A social robot intervention on depression, loneliness, and quality of life for Taiwanese older adults in long-term care

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	Design: A mixed methods approach consisting of a single group, before and after, quasi-experimental design and individual interview.
	Participants: Twenty older adults with depression from four LTC facilities in Taiwan were recruited.
	Intervention: Each participant participated in 8 weeks of observation and 8 weeks of intervention. In the observation stage, participants received usual care or activities without any research intervention. In the intervention stage, each participant was given a Paro robot to keep for 24-hours 7 days a week.
	Measurements: The Geriatric Depression Scale, the UCLA loneliness scale-3, and the World Health Organization Quality of Life Questionnaire for older adults were administered at four time points. Individual qualitative interviews with thematic analysis followed.
	Results: A repeated multivariate analysis of variance and Friedman's test showed no significant changes during the observation stage between T1 & T2 for depression and quality of life (p >.5). For the intervention stage, statistically significant changes in decreasing depression and loneliness, and improving quality of life over time were identified. Three themes emerged from the interviews: [i] humanizing Paro through referring to personal experiences and engagement; [ii] increased social interaction with other people; and [iii] companionship resulting in improved mental well-being.
	Conclusions: There were significant improvements in mental well-being in using Paro. Further research may help us to understand the advantages of using a Paro intervention as depression therapy.
	Keywords: social robot, Paro, older adults, depression, loneliness, well-being, psychosocial intervention

Title page

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Running title: Social robot for older adults with depression

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Abstract

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4

interviews: [i] humanizing Paro through referring to personal experiences and engagement; [ii] increased social interaction with other people; and [iii] companionship resulting in improved mental well-being.

Conclusions: There were significant improvements in mental well-being in using Paro. Further research may help us to understand the advantages of using a Paro intervention as depression therapy.

Introduction

The World Health Organization estimated that the overall prevalence of depressive disorders among older populations generally varies between 10%-20% (Barua *et al.*, 2011). According to a worldwide estimate, approximately 5 million older adults experience late-onset depression, but this number may be conservative as it remains under-recognized and inadequately treated (Viscogliosi *et al.*, 2013). Research shows that people who live in long-term care (LTC) facilities have higher rates of depression than those living in the community (Chau *et al.*, 2019b; Seitz *et al.*, 2010). Reasons for higher rates include physical pain, poor person-environment fit, sleep disturbance and limited social support (Chau *et al.*, 2019a; Seitz *et al.*, 2010). Symptoms of depressive disorders include: depressed mood, diminished interest, loss of energy, and feelings of worthlessness (American Psychiatric Association, 2013). Furthermore, depression is strongly associated with many negative health outcomes for older adults (Novick *et al.*, 2015) and presents as somatic symptoms, such as insomnia, loss of appetite, fatigue, headaches and lethargy (Luppa *et al.*, 2012), as well as increased risk of suicide (Yang *et al.*, 2015). Studies have identified a positive correlation between depression and loneliness where older adults who perceive feelings of loneliness tend to experience a higher level of depression and more negative emotions (Liu *et al.*, 2016; Nyqvist *et al.*, 2013). Thus, psychological and social vulnerability might be exacerbated in older adults in LTC and may eventually impact their quality of life. However, there is limited research on effective psychosocial interventions for depression and loneliness among older adults in LTC (Simning

and Simons, 2017). Therefore, these issues merit more attention to develop effective strategies to manage depression.

Advances in technology have created a vast potential for the provision of new forms of healthcare. Recently, there has been increasing interest in the use of social robots to alleviate psychological distress and encourage social interaction for older adults with dementia (Moyle, 2019). The use of social robots in LTC has led to a proliferation of studies which explore the physical and psychological outcomes of older adults with dementia (Moyle *et al.*, 2017; Petersen *et al.*, 2017).

A range of social robots have been developed for use in LTC. The most common animal companion robot, Paro (Personal Assistive RobOt), was developed in Japan and designed to engender psychological or enrichment effects as a mental commitment robot, that makes people feel an emotional attachment to the robot through interaction with the robot (Shibata *et al.*, 2012). It has been recognized as a potential psychosocial intervention for improving mental well-being in older adults (Chen *et al.*, 2018; Pu *et al.*, 2018). Paro has the appearance of a baby harp seal and is equipped with an array of tactile sensors that monitor sound, light, and touch. Paro can show human-like emotional reactions such as happiness and anger.

