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Getting the Seal of Approval: A Critical Literature Review of the Evidence for the Use of the PARO Robotic Companion Seal with Older Adults with Cognitive Impairment in Long-Term Care

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ABSTRACT

Social isolation and disruptive dementia-related behaviors are common concerns among older adults with cognitive impairment and their caregivers within residential long-term care settings. However, many interventions aiming to improve the quality of life of residents through the reduction of dementia-related behaviors and isolation rely on human contact interventions that often require significant time and resources on behalf of care staff. Robotic companion interventions have recently emerged to meet the growing need for unique, easily implemented interventions for this population. The current literature review examined existing empirical evidence for the use of the PARO seal, one of the leading animal-based robotic interventions currently available, in improving outcomes among older adults in residential long-term care. Seventeen publications that examined the impact of PARO intervention on outcomes specifically related to dementia-related behaviors and social isolation among older adults in long-term care were included in the review. Overall, most studies demonstrated some efficacy of the PARO robot in reducing either dementia-related behaviors (e.g., improvements in irritability/agitation, aggressive behavior, sleep symptoms, and affect) or social isolation. However, findings varied widely, likely due to variations in the application of the intervention, sample characteristics (e.g., range of cognitive impairment, small sample sizes), and methodology (e.g., types of outcome measures used, control group). The current literature generally supports the efficacy of the PARO seal in long-term care. However, further studies are needed to fully parse the extent of its effectiveness while accounting for variability in intervention implementation.

KEYWORDS: Social Commitment Robot; Long-Term Care; Social Isolation; Dementia-Related Behaviors; Older Adults; Cognitive Impairment; Aging; Literature Review.

KEY PRACTITIONER MESSAGE

1. The PARO robotic companion seal is a feasible, non-human intervention option that may have benefits for use with older adults with cognitive impairment within long-term care.
2. The existing literature generally supports the PARO seal's effectiveness in reducing social isolation and some dementia-related behaviors among older adults in residential long-term care; however, results vary widely across studies.
3. The current literature examining PARO's effectiveness is limited by a lack of consistency across implementation and outcome measurement, and further study is needed.

INTRODUCTION

Social isolation and disruptive dementia-related behaviors are two commonly identified problems that emerge among older adults living in long-term care (LTC) settings, especially among the most vulnerable of these adults: those with substantial physical frailty and/or cognitive decline (Boamah et al., 2021; Desai et al., 2012). Researchers and mental health professionals have made longstanding efforts to design and implement effective interventions to foster well-being for individuals living within LTC, with many advancements relying on the availability and quality of social contact, either via engagement with social supports or with professionals implementing a therapeutic program. However, as barriers to consistent social engagement have arisen for many older adults, such as short staffing in facilities, geographical distance from relatives, loss of loved ones, decreased communication ability or mobility, and situational barriers such as COVID-19 restrictions, alternatives to human contact interventions have become increasingly necessary. Various alternatives have emerged to meet this growing need. Some methods have existed for many decades, such as animal therapies, while others have only recently gained momentum, such as robotic companion interventions. This review examines the emerging evidence for the use of one such animal-based robotic companion intervention–the PARO seal–within LTC settings to address the issues of social isolation and dementia-related behaviors.

Long-Term Care Population

Roughly half of all individuals currently turning 65 in the U.S. will require LTC services at some point during their life, whether it be within the home (e.g., caregiving services, home care), outpatient settings (e.g., adult day care), or residential facilities (e.g., assisted living, skilled nursing; Nguyen, 2017). Of the nearly 800,000 residential care and 1.4 million nursing home residents in the U.S., 93.4% and 83.5% of residents are 65 years old and older, respectively (Harris-Kojetin et al., 2019). Residents in these facilities are often managing a variety of chronic physical, cognitive, and psychiatric conditions, with nearly half of nursing home and residential care residents diagnosed with a neurocognitive disorder (e.g., Alzheimer's disease or other forms of dementia) and other common conditions including arthritis, cardiovascular disease, osteoporosis, depression, and diabetes. Additionally, most residents require assistance with at least one basic activity of daily living (ADL), including bathing, eating, dressing, toileting, and ambulation (Harris-Kojetin et al., 2019). Thus, the population of older adults living in LTC represents a large and rapidly growing pool of individuals with unique risks and care needs.

