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Thach, KS;Lederman, R;Waycott, J

Title:
Virtual Reality in Residential Aged Care: a study of adoption and system complexity

Date:
2020-01-01

Citation:
Thach, K. S., Lederman, R. & Waycott, J. (2020). Virtual Reality in Residential Aged Care: a study of adoption and system complexity. ACIS 2020 Proceedings - 31st Australasian Conference on Information Systems, ACIS.

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Kong Saoane Thach
University of Melbourne, kthach@student.unimelb.edu.au

Reeva Lederman
University of Melbourne, reeva.lederman@unimelb.edu.au

Jenny Waycott
University of Melbourne, jwaycott@unimelb.edu.au

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Recommended Citation

Thach, Kong Saoane; Lederman, Reeva; and Waycott, Jenny, "Virtual Reality in Residential Aged Care: a study of adoption and system complexity." (2020). *ACIS 2020 Proceedings*. 56.
https://aisel.aisnet.org/acis2020/56

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Virtual Reality in Residential Aged Care: a study of adoption and system complexity.

Completed research paper

Kong Saoane Thach
School of Computing and Information Systems
The University of Melbourne
Melbourne, Australia
Email: kthach@student.unimelb.edu.au

Reeva Lederman
School of Computing and Information Systems
The University of Melbourne
Melbourne, Australia
Email: reeva.lederman@unimelb.edu.au

Jenny Waycott
School of Computing and Information Systems
The University of Melbourne
Melbourne, Australia
Email: jwaycott@unimelb.edu.au

Abstract

Virtual Reality (VR) has been increasingly adopted by residential aged care facilities (RACFs) for enriching residents' experiences. RACFs are sensitive settings with complex sociocultural elements, thus aged care providers might experience challenges when introducing new technologies. This paper presents findings from a descriptive analysis of survey responses exploring the complexity brought about by adopting VR in RACFs. By understanding technology-in-use as socio-technical systems, this study draws on the work of Greenhalgh et al. to understand how the adoption of health-care technologies is influenced by complexity across seven domains: condition, technology, value proposition, adopter(s), organization(s), wider system, and adaptation over time. The paper details the design of a new survey instrument. Results indicate that it is challenging to sustain a VR program within RACFs due to the complexity arising from residents' conditions and the technology itself, and the complicated challenges involving staff who facilitate VR activities and those who provide training.

Keywords: technology adoption, complexity, usability, virtual reality, aged care.

1 Introduction

Residential aged care facilities (RACFs), also known as residential care homes or nursing homes, are complex environments involving residents with complex conditions and multi-co-morbidities (Dudman et al. 2018). Recently, residential aged care (RAC) has aimed to tranform the nature of care provided from task-oriented to person-centered and relationship-centered. Some care homes have worked to remodel the environment from 'institutional' to 'homelike'. The key focus of this transformation is consideration of residents' experiences across their life course and the different environments in which they previously resided. This consideration could be achieved by innovative models of care and appropriate use of technology (Dyer SM et al. 2019).

During the last ten years, research in the field of technology in aged care has increased. The advent of technologies designed specifically for older adults opens possibilities for not only helping older adults live independently at home as they age, but also for enriching their social world in later life. An emerging technology for enrichment in later life is the use of Virtual Reality (VR). VR is normally used to refer to a three-dimensional (3D) immersive environment that is accessed through a head-mounted display (HMD) (Hodge et al. 2018). Although VR has existed for many years, it has only recently become a viable consumer technology. Despite its relative novelty, VR is now being used by RACFs to provide residents with opportunities to engage in fulfilling and calming experiences (BlueCross 2019; Bolton Clarke 2019; Opal Aged Care 2019). VR is particularly appealing to RAC because it brings the outside world into the confined environment of the care home, enabling people to engage in activities that they can no longer easily do in the real world, such as global travel or underwater discovery.

That said, RACFs are complex environments where people typically have high care needs, including advanced dementia (McVey et al. 2014; Parker 2011). Research shows that introducing emerging technologies into this environment is challenging due to staff training needs and organizational constraints (Cavenett et al. 2018). It is crucial that emerging technologies are carefully designed and deployed to foster benefit for this population. As researchers have demonstrated in recent years, it is especially important that technologies are introduced carefully in sensitive settings such as aged-care, as there can be significant ethical issues if technologies do not produce the desired benefits in such settings (Waycott et al. 2015). Hence, holistically identifying challenges and opportunities in the adoption of VR in RACFs might help the implementation achieve greater likelihood of success.

