 5) (n=3) (mean $\pm$ SD)	Minimally better (1, 2, 3) (n=9) (mean $\pm$ SD)	Stable (0) (n=8) (mean $\pm$ SD)	Minimally worse (-1, -2, -3) (n=3) (mean $\pm$ SD)
Total score	0.06	38 $\pm$ 8.5	56.8 $\pm$ 13.9	41.3 $\pm$ 15.4	58.7 $\pm$ 29.6
Physical aggressive	0.08	14 $\pm$ 2.7	18.7 $\pm$ 8.0	14 $\pm$ 5.9	18.3 $\pm$ 8.1
Physical non-aggressive	0.21	12 $\pm$ 2	20.1 $\pm$ 5.2	12.8 $\pm$ 5.2	17.3 $\pm$ 5.0
Verbal aggressive	0.06	6 $\pm$ 3.6	6.1 $\pm$ 2.6	5.5 $\pm$ 4.1	6 $\pm$ 3.6
Verbal non-aggressive	-0.22	7.3 $\pm$ 4.0	10.8 $\pm$ 5.1	9.3 $\pm$ 7.1	19 $\pm$ 12.1

CMAI=Cohen-Mansfield Agitation Inventory, GRC=Global Rating of Change, SD=Standard Deviation

*p<0.05

Figures

Figure 1

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Figure 2

The flow chart for participant enrollment, allocation, follow-up, and analysis.