Paro interventions are based on human-animal interactions aimed at providing physiological, psychological, and social benefits. Physiological effects are triggered through sensory stimulation with Paro such as stroking and can

result in a reduction in blood pressure (Robinson *et al.*, 2015). Psychological effects are experienced through the comfort derived during close interaction and social benefits are provided through engagement in activity with Paro (Shibata and Wada, 2011). Recent studies have shown Paro can decrease depression (Petersen *et al.*, 2017) and loneliness (Robinson *et al.*, 2013) as well as improve mood (Moyle *et al.*, 2013), and quality of life (Jøranson *et al.*, 2016) in people with dementia. Although extensive Paro research has been carried out with people with dementia, no single study exists which focuses on older adults with depression. Therefore, an effective and innovative psychosocial intervention that aims to reduce depression and improve well-being for older adults with depression in LTC is warranted.

Method

Design

A pilot mixed-methods study with a single group, before and after quasi-experimental design and individual interview were used.

Settings and Participants

This study was conducted at four accredited LTC facilities with more than 100 beds in Southern Taiwan. A purposive sample of depressed older adults living in LTC was recruited. The inclusion criteria of participants were: (1) aged 65 years or older; (2) with a score higher than 6 out of 15 on the Geriatric Depression Scale-Short Form (GDS-SF) (Friedman *et al.*, 2005); (3) no cognitive impairment as determined by the Mini-Mental State Examination

(MMSE) cutoff score of≧24/25 (Zhang *et al.*, 1990) by educational level; (4) able to communicate in Mandarin or Taiwanese; and (5) had been living in LTC for at least 3 months. This was due to relocation as residents often exhibit a higher prevalence of depression following admission into LTC during the first 3 months (Hoover *et al.*, 2010). Participants who: (1) had severe difficulty in communication; (2) were totally dependent on carers for daily activity; (3) had a diagnosis of infectious disease; (4) had a diagnosis of dementia and severe mental illness such as schizophrenia and delusional disorder, were excluded.

Using the PASS version 14 (NCSS, Kaysville, Utah), a target sample of 44 participants was recruited based on a prior study that examined the effect of a Paro intervention on depression (Moyle *et al.*, 2013) and the number of time points at which data were collected. To allow for a 10% attrition rate, this study sought to recruit 22 participants, and as each participant served as his or her own control, this doubled the sample size to 44.

Recruitment

An expression of interest to be involved in the study was sent to directors of LTC facilities via email or telephone. The research contacted the directors of four LTC who had expressed an interest in being involved. Initially, the directors identified and provided a list of potential residents who met the study criteria and introduced the researcher to these potential participants. The researcher subsequently contacted them in person and explained the aims and details of the study, and written consent was sought from each participant before the start of the study. The researcher screened all participants to determine their levels

of depression and cognition, and only those who met the inclusion criteria were recruited into the study.

Intervention

There were two stages in the study, observation and intervention stages. In the observation stage, participants received usual care or activities in the LTC facility without any research intervention for 8 weeks to ascertain their habitual mood and behavior. In the intervention stage, each participant was given a Paro to keep for 24-hours, 7 days a week, for 8 weeks. Participants could choose a suitable time to interact with the Paro according to their preferences. When they did not wish to interact with Paro, they had the choice to put the Paro aside or to take the Paro with them. During the first visit, the researcher introduced the Paro to participants, who were encouraged to make contact and interact with it both verbally and by touching it.

Two staff members from each participating LTC facility were trained by the researcher in (a) how to operate the Paro; (b) introduce it to the participant's family; and (c) solve potential problems that may arise during its use. For hygiene and safety reasons, guidelines for infection control measures when using a Paro were also introduced to staff to oversee.

During the last week of the intervention, the trained staff informed participants that the Paro would be leaving them on the following Friday. On the last day, the researcher gave each participant 10-minutes to say his/her farewell to the Paro.