Recent research indicates that the engagement of older adults in using VR might be affected by varied factors (Baker et al. 2019a; Baker et al. 2019b; Brown 2019; Cavenett et al. 2018; Hodge et al. 2018; Roberts et al. 2019). However, this previous research has mostly focused on either the design or usability issues of the technology itself or issues affecting a specific group of users such as older adults or aged care staff members. Few studies have considered the use of VR as a socio-technical system and provided a holistic view about its challenges and emerging opportunities. In fact, technologies within organizations are, by nature, socio-technical. That is, they influence, and are influenced by, the social setting in which they are used and need to be responsive to the usability issues of all users (Rajanen and Rajanen 2019). The use of VR within RACFs is becoming more commonplace. Thus, an exploration of the socio-technical issues brought about by the adoption of VR in RACFsis critical to aged care providers.

The aim of this research is to identify emerging opportunities and challenges in the adoption of VR for enrichment purposes in RACFs. By understanding technology-in-use as socio-technical systems, this research draws on the NASSS (Non-adoption, Abandonment, Scale-up, Spread, and Sustainability) framework proposed by Greenhalgh et al. (2017) to understand the complexity in the adoption of technologies within organizations. The main contributions of this paper are applying a theoretical foundation and utilizing and building upon previous research to inform the development of a novel survey instrument to survey VR adoption in RACFs. Thus, not only does this paper make a theoretical contribution but it also creates a practical survey instrument for practitioners in aged care settings. In this paper, we also contribute to the literature by reporting findings from an initial application of the survey, which was distributed to staff working for an aged care organization that has recently deployed VR as an enrichment activity in its RACFs. Drawing on the survey results, we examine complexity across seven domains and classify each domain as 'simple', 'complicated' or 'complex'. Greenhalgh et al. (2017) conclude that complexity in multiple domains poses the greatest challenge to scale-up, spread, and sustainability. Thus we use Greenhalgh's framework to further assess whether the VR program could be promisingly sustained within RACFs.

2 Literature Review

VR has been increasingly adopted by RACFs across Australia to provide enrichment experiences for their residents (BlueCross 2019; Bolton Clarke 2019; Opal Aged Care 2019). Enrichment experiences in this research setting refer to activities that provide older adults with positive social and emotional experiences. Due to the broad adoption of VR technology in aged care settings, studies conducted to explore the design of VR experiences with and for older adults for enrichment are emerging. Some issues raised by using VR among older adults have been identified as follows.

Research found that travel was a category of VR applications that had a strong appeal to older adults (Baker et al. 2019a). This appealing category was also identified in other research studies or suggested by older adults (Benoit et al. 2015; Chapoulie et al. 2014; Hodge et al. 2018; Lin et al. 2018; Roberts et al. 2019). Older adults were interested in traveling to the places that they previously thought they might travel to, but they could no longer.

In addition, VR experiences might provide older adults with opportunities to reminisce in new and interesting ways (Baker et al. 2019a; Hodge et al. 2018). Reminiscence, especially life review, can positively influence life-satisfaction and emotional well-being in older adults (Bohlmeijer et al. 2007). This is also shown to be effective for older adults living with dementia (MacKinlay and Trevitt 2010). Existing evidence indicates that increasing the modalities of sensory input in a virtual environment can increase memory for objects in the environment (Dinh et al. 1999). These suggest that reminiscence-based experiences with an integration of multiple sensory modalities could foster the engagement of older adults during VR use.

Suggestions were made by participants in some studies with older adults to enhance the VR experience, including improving the technology and increasing its usability (Baker et al. 2019b; Hodge et al. 2018; Roberts et al. 2019). Particularly, people living with dementia were concerned about looking foolish or silly while wearing a HMD (Hodge et al. 2018) and a participant living with dementia disliked wearing the device (Baker et al. 2019b). Participants also expressed concerns about its weight (Brimelow et al. 2020; Brown 2019; Hodge et al. 2018).

Hodge et al. (2018) conducted afternoon tea sessions with older adults and their caregivers during a participatory design study in which they were co-designing, with participants, meaningful VR experiences. They found that the afternoon tea sessions were an opportunity for participants to spend meaningful time with their loved ones, and to access social support and advice from professional caregivers and from others facing the challenges of dementia. This means that social interaction probably was valuable for older adults. Hodge et al. (2018) revealed that "the VR system [they designed] was an inherently social interaction and served as a point to talk" (p.9). Participants in their study focused on the need to interact with others. Moreover, older adults expressed a wish to be able to share in the same 'live' VR experience with their loved ones (Hodge et al. 2018). So, it is beneficial for loved ones to join the experiences with older adults. These findings indicate that the ability to share experiences with other users and family members and the support from family members could enhance the engagement of older adults in VR experiences.

