Title	Enhancing older people's activity and participation with socially assistive robots: a multicentre quasi-experimental study using the ICF framework
Authors(s)	Obayashi, Kazuko, Kodate, Naonori, Masuyama, Shigeru
Publication date	2018-10-14
Publication information	Obayashi, Kazuko, Naonori Kodate, and Shigeru Masuyama. "Enhancing Older People's Activity and Participation with Socially Assistive Robots: A Multicentre Quasi-Experimental Study Using the ICF Framework" 32, no. 22 (October 14, 2018).
Publisher	Taylor & Francis
Item record/more information	http://hdl.handle.net/10197/12130
Publisher's statement	This is an electronic version of an article published in Kazuko Obayashi, Naonori Kodate & Shigeru Masuyama (2018) Enhancing older people's activity and participation with socially assistive robots: a multicentre quasi-experimental study using the ICF framework, Advanced Robotics, 32:22, 1207-1216, Advanced Robotics is available online at: www.tandfonline.com/doi/abs/10.1080/01691864.2018.1528176
Publisher's version (DOI)	10.1080/01691864.2018.1528176

Advanced Robotics, 2018
https://doi.org/10.1080/01691864.2018.1528176

Enhancing Older People's Activity and Participation with Socially Assistive Robots: A Multicentre Quasi-Experimental Study using the ICF Framework

Kazuko Obayashi [a], Naonori Kodate [b] and Shigeru Masuyama [c]

[a]Social Welfare Corporation Tokyo Seishin-kai, Tokyo, Japan; [b]School of Social Policy, Social Work and Social Justice, University College Dublin, Dublin, Ireland; [c]Travellers Medical Centre, Tokyo Medical University Hospital, Tokyo, Japan

Abstract

This paper reports the usefulness of the International Classification of Function, Disability and Health (ICF) framework, when measuring the impacts of socially assistive robots (SARs) on older people's activities and participation. A total of 67 people aged 65 and over participated in a 24-week-long, quasi-experimental study in six residential nursing homes in Japan. The participants in the robot intervention groups showed greater improvements in their scores for targeted activities and participation than the control group. Statistically significant improvements were observed in communication, self care, and social life. SARs have great potential for improving older people's quality of life.

Keywords: Nursing care; Assistive Robotics - Robotics in Application Fields; Ageing in place; International Classification of Functioning, Disabilities and Health; older people

1. Introduction

Facing the challenge of a global ageing society, scientists and practitioners involved in caring for older people are trying to find practical solutions so that older people could retain their abilities for self care and remain in their homes.[1-2] In recent years, several studies have shown that by introducing a companion robot or 'interactive surfaces' technology into the care mix, older people smile and socialise more frequently, become more active and talkative, and their Behavioural and Psychological Symptoms of Dementia decreased.[3-7] However, the impacts of

https://doi.org/10.1080/01691864.2018.1528176

robotics-aided care on older people's quality of life, particularly their physical and social activities, have so far been underexplored with a few exceptions.[8-10]

As one of the most rapidly ageing economies, Japan is currently faced with a shortage of care workers and relatively low intakes of migrant workers.[11-12] By 2025, there will be a shortfall of 370,000 nurses and care workers in Japan.[13] Robotic-aided care is seen as not only promising but as almost inevitable. In March 2016, a robot-assisted walker was added, for the first time, to the list of reimbursable items under the Long-Term Care Insurance scheme. The list of items is to be expanded in 2017.

Against such a background, this study was designed to investigate whether socially assistive robots (hereinafter referred to as SARs) can positively influence older people in receipt of nursing care, with a particular emphasis on their activities and social participation, as recognised in the International Classification of Functioning, Disabilities and Health (ICF).

The ICF, developed by the World Health Organization, is now regarded as the most encompassing taxonomic model for looking at one's functioning and disability from a universal accessibility perspective.[14-15] In Japan, the ICF has been widely used in the curriculum of social care professionals. However, while nursing care staff in Japan and elsewhere are very familiar with the ICF, the framework has not yet been applied to the evaluation of robotic-based

https://doi.org/10.1080/01691864.2018.1528176

care and its impacts on older people.[16] Finding a realistic approach to data collection and analysis for nursing-care staff using the ICF scheme[17] is therefore also an objective of this study.

