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Original Study

The Psychosocial Effects of a Companion Robot: A Randomized Controlled Trial

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A B S T R A C T

Objectives: To investigate the psychosocial effects of the companion robot, Paro, in a rest home/hospital setting in comparison to a control group.
Design: Randomized controlled trial. Residents were randomized to the robot intervention group or a control group that attended normal activities instead of Paro sessions. Sessions took place twice a week for an hour over 12 weeks. Over the trial period, observations were conducted of residents' social behavior when interacting as a group with the robot. As a comparison, observations were also conducted of all the residents during general activities when the resident dog was or was not present.
Setting: A residential care facility in Auckland, New Zealand.
Participants: Forty residents in hospital and rest home care.
Measurements: Residents completed a baseline measure assessing cognitive status, loneliness, depression, and quality of life. At follow-up, residents completed a questionnaire assessing loneliness, depression, and quality of life. During observations, behavior was noted and collated for instances of talking and stroking the dog/robot.
Results: In comparison with the control group, residents who interacted with the robot had significant decreases in loneliness over the period of the trial. Both the resident dog and the seal robot made an impact on the social environment in comparison to when neither was present. Residents talked to and touched the robot significantly more than the resident dog. A greater number of residents were involved in discussion about the robot in comparison with the resident dog and conversation about the robot occurred more.
Conclusion: Paro is a positive addition to this environment and has benefits for older people in nursing home care. Paro may be able to address some of the unmet needs of older people that a resident animal may not, particularly relating to loneliness.

The growing aging population is a major concern for the future.[1] An increasing number of older people will require formal long term care as their health deteriorates and they cannot source as much human care and support in the community.[2,3] For an older person, admission to an elder care facility is rarely easy and is not a highly anticipated milestone in a person's life.[4] Moving to a nursing home is often precipitated by the loss of a loved one, an inability to look after oneself, declining health, and a lack of control over one's life.[5] These factors, combined with the institutional environment of elder care facilities, means that older people lose aspects of their lives that constitute high life satisfaction.[6] Older people in nursing homes often report feelings of helplessness, boredom, and isolation,[7] increasing their risk of depression[8–11] and loneliness,[12,13] and in general they report a lower quality of life than those residing in the community.[14] Older people may experience problems in nursing homes upon shifting, because residents may find they have fewer of the social connections that previously gave their life meaning. Even when older people have become used to their new living environment, often the feeling of loneliness and isolation does not abate over time as they find it difficult to form new relationships with the people around them.[8] Research has found that there are negative effects on health for older people after entering formal care. Some early studies have reported that there is a high mortality rate among the aged due to institutionalization,[15] whereas other research has found that moving frail elderly from one setting to another results in mental and physical deterioration.[16,17]

Many nursing homes now incorporate animal visitations and interactions into care models. Animals help fulfill criteria aimed at promoting better quality of life by increasing social interactions, decreasing loneliness, countering boredom, and helping foster

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a sense of purpose. Furthermore, almost anyone can interact with an animal regardless of physical and cognitive impairment, as any person can communicate nonverbally with an animal by touching and stroking.[18] Over the past few decades, the health benefits of both pet ownership and animal activities in hospitals and elder care settings have been widely reported in the literature.[19] Research has found that interactions with pets or animals have 3 effects: (1) physiological effect (eg, improvement of vital signs), (2) psychological effect (eg, relaxation, reduction of distress, and improvements in mood and depression); and (3) social effect (eg, facilitate communication).[20–22] Research has found that animals have many positive benefits for people, particularly older people, and in a nursing home setting animals can be a social icebreaker, and can provide companionship, meaning and comfort to a person.[23,24]