Existing evidence indicates that it would be useful to have facilitators to mediate discussion and provide guidance during older adults' VR experiences (Baker et al. 2019a) and utilise information sources about user interests and preferences. The facilitators could be trainers, health care professionals, or persons who can ensure that the activities are being performed correctly. The literature shows that skills and abilities of older adults, with both using and learning to use technology, is generally lower than for other age groups (Barnard et al. 2013); therefore, the needs for facilitation would be highly valuable for them. Facilitation was valued as it enabled a deeper social experience (Baker et al. 2019a). In the context of VR adoption in RACFs, an appropriate facilitator could be a member of the care or lifestyle team. The competences and capabilities of this group in facilitating these activities are critical to the success of the implementation of VR experiences.

A variety of issues brought about by using VR among older adults potentially affects user engagement in this kind of experience. These include the physical design of technology, which may comprise its look and weight (Brown 2019; Hodge et al. 2018); the types of virtual experiences, which refers to the experiences designed in VR such as travel and reminiscence-based experiences, and the integration of multi-sensory modalities (Baker et al. 2019a; Hodge et al. 2018). The opportunity to involve family members may also be important, and could provide older adults with the ability to share experiences with and obtain support from their loved ones; and experience in facilitation, which could ensure that the activities in the VR experiences are performed effectively (Baker et al. 2019a). Given the key role that staff play as facilitators of VR experiences in aged care settings, there is a need to consider the experience

of staff in evaluating VR in this setting. The adoption of VR requires the involvement of varied dimensions of socio-technical systems. Thus, when we investigate the complexity of the adoption of VR in RACFs, we need to consider varied influencing domains incorporating these issues.

Since RACFs are sensitive and complex environments where people typically have high care needs (McVey et al. 2014; Parker 2011), adopting emerging technologies in these settings could be more complex than in other settings. From an analysis of interviews with care staff, Cavenett et al. (2018) found that introducing emerging technologies into this environment is challenging. Skills for facilitating activities using VR, the ability to supervise technology experiencing sessions, educational background causing hesitation in technology use, ability to communicate and understand personal interests of residents are issues raised by RACF staff (Cavenett et al. 2018). Thus, technology-based programs may fail or only achieve partial success. Hence, a holistic investigation of the complexity of this technology adoption is critical. An understanding of technology as socio-technical systems and its technological, social, and cultural dimensions needs to be considered. Therefore, in this research, we draw on seven domains in the NASSS framework to identify the complexity brought about by the adoption of VR in RACFs.

3 The NASSS framework

A core concept of this research is technology adoption. Technology adoption is a process that encompasses a spectrum of responses starting with the user becoming aware of the technology and ending with the user embracing the technology and making full use of it (Renaud and Van Biljon 2008). Researchers in Information Systems, Sociology, and human-computer interaction have developed various theoretical models to predict adoption that, in turn, will lead to persistent use (Renaud and Van Biljon 2008). Some theories focus, at a micro-level, on factors influencing acceptance. The senior technology adoption models (STAMs) (Renaud and Van Biljon 2008) are analytical models that incorporate age-related factors influencing the adoption and use of technologies among older adults. Although these models have proven to be effective in predicting and explaining human behaviors, they are limited in their focus on individual characteristics. Exceptionally, the Diffusion of Innovations Theory (DOI) (Rogers 2010) concentrates on adoption in which the organizational characteristics play a key role. However, this model is not specifically focused on health/care settings. Thus, to enable those seeking to examine the adoption of technology-supported health or social care programs in health/care organizations, Greenhalgh et al. (2017) proposed an evidence-based and theory-informed framework called NASSS (Non-adoption, Abandonment, Scale-up, Spread, and Sustainability).

Greenhalgh et al. (2017) identified seven domains of complexity in health care settings that influence the adoption, non-adoption, abandonment, spread, scale-up and sustainability of health and care technologies including condition, technology, value proposition, adopter(s), organization(s), wider system, and continuous embedding and adaptation over time (adaptation). The condition domain refers to clinical and socio-cultural aspects, and/or the comorbidities of the users. The technology domain refers to the technology's properties, its ease of use, and the kind of data it generates. The value proposition domain refers to values generated for the developer and patients. The adopter(s) domain refers to issues related to adopters such as the need to learn new skills or procedures or adopt new staff roles and practices. The organization(s) domain refers to the scope, resource requirements, and/or interdependencies of delivering the innovation and the associated new service model. The wider system domain relates to political, financial, legal, public concerns, or inter-organizational networking. The adaptation domain refers to the flexibility, and/or resilience of the organization to adapt to changes. Greenhalgh et al. (2017) suggested that a domain which is straightforward, predictable, and has few components is classified as 'simple'. A domain which involves multiple interacting components or issues is classified as 'complicated'. A domain which is dynamic, unpredictable, not easily disaggregated into constituent components is classified as 'complex'. Technologies in which multiple domains are complicated have proven difficult to implement and those with multiple complex domains are less likely to become mainstreamed (Greenhalgh et al. 2017).