Dementia-Related Behaviors and Social Isolation

Dementia-related behaviors (sometimes referred to as 'behavioral disturbance') are one of the most common manifestations of cognitive decline among LTC residents with moderate to severe dementia (Desai et al., 2012; Husebo et al., 2011). These behaviors typically present as a variety of symptoms across four broad categories: mood disorder, sleep disturbance, psychotic symptoms, and agitation, including specific behaviors such as verbal or physical aggression, wandering, repetitive behaviors, depression, apathy, insomnia, hallucinations, and delusions (Desai et al., 2012). Further, many older adults with cognitive impairment also experience increased social isolation and depression (Nikmat et al., 2015). Cognitive impairment in areas such as language ability, attention, memory, executive functioning, and processing speed can impact the quality and quantity of social interaction, leading to consequences such as withdrawal from social engagement and frustration within interactions. Those living in LTC settings may encounter additional risks related to the accessibility of social figures, limited activities, and lack of novel social interactions, especially recently, as the COVID-19 pandemic resulted in stricter visitation policies and limited activities within LTC. Research indicates that social isolation and perceived loneliness can result in poorer physical and mental health among older adults (Coyle & Dugan, 2012). Additionally, the presence of behavioral disturbance can be a major deterrent to social engagement by facility staff, peers, and family and friends, leading to compounding effects on well-being among older adults with severe cognitive impairment (Desai et al., 2012). Thus, behavioral disturbance and social isolation present two pressing concerns for older adults with cognitive impairment and their caregivers that require apt attention and intervention.

Intervention

Many interventions designed to reduce the frequency or intensity of dementia-related behaviors and/or social isolation within LTC require significant time and resources on behalf of LTC staff, caregivers, or other professionals, in addition to funding to maintain programming. Further, many human contact interventions require commitment and motivation from the residents to engage effectively with the intervention to achieve outcomes (e.g., attending groups regularly and following program protocols). In response to these issues, professionals have begun identifying non-human contact interventions for older adults in LTC settings. For example, Dr. Bill Thomas and The Eden Alternative project introduced a comprehensive group of techniques to improve the quality of care and outcomes in LTC, including the use of animal-assisted interventions (Hooker et al., 2002).

Distinct varieties of animal-based interventions have emerged, including visitation therapies (e.g., visits by live animals) and animal-assisted therapy, wherein the animal and handler work more intensively with care staff toward predetermined outcomes (Johnson et al., 2002). Animal-based interventions have shown promise for improving the quality of life among older adults in long-term care, and one literature review outlines a variety of cognitive, affective, and social benefits among residents with cognitive impairment, including increased social engagement and communication, positive attitudes, and opportunities to engage in cognitively stimulating activities (Eaton-Stull & Williams, 2019). However, even non-human contact interventions require access to trained animals (and their handlers) and engagement of the residents during particular times when the intervention is available, in addition to considerations such as pet allergies or risk of exposure to bacterial infection (Kanamori et al., 2002).

Robotic Interventions in Long-Term Care

One alternative to both human contact-based programs and animal-assisted therapies includes social robot interventions. In the last few decades, great strides have been made in advancing robotic technologies to meet the care needs of vulnerable populations such as children, individuals with developmental disabilities, and older adults with cognitive impairment. Research findings indicate that outcomes of robotic companion interventions are often comparable to those of live animals, including improvements in mood, behaviors, and quality of life in LTC settings (Aarskog et al., 2019; Thodberg et al., 2016). Of the many advancements made, several have been designed and implemented for use with older adults, particularly those with cognitive impairment. Designs of these devices range from human-like, such as the NAO robot, to animal-based, such as the PARO seal and the various Joy for All companion pets. Although a full review of these advancements and their features is beyond the scope of this paper, it is important to note that the market of robotic companions available for use with older adults has become highly saturated over the years, with various perks and features unique to each type (e.g., mobile capabilities, unique movements, and sound banks). Mordoch and colleagues (2013) present a discussion of social commitment robots more broadly, with a review of studies examining various companion robots across settings. In the current paper, the focus is instead placed on closely examining the impacts of one of the most widely researched and unique robotic companion animals-the PARO seal. Narrowing the scope of our critical literature review to specifically examine outcomes of the PARO seal, as opposed to cross-comparing with other robots, allows for a more in-depth analysis of the literature. Further, there are many different features inherent to

each robotic companion, and these variations may contribute to differences in research outcomes.