2. Methods

2.1. Study design

This present research employed a quasi-experimental study of multiple facilities in order to address and answer the research questions. When trying to evaluate the effects of robot-aided care on the older people, it was not deemed suitable to carry out double-blind randomisation with SARs as an intervention device. However, in the absence of empirical evidence to support the effectiveness of such devices, we valued the significance of carrying out a study using multiple care homes and evaluating changes after an SAR was used, based on a nursing care plan, personalised goals and the standardised ICF framework. This study is registered at UMIN-CTR (UMIN000025673). This study was commissioned by the Japan Agency for Medical Research and Development (AMED) as part of robot nursing care equipment development research (No.28, 1980).

2.2. Participants

Six facilities in Japan took part in this study (four nursing homes and two rehabilitation facilities

https://doi.org/10.1080/01691864.2018.1528176

for older people). Ten accredited facilities each with more than 15 years of experience were originally approached, six of which agreed to participate. All of the six provide dementia care, and have a high proportion of long-serving licensed care workers. In those six facilities, 80 older people were recruited and agreed to participate.

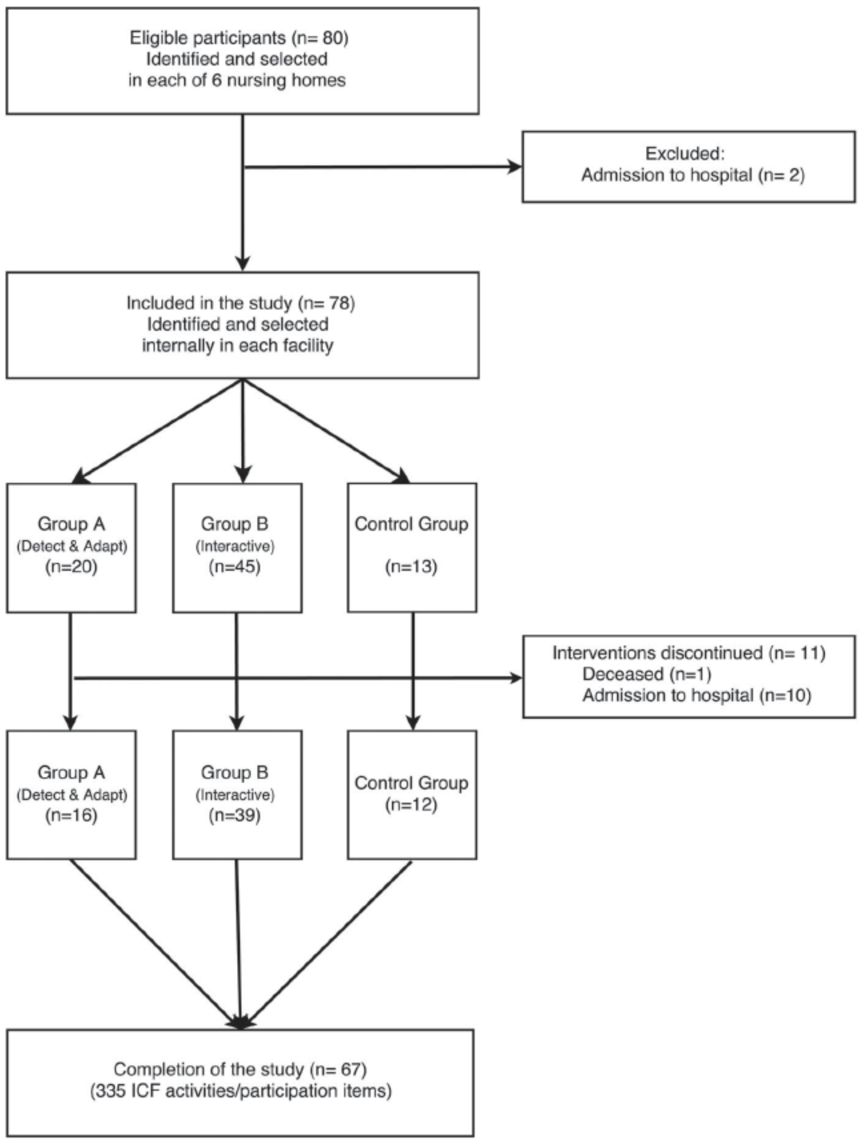

Figure 1. Flow of participants.