The framework showed promise when applied both prospectively and retrospectively in predictions and evaluations of technology-based programs (Greenhalgh et al. 2017). It has been applied in varied health contexts. For instance, Van Velthoven and Cordon (2019) utilized the framework as a guide for identifying stakeholders' perceptions of barriers and the factors that facilitate the sustainable adoption of digital health innovations. Also, Dijkstra et al. (2019) adapted the framework to explore the challenges of implementing a web-based telemonitoring strategy and to evaluate whether they could move their innovation from a demonstration project to one that is sustained within existing sites. These previous examples from the literature suggest the relevance of using the NASSS framework to analyze the introduction of VR in the aged care setting. The framework is intended to be used for understanding

information systems in healthcare organizations at enterprise level, interdependent with other IT systems, and systems that are used and virtually adopted by clinical employees. The use of VR in aged care is somewhat different to these information systems, in that it is an innovation for aged care residents but it shares the socio-technical qualities of enterprise systems. Applying this framework to a study of the adoption of VR in RAC will enable us to identify the most important domains that need to be managed in order for VR to be used effectively in this setting in the future.

4 Study design

In this research, we have partnered with an aged care provider that has recently purchased Oculus Go VR headsets for use across their facilities (known here as ABC – the name of the organization has been de-identified to ensure confidentiality). Though RACF residents and staff are two major stakeholders in this technology-based program, because of complex health conditions of residents and an active role of staff members in VR activities, data has been collected through the lens of staff members. As this research is taking place during the Covid-19 lockdown and aged care organizations have established restricted access to all their homes, online surveys are the most appropriate available method.

4.1 Designing the survey instrument

Each domain in the NASSS framework has been adapted based on the issues identified in the literature review. We denote each proposition to be studied in the survey with 'P*n*'.

Greenhalgh et al. (2017) suggested exploring two major issues in the condition domain including the nature of condition and illness, and the comorbidities and sociocultural influences. At an individual level, which was explored in the unified theory of acceptance and use of technology, user demographic factors such as age, gender, experience, etc. influence users' intention to use the technology and their use behaviour (Venkatesh et al. 2003). In this study within the RACF context, we are focused on the system level. Thus, we consider the intention to use the technology or willingness to use the technology of residents as a proposition to examine in this domain (P1). Furthermore, RACF is a sensitive setting that involves residents with complex health conditions such as dementia and multi-co-morbidities (McVey et al. 2014; Parker 2011) and diversity of sociocultural backgrounds. Hence, older adults may lack access to technologies and lack confidence in their own ability to use technology (Barnard et al. 2013). Meanwhile, a lack of confidence in relevant abilities might result in difficulties in using technologies among older adults (Marquié et al. 2002). Thus, we suggest the following propositions to study: the ability to experience technology (P2), discomfort experiences (P3), and the technology skills of RACF residents (P4).

Despite varied benefits of VR for enrichment among older adults, a common concern is the potential to experience discomfort, particularly cybersickness, which is the feeling of symptoms similar to or related to motion sickness in a virtual environment such as nausea, dizziness, headache, and fatigue (Rebenitsch 2015). Older adults have experienced fear or anxiety and became fatigued during VR experiences (Moyle et al. 2018). In a study partnering with RACFs by Moyle et al. (2018), fatigue in the majority of residents resulted from the motions required to engage in the activity. Therefore, we suggest three propositions to examine complexity existing in the technology domain including the risk of VR activities (P5), the suitability of VR experiences (P6), and the suitability of VR devices (P7).

The major adopters of this technology include staff members and residents who use the technology together. However, in this context, the technology-based program was introduced by the aged care organization, with the activities facilitated by staff members. Residents were not responsible for decisions to introduce VR into the RACF. Also, RACFs are complex environments involving residents with complex conditions and where residents typically have high care needs, the residents were included in the condition domain rather than the adopter domain. Related to staff members, Baker et al. (2019a) found that older adults believed social VR experiences would be improved when there was a facilitator to mediate discussion and provide guidance. Staff members are those who are directly involved in VR activities; therefore, it is essential for them to be equipped with facilitation skills. Hence, in the adopter(s) domain, we suggest facilitation skills of staff members are a proposition (P8) to evaluate the potential complexity. In addition, a study shows that apart from a lack of knowledge about technology and skills, a lack of involvement of staff is emerging as a challenging issue in technology adoption in health care organizations (Kapadia et al. 2015). For this reason, we suggest the openness of staff members in technology adoption as another proposition (P9).

