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INVESTIGATING THE FEASIBILITY OF A 3D VIRTUAL WORLD TECHNOLOGY FOR PEOPLE WITH DEMENTIA

Completed Research

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Abstract

Three Dimensional Virtual Worlds (3DVWs) are computer-generated, simulated, graphical and multi-media environments, designed so that users can 'live in' and engage via their own digital and graphical self-representations known as 'avatars'. The purpose of this study was to evaluate the feasibility of using 3DVWs to enhance engagement and quality of life in people with dementia. A mixed-methods research design, guided by a feasibility framework, was used, with data collected from semi-structured interviews, observations, and surveys. Eleven residents expressed interest in the 3DVWs intervention after reading an advertisement and attended an introductory session. After this, eight people expressed a desire to participate in the six-session intervention. Participants generally enjoyed the experience of using 3DVWs. Of those who completed all six sessions, two-thirds showed a positive change in their quality of life score. Moreover, those who participated in almost all sessions showed higher satisfaction with the use of the 3DVW than those who dropped out. Both residents and care staff perceived the 3DVW as engaging, fun and memory stimulating. The findings support the feasibility of using 3DVWs with people with dementia, and this justifies the need for further research.

Keywords: 3D virtual world, quality of life, feasibility study, people with dementia.

1 Introduction and Background:

Dementia is the collective term for the symptoms caused by a range of disorders affecting the brain. Alzheimer's disease is one such disorder. Although dementia commonly affects older people, it is not a normal part of ageing. It is estimated that there are 47.5 million people with dementia, and around 7.7 million people newly diagnosed each year (ADI 2015). Dementia is a progressive condition and its impact on individuals, families and society increases as the condition worsens. The most common symptoms of dementia include memory loss, impairments of perception, language and cognition, communication difficulties including word finding problems, and eventually loss of language and the ability to communicate. There is also a loss of physical functioning and, as a result, nearly everyone with dementia ends his or her life in long-term care facilities. The symptoms of dementia are associated with major sources of burden, deterioration in quality of life, and reduced psychological wellbeing. There is currently no cure and so it is imperative that researchers, practitioners, and policymakers work together to create opportunities for people with dementia to enjoy a 'life worth living'.

A major challenge when people with dementia move into long-term care is not only the provision of care but also how to maintain their personhood, including meaningful engagement in life. Long-term care facility staff play an important role in maintaining the quality of life of people with dementia, as they are generally the people who undertake activities and offer opportunities for an enhanced quality of life within the long-term care facility environment. However, maintaining quality of life is especially challenging when people with dementia are viewed by staff primarily in terms of their dementia diagnosis and their deficits, and deemed incapable of communicating their experiences or engaging in activities. In addition, apathy, loneliness, and depression are common consequences of dementia that can make it challenging for care staff to engage this population in meaningful activities and, as a consequence, activities are offered in a group format with limited chance for individual stimulation or genuinely person-centred care (Moyle et al. 2011). Consequently, feelings of frustration and agitation are heightened, which can further reduce quality of life and make caregiving even more challenging.

Furthermore, a lack of stimulation and social connection can be particularly detrimental to people with dementia as it negatively influences mood, increases loneliness and agitation, and can increase cognitive decline, which in turn influences care needs (Baker et al. 2015; Moyle & O'Dwyer 2012). Such a situation can result in people with dementia being left alone for long periods of time, in particular if they display agitated behaviour, silencing their contributions, and as a consequence offering limited opportunities for them to find comfort in familiar and meaningful interactions that may stimulate their interest (Moyle et al. 2011). It is imperative that people with dementia are engaged in activities as well as decisions about the activities in which they wish to be involved.

Technologies, including social robots, have in recent times been introduced to people with dementia as a means to engage, comfort and stimulate (Moyle et al. 2013a; Moyle et al. 2013b; Moyle et al. 2014; Moyle et al. 2016). Telepresence robots have also been used to connect the person with dementia to family, in an effort to overcome loneliness and social isolation (Moyle et al. 2011). New opportunities for stimulation have also arisen from technologies that include Three-Dimensional Virtual Worlds (3DVWs). These technologies aim to engage people actively in a playful way. Several researchers have examined the psychological effect of 3DVWs. Kusumi, Ogura, and Miura (2008) investigated the effect of using a three-dimensional online chat environment to improve mental health in people with cancer. Hoch et al. (2012) explored the feasibility of translating a face-to-face stress reduction program into an online virtual world and estimated the effect size of the intervention. Pioggia and colleagues (2010) described a new approach to assessment and treatment of psychological stress based on 3DVWs and Gustafson, Shaw, Isham, Dillon, and Spartz (2008) conducted a drug addiction treatment program using Second Life (one of the most popular 3DVW environments). There have been few studies, however, that have explored the use of 3DVWs in care of people with dementia living in nursing homes. One UK project created several versions of virtual world prototypes to support life engagement for people with