The inclusion criteria for individual participants were whether they can express their will, and conduct two-way communications with their carers and family members. The six facilities were broadly split into two groups: (i) robot intervention group and (ii) control group with no robot intervention. Group (i) consists of 65 residents in five facilities (55 women, 10 men, aged 86.6 ± 8.0 years old), while Group (ii) is composed of 14 people (all female, aged 86.0 ± 10.0 years old) in one of the rehabilitation facilities. Group (i) was further divided into two sub-groups, depending on the type of robots used, which will be described below.

2.3. Socially assistive robots (SARs)

Three different SARs used for this study share some common features, such as cloud computing and a programmed alert system. Their names are: A.I. Sense (hereafter AIS), Palro, and Sota (the specification of each robot can be found in the table in Appendix 1 of the supplementary data). AIS (Group A) is a type of robot that speaks and encourages people to do certain tasks. It also monitors the person with a bed-side infrared camera, which sends alerts to the person as well as the central nursing station in case of emergencies such as falls. Palro and Sota, on the other hand, are both communication and interactive robots (Group B) (Table 1).

https://doi.org/10.1080/01691864.2018.1528176

Table 1. Specifications of three robots.

	AI Sense	Sota	Palro
Photo			
Input / output device	A camera / monaural microphone / speaker / LED. WiFi available.	A camera / monaural microphone / speaker / LED. WiFi available.	a camera / monaural microphone / speaker / LEDs. WiFi and Bluetooth available.
Interactions	Limited. Voices were pre-programmed and personalized according to the needs of each participant.	Highly interactive. Connected to cloud system, it has the ability to strike up advanced conversations.	Highly interactive. After a few one-to-one conversations, it has the ability to identify a person and have a personalized conversation.
Features	Provides safety monitoring via infrared sensor and alert functions, connected to nursing station.	Provides personal communication and companionship.	Provides not only personal communication, but also group recreation and physical activities for rehabilitation.

At any one time, each participant was given only one type of SAR during the study. The intervention group (Group (i)) was further divided into two groups (Groups A & B), due to the limited availability of Palro and Sota. Group B employed Palro for the first 8 weeks (Wave 1), followed by Sota in the second 8-week intervention period (Wave 2).

Table 2. Timeline & use of SARs.

	Week 1–4	Week 5–12	Week 13–16	Week 17–24
Group I-1 (Detect & Adapt type) ($n = 20$)	Preparatory period	AIS	Washout period	AIS
Group I-2 (User-controlled type) ($n = 45$)		Palro		Sota
Group C ($n = 15$)		No robot intervention		No robot intervention

AIS was used in one of the facilities for both periods (Table 2).

2.4. Data collection

Ethics approval was granted by the Social Welfare Corporation Tokyo Sacramental Ethics Committee (TS 2016-002). Consent was sought from each participant and their family. The research was conducted between September 2016 and April 2017.