The PARO Seal

One of the most widely utilized robotic companions introduced to LTC settings across 30 countries is the robotic seal PARO, designed by Takanori Shibata. Designed in the 1990s and officially introduced to the public in 2003, it has gained clearance as a medical device by the U.S. Food and Drug Administration and is considered a biofeedback device and social commitment robot (Shibata, 2012). The PARO seal was named after the Japanese term for 'personal robot' and was designed based on a young Canadian harp seal to avoid preconceived ideas and expectations participants may have about more familiar animals (e.g., cats, dogs). The seal is designed to be attuned to various senses-touch (petting, patting), sight (responsive to light), hearing (recognizing the direction of a sound, detection of common words such as its name and greetings), temperature (detection of warmth), and posture (being held). The PARO seal utilizes surface tactile sensors to respond to user contact and engages in three forms of behaviors: proactive, reactive, and physiological (e.g., diurnal rhythm). It is capable of independent movement (e.g., of head, flippers, and tail) and sound production and is similar in size and weight to a human baby, allowing older adults to hold and move it as desired. The PARO seal is also able to memorize its name and uses reinforcement learning, responding differently to positive (e.g., petting) versus negative (e.g., hitting) contact. A full description of the functions and design of the PARO seal can be found in Wada and Shibata (2007) and Shibata and Coughlin (2014).

Throughout its career as a therapeutic robot, the PARO seal has been documented to have significant positive effects when introduced to LTC settings, including biological, psychological, and social benefits. The PARO seal's mechanism of action is thought to be similar to those found with live animal interventions, as the seal introduces a non-judgmental companion figure that can provide social and recreational support. The research question to be addressed by the current critical literature review is whether the PARO companion robot's efficacy as an intervention within LTC facilities for the improvement of social and dementia-related outcomes is supported by the recent literature. A recent systematic review by Wang and colleagues evaluated outcomes of the PARO seal within elder care facilities across nine studies, with a focus on randomized control trials. Results indicated some evidence for the use of the PARO seal; however, they noted caution due to variability in study design and quality (Wang et al., 2022). This review is intended as a preliminary exploration of the literature through a novel lens (e.g., focus on variability in intervention implementation) in LTC.

A variety of studies utilizing the PARO seal have been conducted over the past two decades, with key studies relevant to the research question highlighted in Table -1. Key studies were defined as contributing unique findings to the literature on the PARO seal's efficacy for use with older adults with cognitive impairment in residential LTC settings, specific to the outcomes of social engagement and dementia-related behaviors.

METHODS

Inclusion criteria included: a) use of the PARO seal as an intervention; b) sample(s) from a residential long-term care setting; c) specific outcomes related to dementia-related behavior and/or social engagement/isolation; d) older adult sample; and e) paper represents unique, published data. Papers were excluded if samples were strictly community-dwelling or outpatient (e.g., adult day care centers), other robotic companions were used without comparison to PARO, papers represented repeated findings from the same project (without unique outcomes), and/or outcomes were unrelated to the target variables. Following exclusion, 17 papers were retained in the final review (See Table 1).

Throughout our review, interventions broadly fell into one of two categories: free access (which means availability of the PARO seal within the facility to be interacted with at the resident's discretion across long periods) or scheduled intervention (wherein the seal was available only during specified intervention periods either in a group or individual format). Differentiation of results by free access versus scheduled intervention was selected due to the high likelihood of this variability in presentation impacting outcomes. For example, access to the PARO seal in free access conditions can impact the duration of exposure up to several hours per day compared to scheduled brief interventions (e.g., five to 60-minute sessions). Further, no reviews to date have discussed this difference that is salient throughout the literature or addressed its potential contributions to the variability in research findings.

RESULTS

Disruptive Dementia-related Behaviors Outcomes

As neurocognitive disorders are some of the most prevalent conditions among older adults in LTC, significant research has investigated outcomes of PARO intervention among residents with disruptive dementia-related behaviors, which can present as some of the most challenging symptoms within this population. Specific outcomes often assessed include affective and mood changes, caregiver/staff stress or burden, overt behaviors (e.g., wandering, aggression), and overall ratings of composite dementia-related behaviors. Use of the PARO seal has been adopted worldwide, and recent developments

have included protocols for use, including protocols from the United States Veterans Administration that recommend the use of the seal for residents with psychomotor agitation (or "busy hands"), resistance to care, emotional distress or depression, and social isolation (PARO Company, personal communication, September 14, 2021). The following sections will describe outcomes of dementia-related behaviors across various studies, distinguished by the type of intervention implemented.