dementia in nursing home care (Siriaraya & Ang, 2014). The 3DVW prototypes were three separate activities that involved a reminiscence room, virtual tour, and gardening activities where people with dementia were engaged in the interactivity of the virtual environment and engaged in picking up objects. The authors identified the importance of a fine balance between the complexity of the virtual activity and the simplicity of the user interaction, in particular where people have more severe cognitive impairment. Alzheimer's Association Victoria, Australia has also been involved in the development and trial of a 3DVW. This 3DVW involves a virtual forest with a stream where people connect with the 3DVW to move objects such as insects, fish and a boat by moving their hands and arms using a gesture-based Kinect device. There is room for further research and, in particular, to refine and test new 3DVW prototypes. The aim of the present study was to evaluate the feasibility of a 3DVW activity used with individuals living with dementia in a long-term care facility in Queensland, Australia.

Many Information Systems (IS) researchers have worked on technology use and its impact in the health sector. For example, Najaftorkaman et al. (2015) provided a Taxonomy of Antecedents to User Adoption of Health Information Systems. Vichitvanichphong et al. (2014) explored the overall impact of assistive technologies through a literature survey. Ghanbarzadeh et al. (2014) came up with a taxonomy providing various usages on 3DVW technology. In line with the literature, this paper seeks to investigate the feasibility of the use of a cutting edge technology called 3DVW for older people with dementia. This current study seeks to fill a gap in the literature on investigating the use and potential impact of the 3DVW technology for people with dementia.

The aim of the present study was to evaluate the feasibility of a 3DVW activity used with individuals living with dementia in a long-term care facility in Queensland, Australia. Feasibility studies are used to determine if an intervention is appropriate for further testing. Such studies are usually undertaken in the practice setting where the intervention is aimed and can determine if an intervention can work in the setting and with the intended audience. There are currently no standards to guide the design and evaluation of feasibility studies. Bowen and colleagues (2009) however, suggest a framework to assist researchers to design a feasibility study. They report that there can be up to eight areas of focus that can be addressed in feasibility studies. These include: acceptability, demand, implementation, practicality, adaptation, integration, expansion, limited efficacy testing (Bowen et al 2009).

2 Method

2.1 Design and sample

This study took a descriptive, exploratory approach, with a mixed-methods design that included the integration of qualitative and quantitative data.

This study recruited a convenient, purposeful sample of residents living in one long-term care facility with whom we have a current partnership. The study involved an intervention followed by data collection, including a questionnaire, qualitative semi-structured interview, and facilitator observations. Participants were provided with the technology, trained and supported in the use of specific technology.

Eleven residents were initially identified by the facility manager as being suitable for the intervention. Ethical approval was received from Griffith University's Human Research Ethics Committee (ICT/04/15/HREC), and an informed consent was obtained from all the residents and/or their families. Participants were those who had a documented diagnosis or probable diagnosis of dementia, were preferably at early stage dementia and aged 60 years or older. We excluded those who had a dual diagnosis of a serious or persistent mental illness, a terminal illness, or unremitting pain or distressing physical symptoms. The Mini-Mental State Examination (MMSE) (Folstein et al. 1975) was used to monitor the person with dementia's cognitive status. The MMSE provided a score of 0-30 for each resident, with lower scores indicative of greater cognitive impairment.

2.2 Intervention

The intervention technology was a 3DVW developed with various features such as an art gallery, supermarket, beach, beach house, helicopter and boat. The art gallery, for example, included a common area, and also private rooms each dedicated and only accessible by the specific resident. The private room included photos of the resident and his/her family. Participants interacted with the 3D virtual environment through an avatar. Figure 1 depicts snapshots from some parts of the designed virtual environment.