Treatment fidelity

Treatment fidelity was monitored through weekly checks of the intervention by the researcher. These procedures included three steps. First, the Paro's condition was checked to ensure it was charged and operating correctly. Second, each visit took 10-15 minutes. Participants' interactions with the Paro in the activity room or bedroom were observed. If participants were in the bedroom while the researcher was visiting, the researcher greeted participants, had a chat and observed the intervention. This step included how often, and when, participants used the Paro, how they interacted with Paro, their non-verbal expressions, and whether they had any questions when they used Paro. These notes were used to help the researcher to understand the participants' experiences and to interpret the results, but they were not used as part of the data analysis. Third, any issues raised by participants to the staff were discussed with the researcher to ensure that staff could resolve these issues.

Data collection

Demographic data and health-related information were collected at baseline. Outcome measurements included the GDS-SF (Liu *et al.*, 1998), the UCLA Loneliness Scale Version 3 (UCLA-3) (Chang and Yang, 1999) and the World Health Organization Quality of Life Questionnaire for older adults (WHO-QOL-OLD) (Liu *et al.*, 2013). The researcher at four time points administered these: a week before the start of the 8-week observation (T1), immediately at the end of the 8-week observation (T2), at the mid-point of the Paro intervention (T3), and immediately at the end of the 8-week Paro intervention (T4). After the Paro

intervention, an interview was conducted to understand participants'
experiences of using the Paro. There was no follow-up assessment after the
end of the Paro intervention as previous two systematic reviews (Chen *et al.*,
2018; Pu *et al.*, 2018) had found no significant effect of a social robot
intervention on depression at follow-up.

Demographic data and health-related information

Demographics such as age, gender, education level, the length of stay in LTC
and previous pet ownership were collected. Health-related information
collected included the type of depressive disorder, any other chronic disease,
a medication audit including anxiolytics, antidepressants and other medications
as well as the Barthel score (Wade and Collin, 1988) for self-care and mobility.

MMSE

The MMSE (Folstein *et al.*, 1975), is a widely used tool that screens the level
of cognitive impairment, using the concepts of orientation, registration, attention
and calculation, recall and language. The MMSE has good internal consistency
with a Cronbach alpha of .91 in older populations (Marioni *et al.*, 2011) and .83
to .84 in older Taiwanese populations (Lou *et al.*, 2007). The MMSE score
ranges from 0 to 30. In this study, the cut-off point was based on the study of
Zhang *et al.* (1990) in which the level of cognitive impairment varies according
to educational level: 17∕18 for older people without formal education, 20∕21 for
those with 1–6 years of education, and 24∕25 for participants with more than 6
years of education in Chinese older adults.

GDS-SF

The GDS-SF (Yesavage and Sheikh, 1986) consists of 15 items with 10 positive items and 5 negative items. The Chinese version of GDS-SF was translated by Yeh *et al.* (1995). GDS-SF is a useful tool to detect depressive symptoms in older populations (Greenberg, 2007). Each item has a 'yes' or 'no' answer response. The scores range from 0–15 and a cutoff of 6 or more indicates the presence of depression as it is conventionally used for differentiating depressed from nondepressed older adults (Friedman *et al.*, 2005). This scale has good reliability with Cronbach's alpha of internal consistency reported at .89 in the original version and .90 in the Chinese version (Lee *et al.*, 1993).

UCLA-3

The UCLA-3 is a 20-item scale that was developed by Russell (1996). Chang and Yang (1999) translated the Chinese version of UCLA-3. It is used to measure a person's subjective feelings of loneliness. Each item on the scale is rated from 1 (Never) to 4 (Often) with a total score ranging from 20 to 80. The higher the score, the more severe the person's feelings of loneliness. This scale has good reliability with Cronbach's alpha of internal consistency ranging from .89 to .94 in the original scale (Russell, 1996) and .85 to .90 in the Chinese version (Chang and Yang, 1999).

WHO-QOL-OLD

The WHO-QOL-OLD (Power *et al.*, 2005) is derived from the World Health Organization Quality of Life Questionnaire-BREF (THE WHOQOL GROUP,

1998). The Chinese version of WHO-QOL-OLD was translated by Liu *et al.* (2013). This questionnaire consists of 24 items with 6 domains: sensory abilities; autonomy; past, present and future activities; social participation; death and dying; and intimacy. Responses are rated on a 5-point Likert scale with a higher score indicating a better quality of life. Internal consistency as measured by Cronbach's alphas of all subscales ranged from .72 to .91 in the original study (Power *et al.*, 2005) and .72 to .95 in the Chinese version (Yao and Chien, 2013).