Free Access

Although only a few studies have examined the impacts of a freely accessible PARO companion robot on dementia-related behaviors in residential care settings, the preliminary findings are promising. Shibata and Coughlin (2014) examined the impact of PARO introduction into two U.S. nursing home facilities by conducting clinical assessments pre- and post-introduction (with no control group). Findings demonstrated that the number of residents with clinical depression (based on MDS2.0 ratings) dropped from 13 to 6, and the number of residents displaying problematic dementia-related behaviors (e.g., verbal aggression) decreased from 20 to 10 following PARO introduction. Research on the effects of the PARO seal among older veterans living within Veterans Affairs (VA) long-term care facilities with free access to interact with the seal also indicated positive impacts on affect and behavior and decreased dementia-related behaviors over a period of 1.5 years, with particular effectiveness among relatively non-agitated residents (e.g., those that are not behaviorally agitated prior to PARO engagement; Lane et al., 2016). Another study conducted in Japan that followed three residents with cognitive impairment over seven months of freely accessible PARO intervention demonstrated decreased caregiver burden and less frequent dementia-related behaviors when PARO was present compared to when it was absent (Hori et al., 2021). This case study also found subjective reports from facility staff of positive emotions among staff members when viewing residents interacting with PARO. Interestingly, the impacts of free access to the PARO seal seem to differ depending on the residential setting. One randomized control trial (RCT) examining free access to PARO in two dementia day care centers and in homes of community-dwelling older adults with dementia demonstrated improvements in affective symptoms and communication but did not find changes in dementia-related behaviors, contrary to findings from within LTC settings, though this may be due to differences in sample characteristics (e.g., severity of cognitive impairment; Liang et al., 2017). Thus, based on the limited research currently available, it seems that the PARO seal may have some merit in reducing disruptive dementia-related behaviors and symptoms when

Table-1. Summary of Key PARO Studies

Study	Sample	Setting	Method	Measures	Outcomes
Wada et al. (2005)	N=14 (cognition varied)	Health service facility (Japan)	Individual interaction for 1 hour twice a week for one year	Face scales; Geriatric Depression Scale; Staff report	Improved mood (decreased depression) sustained throughout the year
Wada & Shibata (2007)	N=12	Care houses (Japan)	PARO is openly available for 9 hours per day in common areas over two months	Interviews; Video monitoring	Increased subjective (self-report) and objective (observation) social engagement and communication
Wada & Shibata (2009)	N=12	Care house (Japan)	PARO is openly available for 9 hours per day in common areas over one year	Interviews; Video Monitoring	Residents had denser social ties following a year of PARO activity
Roger et al. (2012)	Study 1: N=3 (moderate dementia) Study 3: N=4 (moderate dementia)	Long-term care and rehabilitation facility (Canada)	Study 1: 30 minutes per day for two weeks (individual) Study 3: Three 30-minute sessions with a care partner	Face scale; Video recordings; collateral interviews	Study 1: Collateral reports indicated improved mood and decreased loneliness Study 3: Facilitated communication with care partner and improved affect
Robinson et al. (2015)	N=21	Retirement home: rest home care and hospital units (New Zealand)	RCT; 12-week PARO intervention (10-minute interactions)	Blood pressure (before and after interaction)	Decreased blood pressure following exposure, indicating reduced stress
Shibata & Coughlin (2014)	Study 2: N=28 (dementia) Study 3: N=14 (dementia)	Study 2: Nursing homes (USA) Study 3: Dementia units (USA)	Study 2: Pre- and post-test of PARO introduction to units Study 3: Individual therapy sessions with PARO	Clinical assessments (before and after introduction)	Study 2: Decreased depression and problematic dementia behaviors Study 3: Improved affect and relaxation, decreased dementia-related behaviors (wandering, aggression, loneliness)
Takayanagi et al. (2014)	N=19 (mild/moderate dementia). 11 (severe dementia)	Nursing care facility (Japan)	Individual 15-minute sessions, compared to a plush toy	Behavior observation (video)	Greater engagement with PARO than control; positive changes in affect; Less demand for staff when PARO was present (in the mild/moderate group)
Valentí Soler et al. (2015)	Phase 1: N=101 (moderate to severe dementia) Phase 2: N=110 (moderate to severe dementia)	Nursing home (Spain)	Block RCT; 30–40-minute group sessions twice a week for three months (versus NAO robot, live dog, care as usual)	Blind ratings at baseline and post-intervention: GDS; MMSE; sMMSE; APADEM-NH; Quality of Life in Late-Stage Dementia	No improvements in quality of life or MMSE performance. Some improvements in apathy in both PARO and NAO in phase 1 only. Inconsistent changes in sleep, irritability, and inhibition
Jøranson et al. (2016a)	N=30 (dementia)	Nursing homes (Norway)	30-minute group sessions twice a week for 12 weeks	Video recording of behavior (ethogram)	PARO increased engagement and communication, but participants with severe dementia had difficulty engaging compared to those with mild/moderate

Table-1. Continued...