It is important to ensure that residents' needs and concerns remain central, so in the value proposition domain, we have focused on the value of the technology to residents. The value can be evaluated by staff members' observations that the technology has been effective for residents and their perceptions of the

value of VR for enriching older adults' experiences. Thus, we suggest the perceived value (P10), and the observed effectiveness (P11) are propositions to explore the complexity of this domain. In addition, if a product is new, valuable, and surprising, it is considered as a creative product (Boden 2004). Therefore, we suggest considering the perceived creativity of the VR program as another proposition (P16). In fact, if the technology did not bring obvious benefits and it is not valuable for residents, the reasons for the adoption would be more complex and need to be further explored.

When adopting a technological innovation in RACFs, it is essential to make sure the values of technology for residents are well communicated by management. Clear communication could help to avoid unexpected staff resistance resulting from misunderstanding of its values. Also, it is essential to consider how ready the organization is for technology adoption; and whether the organization has faced severe resource pressures in terms of required skilled personnel. From a management perspective, technology adoption in aged care faces some challenging issues such as the quality of documentation and complexity of sharing information across organizations, and lack of ICT integration (Kapadia et al. 2015). Therefore, in the organization domain, we suggest several propositions to explore including: the clear communication of values of VR (P12), the existing routines and practices within the organization (P13), the capacity for adopting the innovation (P14), and the skills sharing capacity across facilities (P15).

For older adults, the wider context often involves family members. Family members may have been the primary caregivers prior to the resident entering a facility and often continue to be involved in many aspects of an older adults' life in the home (Bauer 2006). Benefits of family involvements have been observed and specified in Gaugler (2006). Also, family members might sometimes advise older users to disengage from the use of technology due to concerns on the effects of technology on their loved ones' self-esteem (Waycott et al. 2016). Furthermore, Hodge et al. (2018) mention that older adults expressed a wish to be able to share in the same 'live' VR experience with their loved ones. These findings emphasize that the implementation of VR in RACFs might need the involvement and support of family members. Therefore, we propose two family-related propositions that should be considered including the involvement of residents' family members (P17), and the openness of family to the adoption (P18). Moreover, one of the challenging issues raised by RACF staff is the training required to enhance their facilitation skills. This requires involvement of technology vendors. Thus, we propose the provision of adequate training by the technology vendor at the time technology is introduced (P19) and after it was introduced (P20) are propositions to explore in this domain.

The adaptation domain refers to the flexibility, and/or resilience of the organization to adapt to changes. In this domain, it is important to consider how significant the barriers are to a further adaptation of the technology. In the case of adoption of VR in RACFs, in order to adapt over time, we need to firstly consider the barriers in existing task routines, and therefore to what extent the task routines should be adapted (P21); secondly, the barriers to residents' technology skills and staff facilitation skills, and, therefore to what extent the staff facilitation skills (P22) and technology skills of RACFs' residents (P23) need to be enriched. Importantly, if the technology is to be sustained, it needs to be adapted to the environment, so we need to consider to what extent the technology needs to be adapted to the setting (P24). If there are significant barriers to further adaptation and/or the adaptive action is discouraged in a rigid environment, the complexity would be increased. Those issues are suggested as propositions to be explored in this domain.

Deriving from the propositions identified above, a set of closed-ended questions has been developed to survey staff members' opinion, presented in Table 1. The closed-ended questions are 5-point rating scale questions that require respondents to indicate, on a scale of 1 – strongly disagree, to 5 – strongly agree, the level of their agreement with the statements.

4.2 Research sample and data analysis

The survey has been distributed to ABC homes across Australia. Our research sample is RACF staff members who are responsible for coordinating and facilitating the social activities, including the VR program, offered at ABC homes (lifestyle team members or lifestyle coordinators). Staff members can only take part in the study if they are involved in the deployment of the VR program. Roughly 80 staff members from ABC care homes have been invited to complete an online survey and there have been 10 responses (6 responses from the homes based in New South Wales, 1 response from the home based in Victoria, 1 response from the home based in Queensland, and 2 responses without reporting the location). The respondents have been coded as from ABC 1 to ABC 10. It should be noted that the survey is taking place during Covid-19 lockdown, as described above, and staff have less time than usual to participate in research and so 10 responses are encouraging. Data collected has been subjected to simple descriptive analysis (appropriate for the number of responses), which provides a set of initial interesting findings from which further work can be developed.