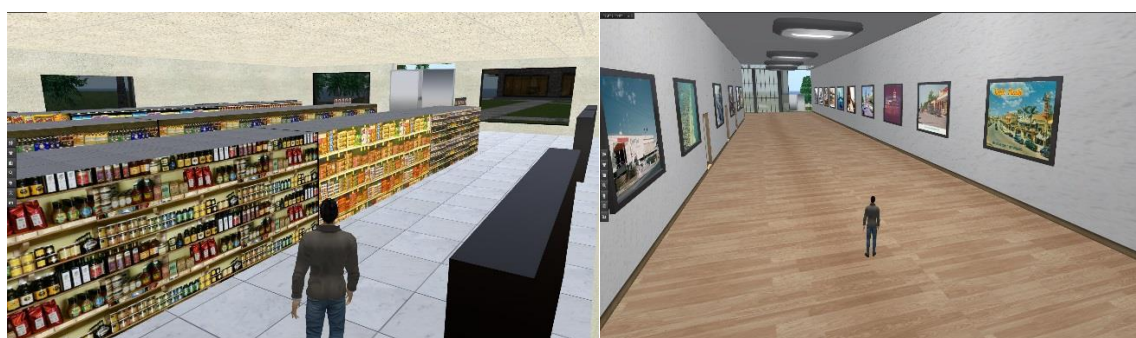


Figure 1. Examples of the environments within the 3DVW

Each participant received the intervention twice per week for three weeks. For practical reasons, the intervention was conducted in two blocks. The first group of participants received the intervention in Block One (weeks 1 to 3) and the second group of participants received the intervention in Block Two (weeks 4 to 6). A facilitator trained each participant for about 15 minutes to demonstrate to the participants how to navigate through the world, how to walk/run/fly and play videos etc. Participants explored the various features of our virtual land for about 30-40 minutes. The facilitator provided assistance throughout this period, as required.

2.3 Data Collection

The data collection included an initial survey completed by participants prior to the intervention, as well as a semi-structured interview with the residents and care staff after the intervention.

The survey captured data on various factors. Data on quality life of the residents was collected both before and after the intervention using Edelman et al.'s (2005) QOL_AD instrument. Participant satisfaction with the use of 3DVWs was also measured. The survey also collected data prior to the intervention on participants' demographic data in terms of age, gender, dementia diagnosis and including date of diagnosis, comorbidities, and length of residence.

Semi-structured individual interviews were conducted with participants (10 to 15 minutes in duration) and with care staff (15 to 20 minutes), to focus on the participants' experience of using the 3DVW, their perceptions of what the 3DVW added to their life, the strengths/limitations of the software, and any suggestions for improvements. The interviews took place within a week of the completion of the intervention.

Session facilitators recorded a brief observation on a form after each session to report: (i) items/places the resident appeared to find most enjoyable; (ii) items/places the resident appeared NOT to enjoy; (iii) comments made by each resident about the 3DVW; (iv) anything that impeded the resident's use of the 3DVW; and (v) any other comments.

2.4 Data Analysis and Feasibility Framework

A thematic analysis was used to explore participant and staff perceptions of using the 3DVW. Descriptive statistics, including frequencies and means, were calculated to describe the sample. This study used Bowen et al.'s (2009) feasibility framework and three aspects of the framework, namely Acceptability, Implementation, and Efficacy (the alignment between the study questions, data sources, and elements of feasibility can be found in Table 1).

Table 1. Bowen's feasibility framework, as applied to this study.

Area	Definition	Study question	Data source
Acceptability	<i>How did the participants react to the intervention?</i>	<i>To what extent is the 3DVW embraced by users in the long-term facility?</i>	Interview
Implementation	<i>The likelihood and extent to which the technology can be successfully implemented as planned</i>	<i>To what degree can 3DVWs be implemented among the intended participants?</i>	Interview Observation
Limited Efficacy Testing	<i>The efficacy and outcome of the intervention</i>	<i>To what degree did the 3DVW demonstrate engagement and an improved QoL among the participants?</i>	Survey Interview

3 Results

3.1 Participants

Participants ranged from 70 to 94 years old and the majority were female. All participants had either a diagnosis or probable diagnosis of dementia and most had co-morbid health conditions. The average length of time they lived in the nursing home was 2.4 years. Detailed demographic information for each participant can be found in Table 2.

Table 2. Demographic data.