Because animal therapy has been so successful with older people, research has turned to creating companion robots that may offer the same benefits as live animals but require less care and are more hygienic. Animals can cause problems in an elder care setting; they may be a trip hazard, may scratch or bite, may introduce parasites and infectious diseases to the environment, and require extra care considerations on top of daily staff duties.[25] A robot animal that does not have to be fed, cleaned, or cared for and that cannot cause harm, may be an adequate substitute for a live animal. Research with companion robots in nursing homes has been conducted predominately with the companion robot AIBO (a metallic doglike robot) and Paro (a white fluffy seal robot). This work has found that these companion robots can have a physiological effects by reducing stress hormones[26,27] and can improve brain functioning.[28] Research has also found that companion robots have a positive psychological effect and can help forge social relationships.[29] For example, in a 5-year longitudinal study[30] conducted in an elder care facility in Japan with 14 residents who suffered from mild to moderate dementia, Paro improved mood and depression and decreased stress levels. The nursing staff commented that Paro is a “necessity” for the facility, as Paro made people laugh and more active. In a different study conducted in Japan over 2 months[31] in a care home with 12 residents, Paro was given a home on a table in a public space for residents to play with for the duration of the day and returned to the office at night. The results showed that Paro encouraged residents to communicate with each other and strengthened their social ties. Overall, the current research suggests that companion robots have positive social, psychological, and physical effects in elder care settings.[26] However, much of the research that has been conducted does not have robust study designs, as control or comparison conditions are not used and studies generally take place with small sample sizes and over a short period of time.[32,33] No previous work has been published that has conducted a randomized controlled trial specifically with Paro in a rest home setting, although some have been conducted with AIBO.[34] Most of the research is exploratory, reflecting that this area is relatively new. Additionally, much of the research with Paro has been done in Japan, with less research performed in other cultures. Overall, more research is needed to see if implementation of robotic therapy with Paro has benefits over a long period of time in different settings and with different cultures. The aim of this research was to address some of the shortcomings of the previous research with Paro by using a randomized controlled trial, and in a Western country. This study aimed to explore how the psychosocial effects of Paro could be compared with a control group. This research also evaluated the impact Paro had on the social environment by observing how residents interacted with the robot and with each other when the robot was present in comparison to when the resident dog was present. Although research with the companion robot AIBO has looked at the difference between interactions with a robotic dog and a live dog in children,[35,36] and one study has looked at the effect of a live dog or AIBO on loneliness,[34] the effects of Paro have not been compared with a live animal.

Methods

Setting

The study was conducted at the Selwyn Heights retirement home, in Hillsborough, Auckland, New Zealand, in the hospital and rest home areas, which provide 24-hour support 7 days a week. In both areas there are a wide range of activities for residents to enjoy, organized by the same activities coordinator. Additionally, the activities coordinator brings her Jack Russell terrier to work each day and the dog is free to visit residents in the hospital and often goes over to the rest home. Ethics approval was obtained from the University of Auckland Human Participants Ethics Committee and written informed consent obtained for all participants. In cases where participants were unable to provide informed consent, enduring power of attorney (EPOA) representatives were contacted asking permission for the resident to participate in the study and written informed consent was obtained.

Participants

Participants were 40 residents (13 men, age range 55–100 years). Twenty residents were randomly assigned to the control group (rest home 11, hospital 9) and 20 were assigned to the Paro group (rest home 7, hospital 13) using a random list generator. Nineteen participants (48%) scored 6 or lower on the Abbreviated Mental Test, which is suggestive of cognitive impairment. There were no significant differences between the intervention and control groups in cognitive impairment.

Procedure

Residents in both groups completed baseline measures assessing loneliness, depression, and quality of life. Loneliness was assessed using the UCLA Loneliness scale (Version 3)[37] that has been used in previous research to assess loneliness in older people before and after interacting with AIBO.[34] Depression was measured using the Geriatric Depression Scale (GDS).[38] This is a short questionnaire composed of 15 yes or no questions pertaining to depressive symptoms experienced over the past week. This questionnaire has been used extensively in older populations and is highly validated.[39] Quality of life was measured using the Quality of Life for Alzheimer's Disease (QoL-AD).[40] This questionnaire has 13 questions that asked participants to rate various aspects of their lives on 4-point scale. Staff also completed proxy ratings of residents. Again, this measure is highly validated in older populations.[41]