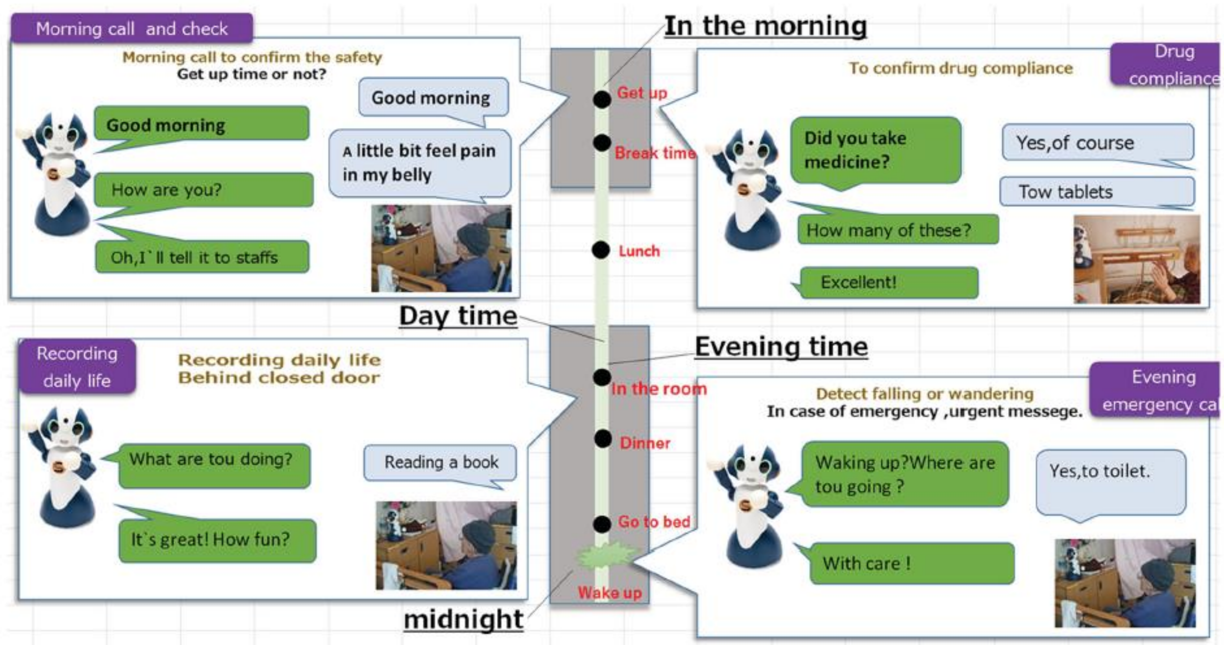

Figure 2. Daily timeline and main functions of SARs in the experiments.

2.5. Procedure

For all participants, a nursing care programme was devised, and a set of goals in the areas of participation and activities was identified by a care team using the ICF framework, in consultation with each participant. For activities and participation, the ICF lists (a) communication, (b) movement, (c) self care, (d) domestic, (e) interpersonal activities, (f) performing tasks in a major life area, and (g) tasks in social and civic life. In each of the seven categories, there are subsets of categories such as ‘transferring oneself’ and ‘hand and arm use’ (see the table in Appendix 2 of the supplementary data). The five most important items from the activities and participation category were selected for each person, and based on those five items, an observation sheet and a daily care plan were drawn up (see the tables in Appendix 3 and 4 of the supplementary data). For the intervention groups (Groups A and B), robots were programmed to reflect the older people's goals. Observations of changes in these items were made on a daily basis, and recorded by nursing staff at the end of the shift.

2.6. Assessment and evaluation of each item

The assessment of each activity, based on the observations, was graded using a 7-point scale (0: total independence; 1: limited autonomy (e.g. walking stick); 2: partial assistance needed (e.g. someone watching over); 3: verbal instruction needed; 4: partial/physical assistance; 5: total dependence; 6: inability to perform the action).

The team recorded the daily performance for each activity and participation numerically, and evaluated the changes throughout the study. We compared the baseline data with post-evaluation data, and gave a rating of 1 for 'improvement', 0 for 'no change' or -1 for 'deterioration'. Since older people's physical condition changes daily, 'improvement' and 'deterioration' were recorded only when the same trend was observed continually. Regarding small changes in a very short period of time, we judged carefully while recording such changes in the assessment as special notes. When data collection was finished, ratings for the five most important items for each person were added up. When the overall rating was positive, 1 was noted, which meant 'overall

https://doi.org/10.1080/01691864.2018.1528176

improvement'. Zero meant 'no change', while -1 signified 'overall deterioration'.

2.7. Statistical analysis

The distribution of 'overall improvement', 'no change' and 'overall deterioration' was determined for each robot, and this distribution frequency was compared with that of the control group using the Chi-square test. The performance average value of each item in the preliminary evaluation period and the performance average value at the end of Wave 1 for all the subjects were compared using the Wilcoxon signed rank sum test. All statistical analyses were performed using EZR (Saitama Medical Centre, Jichi Medical University, Saitama, Japan).[16] $P < 0.05$ was considered statistically significant.