Participant	Gender	Age (Years)	Co-morbidities	Length of residency
P1	Female	94	Restlessness – agitation – Incontinence	5 years
P2	Female	70	Heart disease	3 months
P3	Female	83	Hearing loss/deafness	3 months
P4	Female	89	Fibromyalgia	9 months

P5	Female	95	Nil	2 years
P6	Female	84	Arthritis	1 years
P7	Female	76	Arthritis – Parkinson	3 years
P8	Female	78	Mobility, SOB, one blinded eye	3 years
P9	Female	83	Stroke – Diabetes	5 years
P10	Female	92	Nil	3 years
P11	Male	87	Diabetes type II – Multiple TA/CUAs – Hyper Tension	3 years
Mean		84		2.4 years

3.2 Feasibility:

3.2.1 Acceptability

In this study acceptability is defined as “how all the participants react to the intervention”? In other words, the extent to which the participants in the long-term care facility embrace the 3DVW. The interviews with the care staff and the residents were used in this section. Out of the eight residents that expressed interest in using 3DVWs after actually seeing it, six continued it till the end and only two dropped out. This shows an adherence rate of 75%, which seems quite reasonable for a cutting-edge technology for older adults with dementia.

Both the participants and the care staff reacted positively to the 3DVW. A care staff member said that the majority of the participants welcomed the 3DVW, and embraced it: “*I reckon the majority of the residents really liked it. As time went on they started to get more involved and actually liked it and wanted to go back*” [staff1]. Most of the participants said they wanted to keep using the 3DVW: “*it was beautiful, I’d like to keep going*” [P3]. A care staff member did, however, highlight the importance of gradually introducing new technologies to people with dementia: “*It would just need time to introduce it to everyone and they just all need to see it. I think it’s just time..... It’s just the introduction, like introducing them to it.*” [staff1]

Both participants and care staff identified potential areas of improvement. One participant wanted more moving features: “*I quite like where we went round the animals. Not that I’m an animal lover at all, but that was more interesting because it was moving. When you went to the beach you were just looking out and in the shop you were just looking at things.*” [P4]. Staff members also suggested a bigger screen as a way to improve the quality of the intervention, as well as allowing participants to attend the sessions in pairs: “*What else would benefit? I said the big screen. You might, as I said, two people interacting to do it would be wonderful.*” [staff2]; “*it was sort of like a little event for them. But because they were sort of individual, each individual resident going in, it was more daunting for them. So they were like “what is this?” I think pairs would be great, pairs would definitely work. Because a lot of them do pair up, they have quite close friends that they go everywhere with each other.*” [staff1]

Prior to the intervention, care staff were concerned that participants might be confused or frightened by the technology. After the intervention, however, staff were surprised by the positive response of participants: “*They were just a bit anxious before it happened, because they weren’t too sure about it, when it was like computer software and they weren’t too sure how to use it. But after that they’ve been fine.*” [staff1]

Both care staff and participants identified the stimulation and engagement provided by the 3DVW as a positive outcome of the intervention. One staff member said: “they are not just sitting in a..., well they are sitting in a room, but they’re getting out of the room and going places. I reckon it’s good for them because they’re using their hands as well.” [staff1]. Staff1 also felt that the intervention helped participants with hand and eye coordination, improved their focus, and made them more alert: “so you see them come out and they’re actually, they’re really alert. It’s actually amazing. Like one of the ladies downstairs she’s not so alert in the mornings and that’s when they usually get her and she’s always alert after each session.” [staff1]. Participants also felt that the technology stimulated their minds: “it’s a bit of light and colour, and something to think about afterwards” [P6], and helped them remember things: “The statues and things, because I’ve been to Greece, and we saw a lot of those statues everywhere there. Yes, it reminded me of the time I spent there.” [P6]

Care staff identified the personalised nature of the 3DVW – including music tailored to individual preferences and personal photos – as another positive outcome: “because everyone’s so different and they all like different things. So that made them, I saw that really made them like “Oooh, look they’ve got this song” and they started humming along and they remembered the lyrics. It was actually really cool” [staff1]; “if you introduce music or things people love, then it takes them back to nostalgic times.” [staff2]. Another advantage of 3DVWs which was acknowledged by both staff and residents was how engaging and entertaining it was. A staff member stated “I know some of the ladies like to go on the beach. One of the ladies was just walking along the beach and she said “this is just lovely, isn’t it”, so it’s just like reminiscing as well” [staff1]. Another staff member says, “the feedback I received was that it was a lot fun” [staff2]. Residents were also very excited about the 3DVW. One of the residents states that the 3DVW helps get over boredom and wants to introduce it to her friend: “what I’d really like to do is bring my friend down. I have a friend upstairs my friend’s up there and she’s really bored and I’d really like to bring her down and show it to here” [P6].