Study	Sample	Setting	Method	Measures	Outcomes
Jøranson et al. (2016b)	N=27 (dementia)	Nursing home units (Norway)	Cluster RCT; Group activity twice a week over 12 weeks (versus care as usual)	Quality of Life in Late-Stage Dementia scale; medication usage	Quality of life was stable in the PARO group compared to the decline in control. The PARO group used less psychotropic medication than the control post-intervention
Lane et al. (2016)	N=23 (82% had dementia diagnosis)	VA community living center (USA)	PARO was openly available in communal spaces	Staff observations of mood and behavior (before, during, and after interaction)	Decreased negative behavioral states; increased positive behavioral states
Thodberg et al. (2016)	N=100 (cognition varied)	Nursing home (Denmark)	RCT; individual 10-minute visits twice a week for six weeks with a facilitator (versus stuffed toy or live dog)	Behavior observation (live and video records)	Improvements in engagement and communication were comparable between PARO and live dogs; however, PARO interest decreased over time
Moyle et al. (2017)	N=415 (dementia)	Long-term care facilities (Australia)	Cluster RCT; individual 15-minute sessions, three times per week for ten weeks	Behavioral observation (video); Cohen-Mansfield Agitation Inventory-Short Form	Greater verbal and visual engagement compared to plush toys. Decreased neutral affect and agitation, and increased pleasure compared to usual care
Petersen et al. (2017)	N=61 (mild to moderate dementia)	Dementia care units (USA)	Randomized block design; 20-minute group sessions three days per week for three months	RAID; CSDD; GDS; pulse rate; pulse oximetry; GSV; medication utilization	Oxygen saturation, pulse rate, GSV, RAID, CSDD, and medication use were all positively impacted
Koh & Kang (2018)	N=33 (dementia)	Nursing home facility (Korea)	30-minute group sessions twice per week for six weeks using a manualized program	MMSE-K; Apparent Emotion Rating Instrument; Korean Cohen-Mansfield Agitation Inventory; Video observation	No change in cognition (MMSE); compared to controls, the PARO group showed greater positive emotion, fewer problem behaviors, and increased social engagement post-treatment
Pu et al. (2021)	N=43 (dementia or probable dementia and chronic pain)	Residential aged care facility (Australia)	RCT; daily 30-minute individual intervention for six weeks	Actigraphy (sleep, motor activity)	Sleep patterns improved in the PARO group
Hori et al. (2021)	N=3 (cognitive impairment)	Distributed layout elderly housing (Japan)	Free interaction in a common area during 9-hour blocks over seven months	Dementia Behavior Disturbance Scale short version; Staff interviews	Care staff burden and dementia symptoms were decreased when PARO was present

Note. RAID = Rating for Anxiety in Dementia. GSV = Galvanic skin response. GDS = Global Deterioration Scale. CSDD = Cornell Scale for Depression in Dementia. RCT = Randomized control trial; MMSE = Mini Mental Status Exam. sMMSE = Severe Mini Mental Status Exam; APADEM-NH = Neuropsychiatric Inventory and Apathy Scale for Institutionalized Patients with Dementia-Nursing Home Version.

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readily available in residential units; however, further research is needed to confirm these findings and determine whether effects are maintained across time, as some evidence suggests that when PARO is removed from the facility, behaviors return to pre-intervention frequency (Hori et al., 2021). Further, as these benefits seem to have limited replicability among community-dwelling older adults, further investigation is needed to understand how PARO functions within the social context of residents.

Scheduled Intervention

More research has been conducted examining the impacts of scheduled interactions with the PARO seal on a variety of dementia-related behaviors and symptoms, including affective and sleep symptoms, behavioral presentations (e.g., aggression, wandering), and related factors such as stress and quality of life. One recent RCT (Moyle et al., 2017) compared the PARO seal to a similarly designed plush toy and the usual treatment and found that the PARO seal improved various outcomes compared to the usual treatment group and demonstrated mild improvements above that of the plush toy. Specifically, behavioral observation indicated decreased neutral affect and agitation and increased pleasure among the PARO group compared to usual care, as well as increased verbal and visual engagement with the stimuli compared to the plush toy control. Another study comparing the PARO seal's effectiveness with a stuffed toy indicated that among older adults with both mild to moderate dementia and severe dementia, nursing care residents demonstrated more verbal interaction, more frequent laughter, and more positive affect with the seal compared to the stuffed toy. Additionally, residents also demonstrated a decreased need for staff initiation when PARO was present (Takayanagi et al., 2014). Another study implementing a 12-session group PARO program that included 30 minutes of PARO interactions within a nursing home facility indicated reduced dementia-related behaviors and increased positive emotion among the PARO group compared to controls (Koh & Kang, 2018). Regarding sleep, one RCT conducted over six weeks with individual 30-minute PARO interactions found that PARO intervention improved sleep for residents with cognitive impairment compared to residents receiving treatment as usual. Specifically, they demonstrated greater sleep quantity at night during the first week of intervention in addition to greater daytime wakefulness at week six compared to controls (Pu et al., 2021). Further, an RCT of nursing home residents with severe dementia indicated that residents receiving group PARO seal intervention twice a week over 12 weeks demonstrated stable quality of life at 3-month follow-up compared to decreased quality of life among residents in the control group. Additionally, the PARO group required significantly less psychotropic