Individual Interviews

An individual semi-structured interview was conducted with participants following the Paro intervention. The interview explored participants' experience and perceptions of participating in the Paro intervention to gain a better understanding of the use of Paro in bringing about a change in mental well-being. Each interview took approximately 30-40 minutes and was recorded digitally and transcribed verbatim.

Ethical considerations

Ethics approval for the study was obtained from a University Human Research Ethics Committee (Reference Number: 2017/911) before the commencement of the study. Written consent for participation was obtained before the start of the study from all participants.

Data analysis

Quantitative data were analysed using SPSS 25.0 (IBM, Armonk, NY). An intention-to-treat approach (Gupta, 2011), in which all participants' data were analysed according to their enrolment, was used. Descriptive statistics were used to demonstrate demographic characteristics. A repeated analysis of variance (ANOVA) was used to examine changes in depression and loneliness before and after the Paro intervention. Due to abnormal distribution of data, the Friedman test was employed to examine changes in quality of life. Further post-hoc analysis using the paired sample t-test and Wilcoxon Signed Ranks test were conducted where appropriate. Cohen's d of 0.20, 0.50, and 0.80 were used to represent small, moderate and large effects, respectively. The significance level was set at $p < .05$.

All interview data were audio-recorded digitally and transcribed verbatim in Chinese for data analysis by a research assistant. The researcher checked the quality of transcription by selecting a transcript and re-listening to the digital recording while reading the transcribed text. Qualitative data analysis was guided by the six steps of thematic analysis outlined by Braun and Clarke (2006): (i) familiarization with data; (ii) generation of initial codes; (iii) identification of themes; (iv) reviewing themes; (v) defining and naming themes; and (vi) producing the report. The researcher read through the qualitative data to obtain a sense of overall views and wrote memos about initial perceptions of the data. An initial coding framework was developed by the researcher based on an initial analysis of the first three participant transcripts, using inductive

15

coding and a constant comparative approach. Another researcher checked the accuracy of the language translation of the manuscript and assisted the researcher to recognize important phrases or experiences mentioned by participants, following a reading of the transcripts. The researcher coded each transcript once a comprehensive coding framework was agreed upon. Differences in coding were discussed, resolved, and used in the further development of the coding framework. Themes and sub-themes were compiled together with verbatim quotations.

RESULTS

Participants

Thirty-two eligible older adults with depression were approached before the commencement of the study. Of these, 12 older adults declined to participate due to a lack of interest ($n = 6$), did not return the consent form ($n = 2$), felt stressed ($n = 3$), or did not provide a reason ($n = 1$). Finally, 20 participants consented to participate in this study, all of whom completed the study, and there was no missing data.

Demographic characteristics and health information of participants

The demographic characteristics and health information of the participants are summarized in Table 1. The participants were aged between 65 and 93 years, mean 81.1 ± 8.2. The majority of participants were female (65%) and were widowed (65%). Seventy per cent of participants reported that they did not have a pet before they moved into LTC, and on average, they had lived in LTC for

3.4 years (SD = 2.3).   The mean baseline Barthel score was 54.5 ± 31.4 indicating moderate dependency in self-care and activities of daily living in participants.

All participants had experienced at least one chronic disease or illness. Seventy-five per cent of participants had a diagnosis of mild depression, but only a few of them (5%) took antidepressants, and none received other forms of treatment for depression such as cognitive or electroconvulsive therapy. However, some participants took medications such as anxiolytics (15%), hypnotics (40%), and medications for acute anxiety and psychotic conditions (85%).

Effects of 24-hour PARO intervention on depression, loneliness, and quality of life

Changes in scores of depression, loneliness, and quality of life at each time point are presented in Figure 1. In the observation stage (from T1 to T2), there were no significant changes in these three variables. However, in the 8-week 24-hour Paro intervention (from T2 to T4), the results revealed significant positive changes in these three variables. Mauchly's Test of Sphericity indicated that sphericity was established in both depression ($\chi2$ = 4.09, p = 0.54) and loneliness ($\chi2$ = 5.92, p = 0.32). Repeated ANOVA revealed a statistically significant difference for both depression, F(3, 57 = 87.26, p < 0.001, partial eta squared = 0.821) and loneliness, F(3, 57 = 61.7, p < 0.001, partial eta squared = 0.765). Also, we provided Cohen's d effect size in Table 2. Post-hoc examination using paired sample t-tests was undertaken to

determine the differences for depression and loneliness in each pair of comparison (Table 2). After the 8-week 24-hour Paro intervention (from T2 to T4), there were significant differences in every time point comparison ($p < 0.05$.