3. Results

3.1. Characteristics of participants

Out of 80 older people who originally participated in the robot intervention, a total of 13 dropped out during the course of the study (from 60 women, 7 men, aged 86.5 ± 19.5 years old). Some moved to a different unit in their care home, while others became frail or deceased. The level of care needs for Groups (i) and (ii) was calculated, and there was no significant difference. In Japan, care requirements are assessed through two stages (first by computerised

https://doi.org/10.1080/01691864.2018.1528176

assessment, and second by a group of experts in health and social care) using the scale range 1-5. The average scales for Group (i) and (ii) were 3.4 and 3.5 respectively.

3.2. Effects of SARs on activities and participation of older people

The results of the first 8-week robot intervention (Group A with AIS, Group B with Parlo and the control group) are shown below (Table 3).

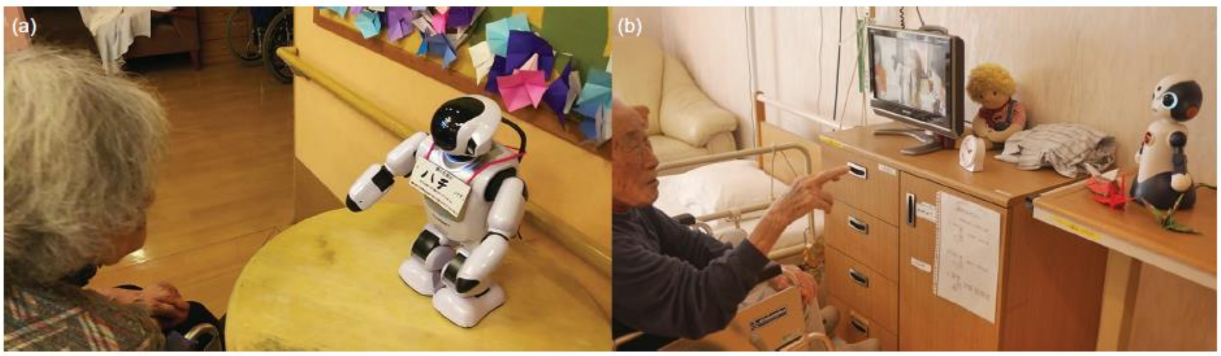

Figure 3. a & b: Examples of participants' interaction with SAR.

The chi-square tests were conducted for both periods, comparing the intervention groups (A & B) and the control group. For both periods, the differences were statistically significant (Wave 1: $\chi^2 = 13.136$, degrees of freedom 4, $p < 0.025$; Wave 2: $\chi^2 = 10.75$, degrees of freedom 4, and $p < 0.05$).

3.3. Improved activities and participation

Wilcoxon signed rank sum tests were conducted with respect to all seven categories of the ICF framework. Statistically significant improvements were found in the three categories: communication, self care, and social and civic life.

https://doi.org/10.1080/01691864.2018.1528176

Table 4 below shows statistically significant improvements classified by type of SAR. Conversation improved by use of AIS and Sota, while self care and social and civic life (participation in recreation and leisure) improved with Parlo and Sota.

4. Discussion

4.1. Main findings

This study examined the impact of SARs used in Japanese care homes on older people's activities and participation. The pre-post, non-randomised, multicentre study may provide insights into the potential use of such assistive technologies in other countries or environments. We report the key findings, strengths and limitations of the study. There were two key findings that are worth highlighting. First, the SARs had positive effects on older people's activities and participation. Applying and adapting the WHO's ICF framework to each participant's care plan and goal enabled both personalised and standardised data collection, and this is the first such scientific study (to our knowledge) albeit on a small scale.[18]