3.2.2 Implementation

As previously mentioned, eight participants took part in the intervention. Table 3 shows the sessions in which each resident participated. Out of eight, six residents participated in almost all sessions (one missed the last session due to sickness), and two dropped out after the second session. Thus, an average 75% of the participants completed almost all intervention sessions, and 25% dropped out after the second session. The average number of sessions per participant was 4.87.

Table 3. Residents’ participation in the sessions.

Resident	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	Total number of sessions per participant
P1	√	√	√	√	√	√	6
P2	√	√	√	√	√	√	6
P3	√	√	√	√	√	√	6
P4	√	√	√	√	√	√	6
P6	√	√	√	√	√	√	6
P8	√	√					2
P10	√	√	√	√	√		5

P11	√	√								2
Average number of sessions per participant									4.875	

Participants and care staff identified a number of factors that facilitated participation in the intervention. The simplicity of the technology was the key facilitating factor: “well there’s not too many things that you’ve got to remember to push, so I quite like that” [P6]. The richness in features of the 3DVW environment was another aspect of the intervention that was acknowledged by many of the residents. For example, a resident showed her enthusiasm by saying, “It was mind boggling to know what they’ve done and how they made it and everything. It’s amazing” [P4].

Participants and care staff also identified a number of barriers to using the 3DVW. A lack of previous computer experience was the most frequently cited barrier. Another barrier which was highlighted by staff members was physical barriers and problems for a couple of residents in working with the computer interface. One of the residents [P11] who dropped out after the second session seems to have left due to perceiving this intervention as yet another memory test. Another resident who dropped out after the second session, acknowledged they liked outdoor activities much better than indoor activities such as those of computing: “I’d rather be out playing bowls” [P8].

3.2.3 Efficacy

Data from semi-structured interviews and the initial survey provide insights of the efficacy of this intervention. We used the QOL_AD (Edelman et al. 2005) instrument to measure quality of life of the residents both before and after the intervention period (see appendix 1 to see the instrument used to measure QoL). Two thirds of the participants who completed all sessions demonstrated a positive change in their quality of life score after participating in the intervention (see Table 4). Moreover, those residents who participated in almost all sessions generally showed higher satisfaction with the use of the 3DVW (six of the eight residents or 75% of the population).

Table 4. Results of the QOL-AD questionnaire before and after the intervention
(1=Poor, 2=Fair, 3=good, 4=Excellent)

	P1		P2		P3		P4		P6		P10	
	Pre-Int.	Post Int.	Pre-Int.	Post Int.	Pre-Int.	Post Int.	Pre-Int.	Post Int.	Pre-Int.	Post Int.	Pre-Int.	Post Int.
Question 1	1	4	3	3	3	3	2	3	3	3	2	3
Question 2	1	2	3	3	3	3	1	3	2	2	3	3
Question 3	2	3	3	3	3	3	4	3	3	4	2	3
Question 4	2	1	3	3	1	2	3	3	4	4	2	3
Question 5	3	1	2	3	3	3	2	3	2	2	2	2
Question 6	1	1	3	3	3	3	4	4	4	3	3	3
Question 7	3	3	3	3	4	4	4	3	4	3	2	4
Question 8	3	3	3	3	3	3	3	3	4	3	1	3
Question 9	1	2	3	3	1	3	3	3	3	3	2	3

Question 10	2	3	3	3	3	3	3	3	2	3	3	3
Question 11	3	3	3	2	2	1	2	3	3	2	4	3
Question 12	3	3	3	3	3	3	2	3	4	3	4	2
Question 13	2	3	3	3	2	4	3	3	3	3	3	3
Question 14	3	2	3	3	1	1	3	3	3	3	3	3
Question 15	3	3	3	3	1	1	3	3	3	3	3	2
Sum of Items	33	37	44	44	36	40	42	46	47	44	39	43
Mean	2.20	2.47	2.93	2.93	2.40	2.67	2.80	3.07	3.13	2.93	2.60	2.87
Change		+		.		+		+		-		+

Residents also suggested that this intervention allowed them the opportunity to visit places they no longer were able to attend (e.g., art gallery, beach, supermarket, farm etc.): *“I’m quite happy here, but we are outside of the world and with the computer it brings the world to me”* [P3]. Many of the residents mentioned that the 3DVW environment was fun, engaging and interesting: e.g., *“It’s all something new, so you get interested”* [P2]. A staff member also confirms this by saying, *“the ones [residents] that were participating and enjoyed something, they felt important, they thought it was something really innovative. And it added to their quality of life”* [staff2].