Paro sessions were scheduled to take place on 2 weekday afternoons for 12 weeks, which was incorporated into the activities schedule. Residents in the control group went on bus trips around the city during this time or an alternative activity, such as crafts, movies, or bingo, was organized. During sessions with the robot, discussion groups were held and all residents had a chance to interact with the robot. If the resident was unable to attend the session because of ill health, the resident had the opportunity to interact with the robot after the session individually. Observations were conducted over the course of the trial to assess residents' social behaviors when the robot was present, compared with when the resident dog was present or when neither were present. After the 12-week trial, follow-up measures were administered to participants. Figure 1 summarizes the design of the study and number of participants. Analyses of covariance (ANCOVAs) were performed to compare changes between

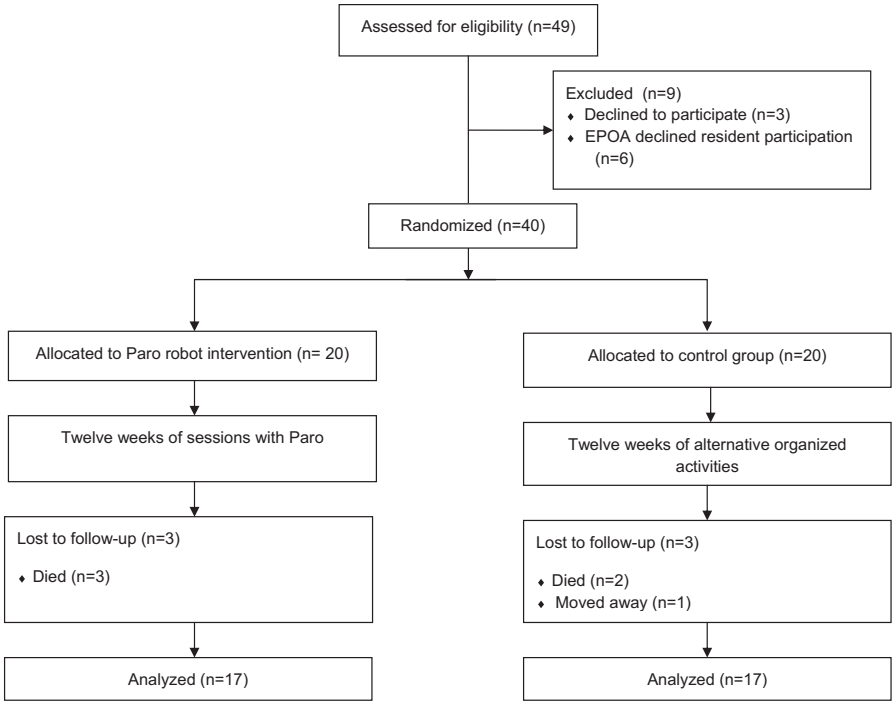

Fig. 1. Consort flow diagram. EPOA, enduring power of attorney.

baseline and follow-up measures of each of the primary outcome measures (quality-of-life ratings, depression and loneliness scores) with corresponding baseline scores entered as covariates. This method was chosen because it takes into account each individual's baseline score and helps to control for any differences between groups at baseline and regression to the mean.[42] To assess how much residents interacted with the robot and the resident dog, *t*-tests or nonparametric equivalents were used. When social interactions with the dog and the seal robot were compared with normal activities Kruskal-Wallis tests and 1-way analyses of variance (ANOVAs) were conducted. For all analyses, a 2-tailed alpha level of less than 0.05 was used.

Paro

Paro is an advanced interactive robot developed by the Intelligent Systems Research Institute (ISRI),[43] a leading Japanese industrial automation pioneer (Figure 2). Paro is modeled after a baby Canadian harp seal and is covered in white artificial fur. It weighs approximately 2.7 kg. Paro has 4 senses: sight, sound, balance, and touch, meaning that Paro responds to contact, as well as to other stimuli in its environment by moving or imitating the noises of a baby harp seal. Paro operates by using the 3 elements: its internal states, sensory information from its sensors, and its own diurnal rhythm to carry out various activities during its interaction with people.