The Friedman test was used to examine changes in quality of life due to an abnormality of data distribution. The results demonstrate that there was a significant difference in the quality of life for participants over time ($\chi 2 = 30.28$, $p < 0.001$). Consequently, post-hoc analysis using the Wilcoxon Signed-Rank test was conducted to examine the differences in quality of life in each pair of comparison (Table 3). There was no significant difference in the observation stage (T1 and T2). After the 8-week Paro intervention, there were significant differences in T2 versus T3 and T2 versus T4, but no significant difference in comparison of T3 versus T4.

Since taking antidepressants might affect the outcome of the study, 5% (n=1) of the participants who had taken antidepressants were excluded. This exclusion did not impact on depression, loneliness, and quality of life results.

Qualitative results

Three themes emerged from the interviews: [i] humanizing Paro through referring to personal experiences and engagement; [ii] increased social interaction with other people through using Paro; and [iii] companionship resulting in improved mental well-being. Participants are referenced by their number followed by gender (F = Female; M = Male) and age (e.g. Case 1, F84).

Theme 1: Humanizing Paro through referring to personal experiences and engagement

Humanizing Paro is defined as attributing human-like qualities to a robot. The naming of Paro was an important first step for this intervention as it determined how participants perceived Paro and affected how they interacted with it. Humanizing Paro by giving it a name through referring to personal experience and engaging with it in a meaningful way emerged as important factors for all participants as they regarded Paro as a valuable object, automatically stimulating them to interact with it. These names were positive identities, related to a close family member, a pet, a nickname, or a memorable object from past experiences. One participant stated: "I called him Brown Sugar Cake, because that was the only dog I had. It reminded me of him. I miss my dog very much [Case 5, M65]". Another participant said: "I called it 'Xiao-Ying', because that was the nickname my husband had for me [Case13, F75]". Assignment of a meaningful name appeared to affect the role assigned to Paro by participants and influenced how participants interacted with it and their attitudes toward it. Hence, humanizing Paro helped participants feel closer to Paro and engage with it.

Theme 2: Increased social interaction with other people through using Paro

This theme involves how Paro provides an opportunity to help participants improve social interactions, such as increasing verbal responses among older adults in LTC. Several participants exhibited increased verbal and non-verbal

19

communication while holding and talking with Paro. They liked to talk with Paro, made eye contact, and paid attention to it. An example follows: "I loved to chat with Da-Xiong in Japanese, Mandarin, and Taiwanese [Case 18, M88]". One participant articulated that Paro provided opportunities to encourage conversations with others since other residents would come to interact with her when she was with Paro. This would not occur when she did not have Paro. She said:" I think I have more conversations with other people because of Xiao-Jin [Case 1, F81]". Another participant stated "When I took it outside, some residents came to play with Du-Du and staff took pictures with it. I have more interactions with other people [Case 4, F86]". Most participants highlighted that Paro provided opportunities to help them improve their social interaction as they experienced the benefits of using Paro as a means of connection to other people.

Theme 3: Companionship resulted in improved mental well-being

This theme refers to Paro providing companionship for older adults with depression and looks at how Paro helped participants to improve their mood and well-being. Companionship is defined as participants feeling a sense of closeness with Paro. This involved Paro being there, wanting Paro to be there, enjoying its company and then developing a relationship that came naturally. Participants had Paro as a companion during the Paro intervention, which provided sufficient time for interaction with it according to their preferences. Participants said that "I had a lot of affection for Xiao-Ying, it felt like an emotional attachment, like someone was waiting for me and needed me [Case

13, F75]". Most participants thought that Paro could comfort them through companionship, and participants reported experiencing a more meaningful life in LTC as Paro blended into their daily routines. A participant stated: "When it stayed with me, I don't feel like a silly old person living here. When it lived here, it made sounds. I felt that time flew faster, life was more meaningful and there was companionship [Case 6, M89]". Some participants saw Paro as a meaningful presence instead of one of the scheduled activities in LTC. One participant said: "Steven helped me to kill time and to forget about things. It should be said that it gave us some level of comfort, like my loved ones, ~ I regard it as a companion, and it is comforting [Case 3, M65]".