medication post-intervention compared to the control group (Jøranson et al., 2016b). Similar findings by Shibata and Coughlin (2014) indicated the decreased need for antipsychotic medication within dementia care units following the introduction of individual PARO therapy services to older adult men. Further, they also found increased relaxation and positive affect in addition to decreased dementia-related behaviors such as wandering, verbal and physical aggression, and loneliness. However, one study comparing PARO's effectiveness to the NAO robot, care as usual, and a live dog demonstrated no consistent impacts of PARO among older adults with moderate to severe dementia within a nursing home (Valentí Soler et al., 2015).

Though a few analyses indicated possible impacts on sleep, disinhibition, and irritability, the authors reported inconsistency and lack of strength of these findings, possibly alluding to a decreased efficacy of the PARO seal among those with severe dementia presentation. Supporting this idea, one systematic review of eight PARO intervention studies indicated that while the PARO seal shows moderate benefits in reducing dementia-related behaviors compared to care as usual in LTC, it may not be significantly more effective than a non-animatronic plush toy, particularly when working with residents with severe forms of dementia (Chan et al., 2022).

Finally, consistent with animal intervention studies, research indicates that the PARO seal can have impacts on physiological outcomes, which may be indicative of stress levels. Robinson and colleagues (2015) found that the PARO seal was effective at decreasing systolic and diastolic blood pressure in addition to heart rate following brief (i.e., 10-minute) interactions between PARO and LTC residents across 12 weeks (Robinson et al., 2015). These findings provide some evidence of the acute impacts of residents' experiences with PARO, which may impact the subsequent emergence of agitation and dementia-related behaviors, though it is unclear how long these effects are maintained. Though non-residential, additional research within adult day care centers supports these findings. One study indicated that the introduction of the seal robot might alleviate both resident and caregiver stress levels within adult day care centers by facilitating increased relaxation among residents, leading to less requirement of active supervision and reduced caregiver burden during time spent with PARO (Wada et al., 2004).

Social Outcomes

Free Access

Many studies have examined the social impacts of companion robots, including PARO, on outcomes among LTC populations. However, few of these studies have examined the long-term impacts of freely accessible PARO companions on social engagement and communication.

Initial studies examining the effects of less controlled interactions with the PARO seal (i.e., the presence of the seal for several hours a day within the residence, available to residents) demonstrate that introduction of the seal to an LTC residence for two months (available for nine hours per day) led to improvements in social activity among residents, both subjectively (via self-report) and objectively (via monitored social behavior), with continued positive outcomes and engagement with the robots over the following year of exposure (Wada & Shibata, 2007; Wada & Shibata, 2009). Specifically, residents in LTC residences in Japan demonstrated increased communication with others in the facility and greater social engagement when PARO was available. Further, residents with free access to the PARO seal in communal areas demonstrated denser social ties following a year of exposure, as noted through interviews and video monitoring of communal behavior (Wada & Shibata, 2009). Potentially, these results may demonstrate that the PARO seal may act as a facilitator of social activity among residents and encourage them to spend time within communal areas of the facility, as opposed to isolating themselves within their rooms with limited social contact.

Scheduled Intervention

Results of scheduled PARO intervention programs have demonstrated fairly consistent positive results of improved social outcomes among older adults in LTC. One study indicated that interaction with the PARO seal for one hour twice a week over a year-long period improved resident mood by decreasing depressive symptoms and facilitated increased communication between residents and caregivers (Wada et al., 2005). Another study indicated that group PARO sessions might facilitate increased social engagement among residents (Koh & Kang, 2018). Further, residents demonstrated a positive attachment to the seals, including naming each robot. This is consistent with studies examining other companion robots that indicate older adults with cognitive impairment often form attachments and project intrinsic motivations and personalities to companion robots (LaRose et al., 2021). Improvements in social engagement and communication following PARO intervention have also been compared to those demonstrated by live animal (i.e., trained dogs) therapies, though sustained interest in the PARO seal over extended periods of time varies (Thodberg et al., 2016). Further studies indicate that family members of LTC residents with moderate dementia reported improved mood and decreased loneliness among their loved ones following residents' daily PARO intervention (Roger et al., 2012). In another study wherein family members were present during an intervention, the PARO seal facilitated improved