Results

Table 1 shows the main results of this study. After adjusting for baseline self-rated quality of life scores and staff-rated quality-of-life scores, respectively, ANCOVAs found there were no main effects of group on changes in self-rated quality of life or staff-rated quality of life between baseline and follow-up. Depressive scores slightly decreased in the Paro group from baseline to follow-up, but increased in the control group; however, after adjusting for baseline depression scores, there were no main effects of group on changes in depression between baseline and follow-up. The results show that loneliness decreased in the Paro group but increased in the control group. After adjusting for baseline loneliness scores, there was a significant difference between groups in loneliness change over time ($P = .033$).

Fig. 2. Paro.

Table 1
Primary Psychosocial Outcomes

	Paro	Control	*F* Test for Group X Change Since Baseline			
	Adj Mean (SD)	Adj Mean (SD)	*F*	*df*	*P*	η_p^2
Quality of Life						
Baseline (T1)	33.94 (7.51)	33.42 (6.99)				
Follow-up (T2)	32.73 (8.24)	31.19 (6.26)				
Change score	−1.33 (5.77)	−1.88 (4.27)	0.22	1, 28	.64	0.01
Staff rated Quality of life						
Baseline (T1)	31.15 (6.70)	32.05 (8.83)				
Follow-up (T2)	26.71 (7.71)	23.94 (5.18)				
Change score (T2−T1)	−5.71 (7.65)	−7.06 (8.36)	1.18	1, 31	.29	0.04
Depression						
Baseline (T1)	4.88 (3.58)	3.33 (3.22)				
Follow-up (T2)	4.15 (2.34)	4.00 (2.62)				
Change score (T2−T1)	−.64 (3.89)	.40 (2.56)	0.00	1, 26	.97	0.00
Loneliness						
Baseline (T1)	36.44 (9.76)	31.71 (9.50)				
Follow-up (T2)	32.23 (9.92)	33.93 (8.52)				
Change score (T2−T1)	−5.38 (7.58)	2.29 (6.19)	5.14	1, 24	.03	0.18

Those in the intervention group decreased in loneliness over time, whereas those in the control group increased in loneliness from baseline to follow-up.

Figure 3 shows residents interacting with the robot in one of the Paro sessions. Table 2 reports how residents interacted with the resident dog in comparison with the seal robot. This shows that residents touched and talked to the robot significantly more than they touched the resident dog, and the number of residents who stroked the seal was higher when taking into account the number of people present. Residents also talked to each other significantly more about the robot compared with the dog. Finally, staff did start conversation significantly more about the robot than the resident dog, but they did not talk to the robot significantly more than they talked to the dog. During normal activities, it was noted how often residents talked to each other and how the presence of the seal robot or the resident dog altered the social atmosphere. Table 3 reports these results.

Overall, there was a significant difference in the number of times residents talked to each other. Mann-Whitney *U* tests found that residents talked more to each other overall in Paro sessions in comparison with normal activities, $U = 21.00$, $z = -2.35$, $P = .02$, $r = 0.51$. Residents talked more to each other when the dog was present compared with normal activities, but this was not significant, $U = 43.50$, $z = 1.78$, $P = .08$, $r = 0.35$. Mann-Whitney *U* tests found that a higher percentage of residents talked to each other in the Paro group than in normal activities, $U = 3.00, z = -3.67, P < .001, r = 0.80$, and also compared with activities when the resident dog was present, $U = 5.50, z = -4.29, P < .001, r = 0.80$. When looking at the number of times staff made conversation with residents, it was found that there were no overall differences between conditions. Similarly, there were no differences in the number of times residents talked to staff.