Additionally, most participants indicated that Paro could reduce the feeling of loneliness through direct interaction such as stroking, petting, and conversation or indirect interactions such as putting Paro next to them. A participant said: "I don't feel as bored because I could talk to Little-Cute. I was able to overcome the feeling of loneliness because I felt that there was someone accompanying me [Case 7, F74]". Most participants indicated that Paro engendered positive psychological effects and provided warmth and companionship to boost their mood and to lift their spirits. One participant said: "I felt that there was an improvement in my mood, and this has continued. There are many good things about Xiao-Qiu, it will be helpful to us living here [Case 16, F76]".

However, difficulty with disengagement from Paro indicated the existence of a rewarding relationship between the participants and Paro after the

termination of the intervention. Although participants enjoyed the opportunity to engage with Paro, some of the participants reported that they encountered difficulties with disengagement when the social robot was removed. For example, "After Chubby left, I felt lonely and disappointed. The care staff teased me and said: 'Since Chubby went back, I cannot fall asleep'. I used to get up at 5:30 in the morning, but now I get up at 4:30. I haven't sleep well in the last few days. It's affected my sleep a little. I feel like I have lost a companion (Case 8, F84)". However, these symptoms presented for only one to two days, and then they returned to their usual activities prior to their time with Paro.

DISCUSSION

Advances in technology have created a potential for the provision of a new form of health and social care. Recently, there has been increasing interest in the use of social robots to alleviate psychological distress and encourage social interaction for older adults. However, very little is known about Paro as an intervention for depressed older adults living in LTC. This study is distinctive because it is the first study using a 24-hour Paro intervention to examine the effects of Paro on depression and well-being for older adults and to explore participants' experience of Paro. As significant improvements in mental well-being were noted in this study, there may be advantages in using Paro alone or in combination with a suite of other psychological interventions. Older adults indicated positive experiences with Paro and mood improvement during the intervention. Consequently, these findings provide a number of important implications for meaningful future research. Quantitative results demonstrated

22

that Paro can potentially alleviate depression and loneliness and improve quality of life. Qualitative findings identified key factors, which improved mental well-being, including humanizing Paro through referring to personal experiences, increased social interaction, and companionship resulting in mood improvement.

The findings of this study are consistent with previous studies, which have demonstrated that participation in Paro interventions could decrease depressive symptoms (Petersen *et al.*, 2017; Thodberg *et al.*, 2016), anxiety (Petersen *et al.*, 2017), loneliness (Robinson *et al.*, 2013), improve mood (Lane *et al.*, 2016), and quality of life (Jøranson *et al.*, 2016; Soler *et al.*, 2015). However, these positive outcomes in depression contrasts with those of other previous studies (Jøranson *et al.*, 2015; Robinson *et al.*, 2013), which indicated that there were no significant changes in levels of depression after a Paro intervention. This discrepancy could be attributed to the low baseline depression scores recorded where different instruments were used. The Cornell Scale for Depression in Dementia (CSDD) and the Geriatric Depression Scale (GDS) were used in the study of Jøranson et al. (2015) and Robinson et al. (2013) respectively. Low scores of depression at baseline were recorded in both studies where the flooring effect may have confined the potential for an improvement in depression in both studies.

Uncertainty remains as to whether Paro has sustained effects on depression and loneliness. Findings of a cluster RCT (Jøranson et al., 2015) demonstrated no immediate effect of a Paro intervention in decreasing

depression but interestingly found a significant sustained effect on depression three months after the Paro intervention. In contrast, studies by both Moyle et al. (2017) and Liang et al. (2017) found no evidence of longer-term sustained effects of Paro on mood improvements post-intervention. Furthermore, while Paro interactions can positively reduce loneliness (Robinson et al., 2013), there was a lack of studies to assess the longer-term sustained effects of Paro on loneliness. Further research is thus needed to determine the sustained effects of Paro intervention on depression, mood, and loneliness.