communication between the resident and their care partner, including improved affect during interaction and broader verbal engagement with their partner (Roger et al., 2012). However, the sample sizes were significantly limited in these two studies. That said, one study outside of the LTC setting has also found preliminary support for PARO's role in improving interactions with caregivers, though results vary across individuals and families (Inoue et al., 2021). Shibata and Coughlin (2014) also found that older men with dementia residing in dementia care units expressed less loneliness during clinical assessment following the introduction of individual PARO therapy services. Results appear to be mixed in terms of sustained impact on communication and affect over time, with some research indicating that effects are maintained for up to a year (Wada et al., 2005) and others indicating decreased engagement over time (Thodberg et al., 2016). Some findings suggest that impact and engagement with the PARO seal vary by the cognitive status of residents, with individuals with severe cognitive impairment experiencing greater difficulty engaging and benefiting compared to those with mild to moderate decline (Jøranson et al., 2016a). Likely, engagement and sustained impact of intervention depend on a) sample (e.g., the severity of cognitive impairment, residential setting) and b) intervention variability (i.e., type of exposure, duration of interaction, accessibility).

CONCLUSION

Social isolation and disruptive dementia-related behaviors are two of the most common concerns raised by staff and older adult residents in LTC settings. Further, the presence of cognitive impairment, a highly prevalent concern among older adults in LTC, can compound the effects of social isolation, leading to poorer quality of life and well-being (Boamah et al., 2021; Desai et al., 2012). The PARO companion robot has been introduced as one potential intervention to improve the lives of LTC residents and their caregivers by decreasing social isolation and dementia-related behaviors, and researchers have spent the last two decades determining its efficacy within these settings. Based on the current literature, older adults with mild to moderate cognitive impairment appear to benefit the most from PARO intervention, and the frequency and quality of exposure likely impact the nature and extent of benefits for residents. Based on this critical literature review, it appears that structured PARO interventions with limited time of exposure may provide immediate benefits such as reduced stress, improved affect, and increased social engagement and communication; however, the lasting impacts of these sessions may be limited. Fewer studies have examined the impact of the PARO seal on residents when accessibility is longstanding, but current

findings suggest that long-term impacts of a highly accessible PARO seal may be retained for extended periods, up to a year or beyond, depending on length and type of exposure. Long-term impacts were found in the quality and quantity of social engagement and communication as well as mood and affect, both of which may impact the emergence of other dementia-related behaviors such as agitated behavior and aggression.

Further, the PARO seal seems to present benefits for care staff in addition to residents, possibly due to the availability of an alternative social figure (the seal) and recreational activity. Caregivers and staff seem to benefit from fewer care demands from residents when PARO is available, and two studies indicated reduced stress among staff, likely due to the positive impacts of PARO on residents' behavior and attitudes as well as these decreased demands. That being said, evidence to support PARO's use with individuals with severe dementia, as opposed to mild to moderate cognitive impairment, is less consistent. While some studies demonstrated potential benefits of the seal among those with severe cognitive impairment, others indicated little to no effect of the seal compared to other treatment options (e.g., plush toy, care as usual), and few studies clearly delineated results based on level of cognitive impairment. Additionally, some studies indicated that the level of agitation at the onset of interaction may impact engagement with PARO. Thus, it may be that PARO is most effective when readily accessible among those with mild to moderate cognitive impairment and among those who are not actively agitated.

Overall, the PARO seal's effectiveness in LTC populations of older adults with cognitive impairment has been reliably suggested across studies, settings, samples, and geographical locations, though findings continue to vary due to the inconsistent methodologies applied. Further, much of the current literature is limited based on sample size and methodological constraints. However, the PARO seal's suggested benefits seem to be comparable to other non-robotic interventions (e.g., animal-based interventions), with minimal risks associated with or requiring human resources. For example, the seal can be made readily accessible to residents, requiring minimal staff oversight or responsibility of residents to engage in specified ways with the intervention. The benefits provided by PARO are likely attributable to similar mechanisms as animal-based approaches, as residents are provided with a supportive, non-judgmental figure through which they can communicate freely and receive comfort.