Discussion

This study investigated the effects of an intervention program incorporating the use of a seal robot primarily as a way to improve quality of life, mood, and loneliness for older residents in a nursing home facility. This research found that after a 12-week intervention, in which residents interacted with a seal robot twice a week, residents had decreases in loneliness scores from baseline to follow-up, in comparison with a control group. This is an important finding, as although other research with Paro has documented the positive effects the robot has on mood and the effect the robot has on the social atmosphere, loneliness has not been measured with this robot. With the robot dog, AIBO, research in the United States has found that loneliness decreased in older people who received 30-minute weekly visits from a living dog or from AIBO over 8 weeks in comparison with a control group.[34] Similarly, another study conducted in Japan[44] found that after 20 activity sessions with AIBO older people in a nursing home had improved loneliness scores compared with baseline scores. Improvements in loneliness may mean improvements in other areas of life, as a person feels less socially isolated in his or her current living situation. This finding further supports findings that animals do help to reduce loneliness and indicates that a companion robot is an adequate substitute for live animals in nursing home facilities. For example, it has been reported that residents in a nursing home who had greater levels of interaction with a pet experienced less loneliness than those who had lower levels of interaction.[45,46] Overall, loneliness in rest home settings has been related to a number of other issues, including depression and mortality.[47,48] If the presence of a companion robot can help decrease loneliness, keep older people company, and comfort people when they feel ill or unhappy, then the robot would be useful in elderly care to help older people adapt to their environment and age successfully. Some older people in this study commented that the robot made them feel better when they were sick, feeling down, or feeling lonely and care staff also noted the effect the robot had on residents.

Interestingly, there is a great deal of research looking at how companion robots and animals impact the social environment. From the research conducted with Paro previously, it has been found that Paro is capable of stimulating conversation between residents,[49,50] strengthening social ties between residents,[31] and providing an "icebreaker" topic for staff and visitors to use when talking to older people.[51] In this research, it was found that in comparison with the resident dog, residents touched and talked to the robot, and talked to each other more about the robot, showing how the robot is just as easy to interact with as a live animal and in some instances had an

Table 2
Observations of Residents With Paro and the Resident Dog

Behavior	Paro Sessions (n = 11)	Resident Dog (n = 17)	*t/z*	*P*	*r*
Interaction with seal robot/dog					
No. of times stroked*	38 (12–62)	2 (0–10)	−4.44	<.001	0.84
No. of times stroked/No. of residents present*	4 (1.67–6.56)	.07 (0–.63)	−4.43	<.001	0.84
No. of residents who stroked*	6 (3–10)	2 (0–6)	−3.72	<.001	0.70
No. of times talked to/No. of residents present*	2.36 (1.21–5.78)	.24 (0–1.40)	−4.35	<.001	0.82
No. of residents who talked to*	4 (3–7)	2 (0–7)	−3.30	<.001	0.75
Social behavior					
No. of times residents talked to each other about dog/robot†	30.09 (9.96)	16.12 (12.57)	3.10	.01	0.51
Percentage of residents who talk to each other about dog/robot*	95.45 (42.86–100)	31.58 (21.74–60)	−4.29	<.01	0.80
No. of times staff member starts conversation about dog/robot*	19 (2–41)	9 (0–44)	−2.57	.01	0.49
No. of times staff talks to dog/robot*	4 (1–14)	4 (2–33)	−0.57	.58	0.11

*Non-parametric - results displayed as median (min-max) and *z* score reported instead of *t* value.
†Parametric - results displayed as mean (SD).

Fig. 3. Residents interacting with Paro during group sessions.

advantage over the dog. Often residents were unable to talk to or touch the dog because the dog could choose who it interacted with, whereas the robot could be put on the lap of all residents and would respond to them. This research also found that Paro was able to impact the social environment. Furthermore, no research to date has compared how older people socialize in the presence Paro or a live animal, although observations have been conducted of children with AIBO[35] and one study has looked at how AIBO and a live dog affect loneliness in older people in a rest home.[34] Analyses found that a higher percentage of residents talked to each other specifically about the robot compared with instances when the dog was present and residents talked to each other specifically about the dog. Overall this shows that the robot has benefits over and above a live dog and by impacting the social environment and providing a conversation topic for residents and staff. This research found that residents socialized just as much when the resident dog was present as during activity sessions with the robot when general conversation was taken into account. Furthermore, when the dog and the robot were not present, the residents were less social, as indicated by the amount they talked to each other. The results of this study also show that staff make more conversation with residents during normal activities than Paro activities. Although this was not significant, a reason for these results could be that staff find it difficult to keep residents engaged in conversation and activities and have to make more conversation with residents to keep them entertained. In the Paro condition and when the dog was present during activities, conversation was easier for staff. Of note, the dog was not always in the room for the whole duration of activities. Although previous research has not looked at how much a robot affects socialization in comparison with other activities, research has found that the presence of animals did affect the amount residents socialized in comparison with activities, such as bingo and crafts.[52] Although that study did not use a control group, their findings are similar to the current research, which compared social behaviors when the robot and dog were present with activities, including bingo, discussions, and crafts.