Humanizing a robot does not necessarily imply an anthropomorphic appearance and robots do not need to emulate all possible human activities or simulate human emotions (Sciutti *et al.*, 2018). Humanization impacts people's expectations of how to interact with a robot and their views of what it is or what it is not. Furthermore, appropriate use of robots varies according to the extent to which they are perceived as having human qualities (Robert, 2017). The qualitative findings illuminated that participants humanized Paro by giving it a name by referring to personal experiences and engaging with the robot in a meaningful way. This was an initial and crucial step to facilitate interaction and engagement with Paro since this process could help older adults to recall prior positive experiences related to an important event, object, or person in their early life. Older adults had the opportunity to name the Paro to facilitate rapport building, which could motivate interaction and engagement with Paro. This experience affected their connection and interaction with Paro, which influenced the manner and the frequency of interactions with Paro in the weeks that followed.

Studies have reported that Paro can improve social dynamics, by increasing opportunities for interaction among older adults, care staff, and their relatives and this can lead to an increase in social exchange (Hung *et al.*, 2019; Shibata and Wada, 2011). The qualitative results of the study revealed that older adults increased communication and social interaction with other people through Paro. These results are in line with those of previous studies, which revealed that Paro functions as an icebreaker or a stimulus to start conversations in a group activity (Robinson *et al.*, 2015; Takayanagi *et al.*, 2014). In this study, we found that Paro can play the role of a promotor or intermediator to connect participants with other people. Thus, it can help older adults with depression to expand their interpersonal interactions.

Prieto-Flores *et al.* (2011) indicated that a lack of companionship is the most common factor related to depression and loneliness in LTC. The clinical environment of residential settings and lack of alternative approaches to care have been identified as depression risk factors (Dow *et al.*, 2011). Since a LTC often has limited funding and staff resources, these may impede the introduction of individual and innovative interventions for older adults. The qualitative results indicated that Paro could comfort participants through companionship and help them experience a more meaningful life in LTC as Paro blended into their daily routines. These findings were consistent with previous studies (Moyle *et al.*, 2018) which revealed that Paro may be an appropriate strategy for treating depression among older adults in LTC, as it is useful in encouraging people to interact with each other, has a calming effect and provides companionship, motivation, and enjoyment. Although Paro

presented a positive impact on depression, and well-being in older adults with depression at the end of the intervention, there was a lack of evidence regarding sustainability and long-term effect.

Strengths and limitations

These findings provided valuable information for designing and specifying the 24-hour Paro intervention for deployment with older adults with depression in LTC to aid in improving their mental well-being. Additionally, the study helped in understanding the benefits of Paro for reducing depression. However, this study also had some limitations. First, this study did not compare changes in participants' psychological responses against a comparison or control condition. Therefore, a randomized controlled trial is needed to determine the psychological effect of the intervention. Second, the Paro intervention lasted for 8 weeks, but participants used the Paro for varying amounts of time. It was challenging to record the amount of time participants spent interacting with Paro within a 24-hour time period, due to a lack of human resources and the reliable recording means such as an inbuilt function in Paro to record interaction time. Therefore, it is conceivable that the amount of time interacting with a PARO might be a mediator that impacts the outcome of the intervention. Third, although qualitative interviews were performed by the principal investigator, analyses were conducted by two researchers. Therefore, there was no investigator bias. However, investigator bias may occur in this study due to the lack of blinding.   Therefore, these might limit the interpretations of the study.

Last, due to the purposive sampling of depressed older adults living in LTC, there was a limitation for generalizability of the study findings.

CONCLUSION

As significant improvements in mental well-being were noted in this study, there may be advantages in using Paro alone or in combination with a suite of other psychological interventions. Older adults indicated positive experiences with Paro and mood improvement during the intervention. Consequently, these findings provide a sound foundation for meaningful future research.

analysis, interpretation and reporting of findings or preparation of the manuscript.