	Closed-ended questions	Propositions
Q1	Aged care residents are willing to participate in VR activities	P1
Q2	Aged care residents do not have the ability to participate in VR activities	P2
Q3	Aged care residents frequently experience discomfort when using VR	P3
Q4	Aged care residents need to be equipped with technology skills to use VR	P4, P23
Q5	VR experience is not a high-risk activity	P5
Q6	VR experience is suitable for aged care residents	P6
Q7	VR devices need to be adapted for aged care residents	P7, P24
Q8	Virtual experiences provided in VR activities need to be adapted for aged care residents	P6, P24
Q9	Staff have enough skills for facilitating VR activities	P8
Q10	Staff are generally open to adopting VR	P9
Q11	Staff need to take more training in VR use	P8, P22
Q12	Family members are generally open to VR program being offered for their relative	P18
Q13	Using VR is a valuable experience for aged care residents	P10
Q14	Introduction of VR in the aged care home is a creative innovation	P16
Q15	It is clear when aged care residents enjoy using VR	P11
Q16	When the VR program was introduced in this home, the technology company provided adequate support	P19
Q17	Management clearly communicated their motivations for introducing VR to ABC homes	P12
Q18	Aged care homes have enough capacity to deploy VR activities	P14
Q19	I worry that I do not have the skills to implement VR in aged care	P8
Q20	Skills developed from facilitating VR activities are easily shared among staff	P15
Q21	In order to use VR, we need to make changes to the routine in the aged care home	P13, P21
Q22	It would be beneficial to have family involved in VR activities	P17
Q23	The technology company has provided adequate training regarding VR use	P19, P20
Q24	The technology company was not involved in the VR program after it was introduced	P20

Table 1. Proposed statements included in the questionnaire

5 Results

Figure 1 shows the number of people who responded with their level of agreement/disagreement to each statement. The respondents generally agreed that aged care residents appear willing to participate in VR activities (only two respondents disagreed) and residents' ability to experience VR does not appear to impede the adoption process (only one respondent disagreed). However, some respondents pointed out that there are residents that would not be suitable for the VR program. Also, some residents are not willing to participate in VR activities, as ABC 3 and ABC 8 responded, and the residents might still frequently experience discomfort when using VR (ABC 2 and ABC 10). Moreover, most respondents agreed that aged care residents need to be equipped with technology skills (only two respondents disagreed). Thus, the challenges in the condition domain are likely dynamic and unpredictable. The condition domain is therefore classified as *complex*.

Though half the respondents agreed that VR is not a high-risk activity and only ABC 3 and ABC 8 disagree that VR experience is suitable for residents, most respondents agreed that VR devices (8/10) and VR experiences (9/10) need to be adapted for aged care residents. Possibly, the adaptation of VR devices and experiences provided might help address the potential risks of VR activities. For instance, VR device could be adapted to be more ageing-friendly and focused on ease of use. Also, VR experiences could incorporate more multisensory reminiscence. However, the iterative adaptation of VR to be appropriate to the complex condition of residents is challenging. The technology domain is therefore classified as *complex*.

Respondents agreed that it is clear when residents enjoy using VR and using VR is a valuable experience for aged care residents (only ABC 5 disagreed). Most respondents (8/10) agreed that introduction of VR in aged care homes is a creative innovation, except two respondents (ABC 2 and ABC 8) who neither disagreed nor agreed. Except for residents with high clinical conditions and advanced dementia, the benefits and value of VR technology for residents are clear and straightforward. Therefore, the challenges of the value proposition domain is classified as *simple*.

In RAC settings, respondents did not worry too much about their skills to implement VR activities (only one respondent agreed with the statement that I worry that I do not have the skills to implement VR in aged care). However, in response to the statement that staff have enough skills for facilitating VR activities, two respondents strongly disagreed (ABC 3 and ABC 10), one respondent agreed (ABC 9), and three respondents neither disagreed nor agreed (ABC 2, ABC 6, and ABC 8). Furthermore, when it comes to a statement about the need for taking more training, six respondents agreed or strongly agreed that staff need to take more training in VR use, whereas four respondents neither agreed nor disagreed (ABC 1, ABC 5, ABC 7, and ABC 8) and no respondents disagreed. If the training is required, more interacting components will be involved. These responses possibly indicate that the issues of the adopter domain (staff related issues) are *complicated*.