https://doi.org/10.1080/01691864.2018.1528176

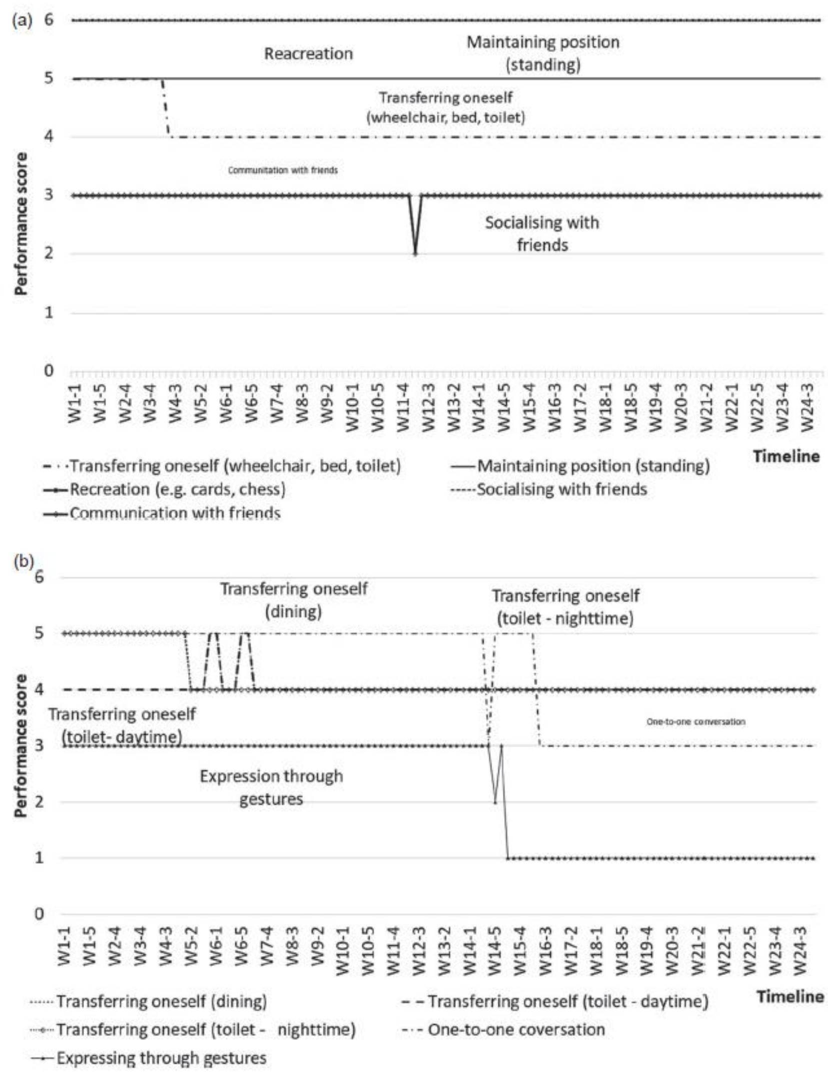

Figure 4. a & b: Observation charts (after data aggregation for five targets) for Ms A and Mr B.

While previous studies proved the positive impacts of SARs in the nursing care domain, particularly on the alleviation of loneliness [3-4] and emotional security of care recipients,[19-20] our findings, combined with the use of the ICF framework, are noteworthy. The second main result is that statistically significant improvements were found not only in 'communication', but also in 'self care' and participation in 'community, social and civic life'.

SARs with communication and interactive functions, such as Parlo and Sota, brought about positive changes beyond mere conversation.

Table 3. Effects of the interventions (Waves 1 and 2).

	Overall improvement	No change	Overall deterioration	Total
3a. Effects of the interventions (Wave 1)				
Group A	13 (65%)	5 (25%)	2 (10%)	20 (100%)
Group B	33 (73.3%)	6 (13.3%)	6 (13.3%)	45 (100%)
Control	3 (23.1%)	4 (30.8%)	6 (46.2%)	13 (100%)
Total	49 (62.8%)	15 (19.2%)	14 (17.9%)	78 (100%)
3b. Effects of the interventions (Wave 2)				
Group A	6 (37.5%)	4 (25%)	6 (37.5%)	16 (100%)
Group B	22 (56.4%)	4 (10.3%)	13 (33.3%)	39 (100%)
Control	1 (8.3%)	5 (41.7%)	6 (50%)	12 (100%)
Total	29 (37.2%)	13 (19.4%)	25 (37.3%)	67 (100%)

Table 4. Statistical analysis of effects of robot interventions on activities using ICF classification (Wilcoxon signed-rank sum test).