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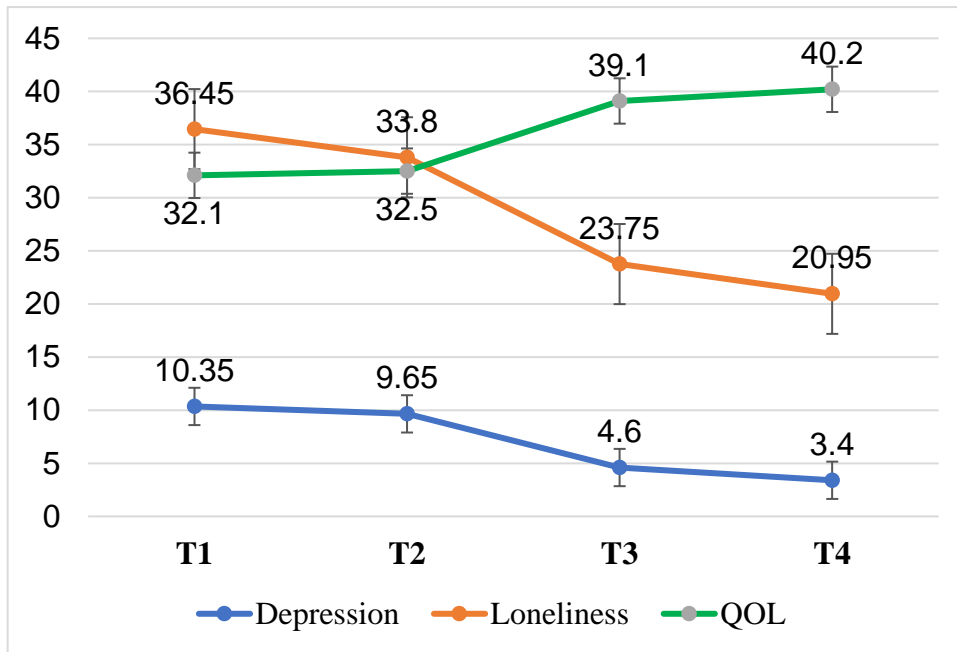
Figure 1 Changes in mean scores of depression, loneliness, quality of life

Tables

Table 1 Demographics of participants (n = 20)

Variable		%
Categorical Variables		
Gender	Male	35
	Female	65
Religion	Buddhist	55
	Daoist	40
	Christian	5
Level of Education	No education	25
	Primary	45
	High school	20
	University/college	10
Marital status	Single/never married	5
	Married	20
	Widowed	65
	Separated	10
No. of children	0	5
	1-3	40
	> 4	55
Frequency of family visiting	Every day	10
	Twice/week	10
	Once/week	55
	1-2/month	25

Type of mobility	Full mobility	10
	Walker	30
	Wheelchair	60
Previously having pet	No	70
	Yes	30

Continuous Variables

Age	M = 81.1 (*SD* = 8.2)
Barthel score	M = 54.5 (*SD* = 31.4)
No. years living in LTC	M = 3.4 *(SD* = 2.3)
MMSE	M = 26.50 *(SD* = 2.12)

Note: MMSE, Mini-Mental State Examination

Table 2 Post-hoc analysis of depression and loneliness over time using paired sample t- tests with effect size

| | **Paired Sample T-Tests** | | | | | | | |
| | | | 95% CI | | | | | |
	M	*SD*	LL	UL	*t*	df	*p*	Cohen's *d*
Depression								
T2 vs T3	5.45	2.21	4.41	6.49	11.02	19	**<.000**	2.93
T2 vs T4	6.55	2.35	5.45	7.65	12.46	19	**<.000**	3.44
T3 vs T4	1.10	1.83	0.24	1.96	2.68	19	**.015**	0.65
Loneliness								
T2 vs T3	7.55	3.82	5.76	9.34	8.84	19	**<.000**	1.95
T2 vs T4	10.80	5.70	8.13	13.47	8.47	19	**<.000**	2.50
T3 vs T4	3.25	5.87	0.50	6.00	2.48	19	**.023**	0.75

Note.T = Time; CI = confedence interval; LL = lower limit; UL = upper limit.

Table 3 Post-hoc analysis of quality of life over time using Wilcoxon signed ranked test with effect size (n = 20)

	Test Statistics[a]			
	T2–T1	T3–T2	T4–T2	T4– T3
Z	-.28[b]	-3.42 [b]	-3.57 [b]	-.98 [b]
p	.78	**.001**	**<.000**	.326
Cohen's *d*	0.04	0.54	0.57	0.16

Note. a = Wilcoxon signed ranks Test; b = based on negative ranked, T = time

point