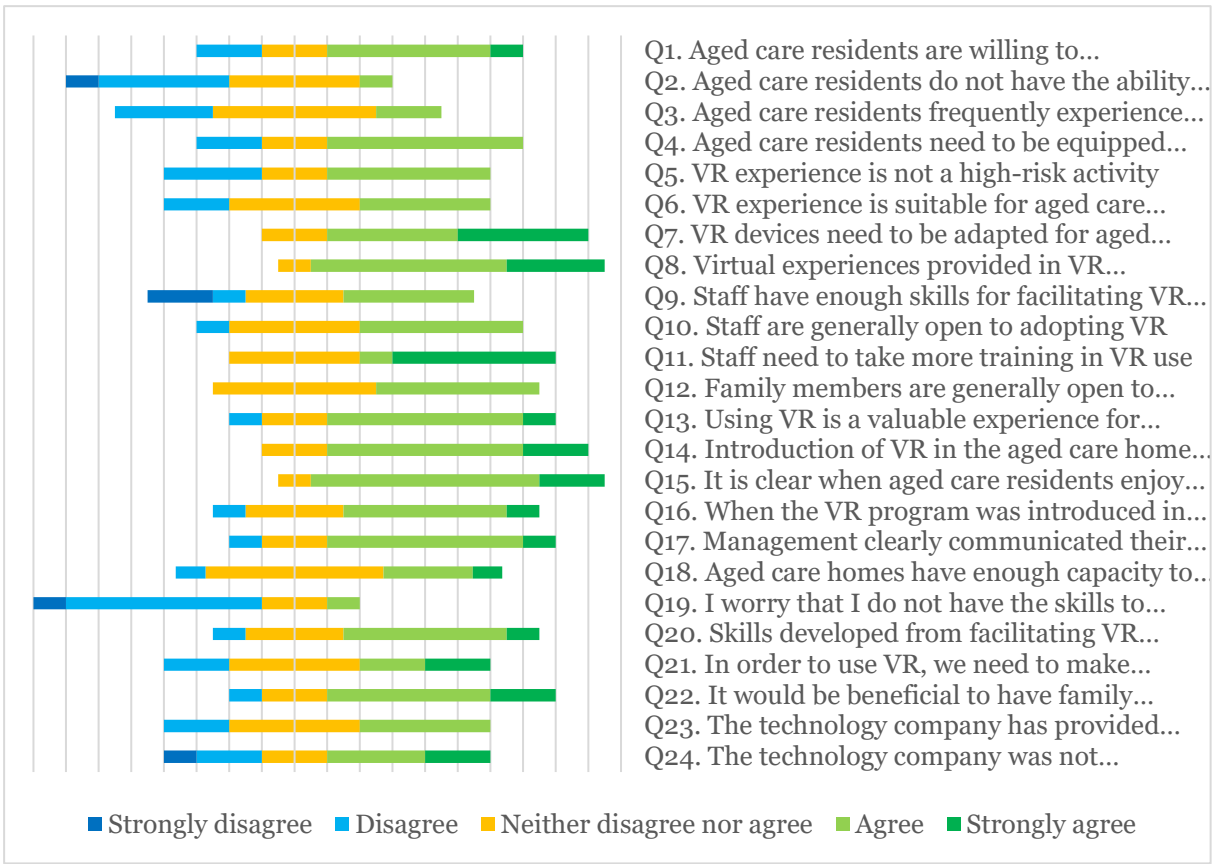


Figure 1: The number of responses with levels of agreement to each statement

In terms of organizational aspects, staff members seem unsure about the capacity to deploy VR activities in their aged care home, with over half the respondents (6/10) neither agreeing nor disagreeing that aged care homes have enough capacity to deploy VR activities. However, staff acknowledged that ABC management board clearly communicated their motivations for introducing VR to ABC homes (7/10 respondents agreed) and skills developed from facilitating VR activities are easily shared among staff members (6/10 respondents agreed or strongly agreed). Also, the VR program is likely to fit with task routines and practice within the aged care homes. This indicates that organizational issues are not significantly challenging to the adoption of the VR program. Therefore, the organization domain is classified as *simple*.

The respondents revealed that apart from experienced lifestyle team members, it would be beneficial to have family involved in VR activities (only ABC 5 disagreed). Meanwhile, half the respondents agreed that family members are generally open to VR program being offered for their relative. Thus, family related issues are not significantly challenging to the VR program. Relating to the technology company,

respondents agreed that when the VR program was introduced in their home, the technology providers provided adequate support (5/10) and training regarding VR use (4/10). However, staff are recommended by respondents to take more training in VR use. In this situation, technology providers and/or experienced lifestyle team members might be required to be involved to provide training for staff members. Therefore, the wider system domain is classified as *complicated*.

In order to successfully adopt the VR program, respondents suggest adapting varied issues within most of the domains. For instance, most respondents agree that aged care residents need to be equipped with technology skills. Most respondents agree that VR devices and VR experiences provided in the VR program need to be adapted for aged care residents. Respecting adopters, staff are recommended by respondents to take more training in VR use, specific to its use within the aged-care setting. Meanwhile, if more training is required, the technology company's involvement is essential. If it is beneficial to have family involved in VR activities, the involvement of residents' family members should be considered. In the RAC environment where people typically have high care needs, these issues are significantly challenging. Therefore, the adaptation domain is classified as *complex*.

Table 2 summarizes the level of complexity of seven domains. Five of the seven domains in aged care can be considered complex or complicated. This necessarily impacts on technology adoption.