		Group A	Group B	
		AIS	Palro	Sota
Communication	Conversation	< 0.05		< 0.01
	Total	< 0.05		< 0.01
Self care	Total	0.08	< 0.01	< 0.01
Social and civic life	Recreation and leisure		< 0.05	< 0.01
	Total		< 0.05	< 0.01

4.2. Strengths and limitations

As with all intervention studies involving human subjects, particularly older people, ethical considerations are of paramount importance. As there was the additional dimension of introducing robots into five care homes, considerable care was taken in designing and carrying

https://doi.org/10.1080/01691864.2018.1528176

out this study. The research team was conscious of any bias that could interfere with the study, and made every effort to eliminate the scope for bias as much as possible.[20] Use of the standardised observation sheet and a simple but elaborate evaluation method helped a great deal. Our results suggest that the evaluation criteria can be standardised and embedded in daily care programmes, utilising goal-setting priority items identified in the ICF framework.

In terms of eliminating bias, the team leader (KO) and consultant geriatrician (SM) discussed the data throughout the study period, and agreed on the aggregate scores. With these carefully designed methodological, assessment and evaluation processes, and statistical analyses, the study was rigorously conducted to investigate the impacts of robot interventions.

However, as this study was not carried out as a randomised clinical trial using a double-blind method, there is still scope for bias and interpretations. Furthermore, the sample size is relatively small, while the scale of this project (data collection involving SARs), embedded as part of daily nursing care provided in each facility, was tremendously large, and testing for the capacity of the team.

The limitations of this study are therefore linked to the challenging environment in which nursing care is provided and how this type of research could be implemented on a larger scale, with qualitative data. The replicability of this study may be limited in a different cultural sphere

https://doi.org/10.1080/01691864.2018.1528176

where SARs are less familiar and accepted, although recent studies highlight socio-cultural factors can be mitigated by others such as perceived ease of use, adaptability, social influence and social presence.[21-24] There is also heterogeneity in the three types of SARs used in this study. Nevertheless, the functions of proactively speaking and sending alerts to older persons were shared across all three, and they all prompted and encouraged many of the participants to engage in their targeted activities. The development of these SARs is still ongoing, and the conversation engine of the communication robots in particular needs further improvement. Specifically, in order to fulfil interactive components between a human being and the robot, more sophisticated speech analysis ability and accuracy of understanding language are desired. In terms of AI-supported cloud robotics, there are a number of issues to be resolved in the fields of face recognition, verification, and security.

5. Conclusion

There is no question that the demands for high-quality care for older people and reforms for more integrated care will increase in the near future. The effects of SARs on older people's care, and their quality of life can and should be measured both quantitatively and qualitatively, before these types of technologies become widely available in various settings, including private homes.

Disclosure statement

There is no potential conflict of interest.

Funding

This study was in part financially supported by the AMED and the Universal Accessibility Evaluation Organization (a general incorporated association), Japan.

Supplementary Data

Supplementary data related to this article can be found online.

Acknowledgements

The authors wish to thank all the participants, and staff members at the six facilities who provided help with the collation of data.

ORCID

Kazuko Obayashi http://orcid.org/0000-0003-4309-2235
Naonori Kodate http://orcid.org/0000-0002-6480-7327
Shigeru Masuyama http://orcid.org/0000-0002-9922-6258

References

[1] Hennessy CH, Walker A. Promoting multi-disciplinary and inter-disciplinary aging research in the United Kingdom. Ageing Soc 2011; 31(1): 52– 69.
[2] Walker A (ed.). The New Science of Ageing. Bristol: Policy Press, 2014.
[3] Jøranson N, Pedersen I, Rokstad AM, et al. Effects on symptoms of agitation and depression in persons with dementia participating in robot-assisted activity: A cluster-randomized controlled trial. J Am Med Dir Assoc 2015; 16:867-873.
[4] Robinson H, Macdonald B, Kerse N, Broadbent E. The psychosocial effects of a companion robot: a randomized controlled trial. J Am Med Dir Assoc. 2013; 14(9): 661– 667.
[5] Moyle W, Jones CJ, Murfield JE, et al. Use of a robotic seal as a therapeutic tool to improve dementia symptoms: A cluster-randomized controlled trial. J Am Med Dir Assoc 2017; 18:

766-773.
[6] Liang A, Piroth I, robinson H. A pilot randomized trial of a companion robot for people with dementia living in the community. J Am Med Dir Assoc 2017; 18: 871-878.
[7] Pearce AJ, Adair B, Miller K, et al. Robotics to enable older adults to remain living at home. J Aging Res. 2012; 2012: 538169.
[8] Braun SM, Kleynen M, Bleijlevens MH, et al. "Interactive surfaces" technology as a potential tool to stimulate physical activity in psychogeriatric nursing home residents. Disabil Rehabil Assist Technol. 2014; 10(6); 486-492.
[9] Bemelmans R, Gelderblom GL, Jonker P, De Witte L. Social assistive robots in elderly care: a systematic review into effects and effectiveness. J. Am. Med. Dir. Assoc. 2012; 13(2): 114-120. e111.
[10] Kharksar SMS, Kjps;a R, Chu MT, Shahmehr FS. Service innovation using social robot to reduce social vulnerability among older people in residential care facilities. Technol. Forecast. Soc. Chang. 2016; 113: 438-453.
[11] Ś witek B. Representing the alternative: demographic change, migrant eldercare workers, and national imagination in Japan. Contemp Japan. 2014; 26(2): 263-280.
[12] Kodate N, Timonen V. Bringing the family in through the back door: the stealthy expansion of family care in Asian and European long-term care policy. J Cross Cult Gerontol 2017;32(3): 291-301.
[13] Japanese Ministry of Health, Labour and Welfare. White Paper on Long-term Care Personnel and Labour. 2016. MHLW. Tokyo, Japan.
[14] Castaneda L, Bergmann A, Bahia L. (2014) The International Classification of Functioning, Disability and Health: a systematic review of observational studies. Rev Bras Epidemiol. 2014;17(2):437-51.
[15] Towards a Common Language for Functioning, Disability and Health ICF, WHO/EIP/GPE/CAS/01.3.
http://www.who.int/classifications/icf/training/icfbeginnersguide.pdf
[16] Matsumoto Y, Nishida Y, Motomura Y, Okawa Y. A concept of needs-oriented design and evaluation of assistive robots based on ICF IEEE Int Conf Rehabil Robot. 2011;2011:5975437. doi: 10.1109/ICORR.2011.5975437.
[17] Tanaka H, Yoshikawa M, Oyama E, Wakita Y, Matsumoto Y. Development of Assistive Robots Using International Classification of Functioning, Disability, and Health: Concept, Applications, and Issues. J. Robotics. 2013; 2013. http://dx.doi.org/10.1155/2013/608191
[18] Kanoh M, Oida Y, Nomura Y, Araki A, Konagaya Y, et al. Examination of practicability of

communication robot-assisted activity program for elderly people. J Robotics Mechatronics. 2011; 23(1): 3-12.

[19] Broekens J, Heerink M, Rosendal H. Assistive social robots in elderly care: a review. Gerontechnology. 2009; 8(2): 94– 103 doi: http://dx.doi.org/10.4017/gt.2009.08.02.002.00

[20] Schulz KF, Altman DG, "CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials". Br Med J. 2010; 340: c332.

[21] Heerink M, Kröse B, Evers V, Wielinga B. Influence of social presence on acceptance of an assistive social robot and screen agent by elderly users. Advanced Robotics. 2009; 23: 1909-1923.

[22] Flandorfer P. Population ageing and socially assistive robots for elderly persons: the importance of sociodemographic factors for user acceptance. Int J Population Res. 2012; 1-13.

[23] Torta E, Werner F, Johnson DO et al. Evaluation of a small socially-assistive humanoid robot in intelligent homes for the care of the elderly. J Intell Robot Syst. 2014; 76: 57-71.

[24] Di Nuovo A, Broz F, Wang N et al. The multi-modal interface of Robot-Era multi-robot services tailored for the elderly. Intel Serv Robotics. 2018; 11:109-126.