4 Conclusion

This research employed a mixed-method research design to investigate the feasibility of using 3DVWs by people with dementia. Employing an adaptation of the Bowen et al. (2009) feasibility framework, this study demonstrated that it is feasible for people with dementia to use 3DVWs. Both residents and care staff generally perceived this technology as engaging, fun and memory stimulating. The simplicity of the technology, the richness in features of the 3DVW environment, and personalised nature of the 3DVW were factors that facilitated participation in the intervention.

Whereas the 3D virtual world technology has been applied in some aspects of the health sector, there is a lack of studies, which investigate the feasibility of using 3DVW by people with dementia. The current paper sought to fill this gap, and also found that most of the participants who completed all 3DVW sessions had a positive change in their quality of life score after participating in the intervention.

Prior to the intervention, care staff were concerned that participants might be confused or frightened by the technology. After the intervention, however, staff were surprised by the positive response of participants. Both participants and care staff identified potential areas of improvement; for example, using a bigger screen, or allowing participants to attend the sessions in pairs. A lack of previous computer experience, physical barriers and problems, and perceiving the intervention as “yet another memory test” were among the barriers to using the 3DVW.

Despite such barriers, participants generally enjoyed the experience of using 3DVWs, and most of the residents who completed all sessions had a positive change in their QOL score after participating in the intervention. The findings support the need for a pilot controlled trial that includes an extension of the present trial and a larger sample size to investigate the impact of using 3DVWs by people with dementia.

Finally, we acknowledge that changes in the quantitative data are trends only, and that a larger study is required to determine statistical significance and meaningful change.

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Appendix 1. Instrument for Quality of Life (QoL) adapted from Edelman et al. (2005)

1. First of all, how do you feel about your physical health? Would you say it’s poor, fair, good or excellent? Circle whichever word you think best describes your physical health right now.

Poor	fair	Good	Excellent
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2. How do you feel about your energy level? Do you think it is poor, fair, good or excellent? *If the participant says that some days are better than others, ask him/her to rate how she/he has been feeling most of the time lately.*

Poor	fair	Good	Excellent
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3. How has your mood been lately? Have your spirits been good or have you been feeling down? Would you rate your mood as poor, fair, good or excellent?

Poor	fair	Good	Excellent
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4. How about your living situation? How do you feel about the place you live now? Would you say it’s poor, fair, good or excellent?

Poor	fair	Good	Excellent
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5. How about your memory? Would you say it’s poor, fair, good or excellent?

Poor	fair	Good	Excellent
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6. How about your family and your relationship with family members? Would you describe it as poor, fair, good or excellent? *If the participant says they have no family, ask about brothers, sisters, children, nieces, nephews.*

Poor	fair	Good	Excellent
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7. How do you feel about your relationships with people who work here? Do you feel it's poor, fair, good or excellent?

Poor	fair	Good	Excellent
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8. How would you describe your current relationship with your friends? Would you say it's poor, fair, good or excellent? *If the participant answers that they have no friends, or all their friends have died, probe further.* Do you have anyone you enjoy being with besides your family? Would you call that person a friend? *If the participant still says they have no friends, ask how do you feel about having no friends – poor, fair, good or excellent?*

Poor	fair	Good	Excellent
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9. How do you feel about your self – when you think of yourself overall and all the different things about you, would you say it's poor, fair, good or excellent?

Poor	fair	Good	Excellent
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10. How do you feel about your ability to keep busy? Would you say it's poor, fair, good or excellent?

Poor	fair	Good	Excellent
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11. How about your ability to do things for fun, things that you enjoy? Would you say it's poor, fair, good or excellent?

Poor	fair	Good	Excellent
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12. How do you feel about your ability to take care of yourself? Would you say it's poor, fair, good or excellent?

Poor	fair	Good	Excellent
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13. How do you feel about your ability to live with others? Would you say it's poor, fair, good or excellent?

Poor	fair	Good	Excellent
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14. How about your ability to make choices in your life? Do you feel it's poor, fair, good or excellent?

Poor	fair	Good	Excellent
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15. When you think of your life overall now, everything together, how do you feel about your life? Would you say it's poor, fair, good or excellent?

Poor	fair	Good	Excellent
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