	Condition	Technology	Value proposition	Adopter	Organization	Wider system	Adaptation
Level of complexity	complex	complex	simple	complicated	simple	complicated	complex

Table 2. The level of complexity of seven domains

6 Discussion

By understanding technology-in-use as socio-technical systems, the NASSS framework proposed by Greenhalgh et al. (2017) enables us to identify emerging opportunities and challenges brought about by the adoption of VR in RACFs and to understand how complex the seven domains, as reflected in the framework, are in this context. Regarding opportunities, it is agreed by many respondents that the use of VR in aged care homes is a creative innovation. It is clear to staff that many residents enjoy using VR. The technology is valuable for some aged care residents. Notably, aged care staff members are generally open to adopting the VR program. They do not worry too much about their skills in implementing VR activities in the homes. Also, skills developed from facilitating VR activities are easily shared among staff. They believe the VR program is likely to fit with task routines and practice within the aged care homes.

On the other hand, possible challenges have been identified. Residents' conditions and VR technology itself raise complex challenges that could impede adoption. Respondents have perceived that there are still residents who would not be suitable for the current VR program. Some residents might frequently experience discomfort when using VR. Aged care residents need to be equipped with more technology skills to participate in VR activities. The VR program has been perceived as a high-risk activity by some respondents and the technology including HMD devices and experiences provided in VR activities need to be adapted to be more appropriate for aged care residents. The adopters, particularly RACF staff members who facilitate VR activities, bring complicated challenges to the adoption. There needs to be more training in terms of VR use and facilitating skills among involved staff members. These challenges are to some extent caused by usability issues of the technology.

Using the Greenhalgh et al. (2017) framework in the context of adoption and use of VR in RAC, we have classified the condition domain and the technology domain as complex since the challenges of these domains are dynamic and unpredictable. The adopter domain and the wider system domain is likely classified as complicated due to multiple interacting components potentially involved. External stakeholders such as technology providers and/or experienced lifestyle staff members might be required to be involved by providing staff members with more training related to VR activities. The complex challenges of the condition and the technology and the complicated issues of the adopter domain and the wider system would result in complex issues in the adaptation domain. On the other hand, the value proposition domain is likely classified as simple since most respondents acknowledged the value that VR technology can bring to aged care residents. Similarly, the complexity of the organization domain is likely classified as simple since not many organization-related challenges have arisen, based on the examples sampled such as support from management. However, this finding is not consistent with what

were found by Cavenett et al. (2018) that the aged care industry is under considerable strain and there are likely to be complex organisational issues to consider.

Greenhalgh et al. (2017) suggested that technologies in which multiple domains are complicated have proven difficult to implement, whereas those with multiple complex domains may not even become mainstreamed. Drawing on the levels of complexity, it can be implied that it is challenging to sustain a VR program within RACFs due to a complex interplay of issues arising from residents' conditions and the technology itself, and the complicated challenges involving staff who facilitate VR activities in residential care homes. In order to enable the VR program to be successfully implemented and sustained within existing sites, the complex challenges in the condition domain and the technology domain, and the complicated challenges in the adopter domain and the wider system domain need to be addressed. However, these findings need to be further validated by performing a statistical analysis once more survey data is collected. It is expected to have around 250 responses or more to validate the survey instrument, to ascertain how well each set of questions measures each domain, and to understand how these domains influence each other within this care setting.

Furthermore, some issues should be also further investigated to clarify existing issues brought about by this adoption. Firstly, it is vital to explore why (and how frequently) residents in several homes experience discomfort when using VR, while others do not. Secondly, it is essential to explore why some respondents disagree that the VR experience is suitable for aged care residents, why some perceived that VR activities are high-risk, and that VR activities are not valuable for residents. Thirdly, it is critical to investigate reasons why some respondents disagree and even strongly disagree that staff have enough skills for facilitating VR activities, and why staff members are not open to adopting the VR program. It is important to investigate to what extent these challenges result from usability issues of the technology when we consider usability in its wider socio-technical context. These might be achieved by conducting observation studies on the VR use in the ABC homes and/or follow-up interviews with respondents from those RACFs.

7 Conclusion

This paper contributes by presenting an approach to adapting and converting the NASSS framework into a questionnaire for identifying the complexity brought about by adopting VR to enrich the experiences of older adults living in nursing homes. The paper investigates how this complexity influences system adoption. A descriptive analysis of the survey responses indicates that varied complex and complicated issues have considerably challenged the implementation of the VR program, especially in the residents' condition domain, the VR technology itself, the adopters, and the wider system domain. In order to enable the VR program to be successfully implemented and sustained within this setting, complex challenges involving technology, its adoption and the wider system domain need to be resolved.

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Acknowledgements

This research is supported by a Melbourne Research Scholarship and an Australian Research Council Future Fellowship award (grant number FT170100420). The research was conducted in accordance with the ethical standards approved by The University of Melbourne Human Research Ethics Committee (Ethics Approval ID: 1954415.2).

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