Similar to a live animal companion, the seal is able to respond to interaction, providing support for residents that may cross boundaries that communication

limitations may present with other people (e.g., for residents with declining language ability and/or sensory disabilities). The intervention requires little mobility or demands on the residents, and when applied in a free-access manner, it can be readily available for use at the resident's discretion, which may aid in preventing dementia-related behaviors prior to the escalation of mood or behavioral disturbance. For example, residents can seek comfort from the seal when agitated or lonely, potentially alleviating symptoms. Further, the seal has additional benefits in facilitating communication and activity among residents, acting as a point of conversation and social activity that may promote more frequent use of communal areas within facilities. Thus, PARO seems to be a promising addition to existing care structures within LTC facilities and may improve resident quality of life when used to supplement care as usual and existing systems for social support.

Limitations and Future Directions

There are several important limitations of the current literature to be addressed. Of note, existing studies of robotic companion interventions like PARO are highly variable in the method and duration of intervention used, which may lend itself to inconsistent results and variability in findings. That being said, some research indicates that a one-size-fits-all approach to PARO intervention may not be ideal and that there is high variation in responses to PARO overall (Moyle et al., 2019). Furthermore, the lack of control groups in some of the studies limits conclusions made from the results (i.e., that the results are from the intervention itself rather than other variables), and few studies reported effect sizes in their results. Concerns have also been raised about the presence of bias and the quality of results and reporting seen throughout PARO study publications, indicating a need for stronger evidence of its effectiveness beyond what is currently available to draw solid conclusions (Wang et al., 2022). Along these lines, measurement of dementia-related behaviors and social outcomes among LTC residents can be challenging, and many studies rely on collateral reports, staff observations, or limited self-report data to evaluate social and behavioral outcomes. In instances of the staff report, blind reporting is typically impossible due to the nature of staff observation of behaviors, leading to possible biases in reporting, which may impact data fidelity. Finally, sample sizes among most studies utilizing the PARO seal are small, which may lead to issues such as a lack of generalizability of findings and insufficient statistical power. Thus, future research should investigate the replicability of existing findings and expand research methods to include large, diverse samples and multiple data collection forms. Additional research in the realm of social robotics has also begun to examine the ways in which caregivers utilize PARO and the role

through which the seal functions in the context of the care setting (Pfadenhauer & Dokat, 2015). With these limitations and new directives in mind, it is imperative that additional research is done to understand what components of the PARO seal (and other similar interventions) are truly responsible for intervention outcomes. Further clinical trials are needed to parse out the most effective forms of intervention when using the PARO seal (e.g., free access versus scheduled, individual versus group). Additionally, further investigation into the benefits of PARO in other treatment settings may also expand our understanding of the utility of the PARO seal. Existing studies have primarily focused on outpatient settings such as adult day cares (Wada et al., 2004) and acute care settings such as hospitals (Kelly et al., 2021), however as the use of the PARO seal in individual homes by caregivers is rising, especially in Japan (Pfadenhauer & Dokat, 2015), further information is necessary to understand the benefits of introducing PARO as a household item, especially for caregivers of older adults with cognitive impairment. This need for additional research among caregivers is further supported by existing research, as even within LTC settings, some studies provide evidence that family care partners may experience improvements in interactions with care recipients when utilizing PARO (Roger et al., 2012) and caregiving staff may experience less care burden (Hori et al., 2021). However, other research indicates that caregivers and staff may experience barriers to PARO implementation (e.g., unclear protocols, cost, and learning to use the technology) and that outcomes may vary based on the effectiveness of staff use (Share & Pender, 2021). Thus, future studies should further explore the impacts of PARO on caregiver outcomes and evaluate the ease of implementation for both formal and informal caregivers.

Further, the current critical literature review represents a preliminary investigation of the existing support for using the PARO seal with older adults in LTC. Based on the current findings, a full systematic review of this literature appears warranted and could add additional insights into its effectiveness across studies. Additionally, including other robotic companions as a comparison could be beneficial in a broader review of current intervention options for LTC. Future research should also investigate the precise mechanisms underlying the effectiveness of robotic companions such as the PARO seal.

Finally, recent advancements have begun to move beyond stationary robotics that require human intervention to initiate and/or control. These new advancements are making initiatives to create systems that can detect and respond automatically to behavioral disturbance through sensors and response mechanics that allow them to independently transport to an individual and soothe the behavior, with alarm

technologies installed to alert staff if the intervention is unsuccessful. These responsive robotics are programmed with auditory stimuli to soothe the resident, such as singing a song, asking questions, and reporting on news events. One instance of this new technology has been applied to the NAO robot, with enhancements made for quicker and smoother mobility, with results adding to the literature on effective ways to position and model this form of robotic intervention (Nauta et al., 2019). Thus, the future of social commitment robotics looks bright, and future directions should seek to compare these new advancements to existing interventions, such as the PARO seal, to determine the most effective and feasible treatment options for LTC residents.

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