This study has a number of strengths in comparison with previous research with Paro and other companion robots. This is the first published randomized controlled trial conducted with Paro. Although other research has been conducted in Japan with Paro in quasi-experimental settings, no published studies have compared the robot activities with a control group. This research is important because it means the efficacy of the intervention can be assessed, particularly in terms of loneliness, which has not been assessed with Paro. This research also aimed to conduct a study with a greater number of participants than previous research over a longer period of time. Other research has used Paro in short-term studies ranging from 4 to 8 weeks, with the exception of one ongoing study that has been conducted for 5 years in Japan. These studies have used only small sample sizes, ranging from 5 to 26 participants.[32]

Like other studies conducted with companion robots and animals, this research has a number of limitations. Because of the population chosen and the environment, obtaining a large sample is difficult, as health problems limit the ability for older people to complete a study of this nature and assess the primary outcomes. In this research,

Table 3
Observations of Residents' Social Behavior in Normal Activities, Paro Activities, and Normal Activities With the Resident Dog Present

Social Behavior	Normal Activities (n = 9) Mean (SD)	Activities When Resident Dog Is Present (n = 17) Mean (SD)	Paro Activities (n = 12) Mean (SD)	*df*	*F/H*	*P*
No. of times residents talk to each other overall*	29.44 (27.62)	57.00 (49.05)	57.42 (20.11)	2	6.06	.05
Percentage of residents who talk to other residents out of entire group*	36.37 (13.89)	36.99 (11.29)	87.04 (18.58)	2	21.6	<.01
No. of times staff make conversation with residents†	89.11 (50.58)	95.52 (28.42)	80.83 (27.24)	2, 35	0.64	.53
No. of time residents talk to staff†	52.22 (41.24)	54.41 (21.57)	55.50 (21.59)	2, 35	0.38	.96

*Non parametric data. Kruskal-Wallis tests were performed and *H* is reported instead of *F*.
†Parametric data.

a number of residents were not identified as being appropriate for this study because of physical and or mental disabilities. Of those who did participate, sickness and disabilities greatly limited participants in their attendance of sessions and ability to interact with the robot. Some of the residents identified were not able to complete the entire baseline questionnaire because of communication difficulties. Although the research calls for larger sample sizes, realistically large samples are difficult to attain because of attrition and declining health. To find the robot had a positive effect on loneliness in this small sample is very encouraging. Future research should strive to recruit a greater number of participants to attain greater power.

Another limitation of this research was the lack of comparison groups to control for extraneous variables. For example, research has compared Paro in the "on" setting or the "off" setting to when the researcher only was present.[50] The researchers found that there was just as much social activity when the observer was present alone to when the robot was on. They concluded that learning about the observer was just as interesting as learning about Paro. Although in the current trial the robot was left with the activities staff to do what they wished in sessions, for the trial to run smoothly, the researcher was present to help get residents to the sessions and run the sessions when a staff member was sick or unavailable. Hence, the presence of the researcher as a visitor may have had an effect on the social setting. However, the researcher was also present to conduct observations in the control group activity sessions. Another limitation to this research is that the robot and the resident dog were not introduced at the same time. The resident dog had been at the facility approximately 3 months before this trial began and residents may have been more familiar with the dog, affecting how they interacted and discussed it. In this study, it should be noted that activities did not center around the dog in a structured manner, like the Paro sessions. This structuring may be a critical component to the seal's therapeutic effect.

Conclusion

Overall, future work needs to address the identified problems in the current research with companion robots. Randomized controlled studies with larger sample sizes, with different populations in different living situations, and with different cognitive capabilities should be conducted to further determine for whom the robot is best suited. Overall, this research found that loneliness can be improved using companion robots and the robot has an affect comparable to a live animal on the social environment. Paro is capable of improving loneliness in older people in elder care facilities and should be considered in future care plans.

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