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**To cite this Article:** Turja, T. ; Rantanen, T. & Oksanen, A. (2017) Robot use self-efficacy in healthcare work (RUSH): development and validation of a new measure. AI & SOCIETY.

URL: <https://link.springer.com/article/10.1007/s00146-017-0751-2>

DOI: 10.1007/s00146-017-0751-2

This is a postprint version of the article:

Turja, T., Rantanen, T. & Oksanen, A. (2017) Robot use self-efficacy in healthcare work (RUSH): Development and validation of a new measure. *AI & Society* DOI: 10.1007/s00146-017-0751-2.

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**Robot use self-efficacy in healthcare work (RUSH):  
Development and validation of a new measure**

**Abstract**

The aim of this study was to develop and validate a measure of robot use self-efficacy in healthcare work (RUSH) based on social cognitive theory and the theory of planned behavior. This article provides a briefing on technology-specific self-efficacy and discusses the development, validation and implementation of an instrument that measures care workers' self-efficacy in working with robots. The validity evaluation of the Finnish-language measure was based on representative survey samples gathered in 2016. The respondents included practical and registered nurses, homecare workers, and physiotherapists. A majority of the respondents were female. The full instrument consists of a set of six task-specific self-efficacy items concerning general views of technological skills, confidence in learning robot use, and confidence in guiding others in robot use. Three items were chosen for the shorter version of the measure. The face validity, construct validity, and reliability were established to validate the instruments. Both 3-item and 6-item measures were found to be highly consistent in structure. Respondents with high levels of RUSH also reported more general self-efficacy and interest in technology, on average. A very brief instrument of three items is convenient to include in repeated employee surveys.

**Keywords:** care work; nurse; service robot; task-specific self-efficacy; technology

**1 Introduction**

An aging population and increasing care needs have established major societal challenges in Western societies (e.g., Kang 2012). At the same time, elderly care work does not appeal to young generations (Koskinen et al. 2014), and the current nursing staff is concerned about the quality and resources of care. This is shown by the healthcare workers' reports about their overly heavy workloads and administrative tasks that take away from the actual care work and interaction with patients (Ball et al. 2014; Erkkilä et al. 2016; Menon 2015).

Service robotics is seen as one solution to these challenges that can modernize and rationalize care work. When integrated into healthcare, robots could assist in burdensome, dangerous, or routine-like tasks and even reorganize care

work as a whole (Decker 2008; Dotson 2014). However, the robotization discussions today are not dominated by the opinions of individuals but by broader ethical (Sharkey & Sharkey 2012) and juridical (Beck 2016) questions. Precisely from the ethical and juridical point of view, telecare technology is considered a safe precursor to more independently operating care robots.

Robots range from fully tele-operated devices to intelligent systems of high degree autonomy. The level of autonomy is reached by the robot's ability to accommodate variations in its environment without constant external control (Bekey 2005, 1). Mobile telepresence robot (e.g. "Double") is completely remote-controlled and used as an alternative to an ordinary video call between nursing staff and homecare patients (Koceski & Koceska 2016), or as a form of conducting doctor rounds in a hospital (Marini et al. 2015). In Finland's capital city Helsinki, one in ten clients in home care already receive virtual care (Laanala 2017).

Patient-lifting robots can be semi-autonomous through, for example, machine vision (e.g., "Riba Bear") and force recognition, meaning that the robot can perform tasks automatically but still under human supervision (Mukai et al. 2010). In a similar vein, when robotic wheelchairs (e.g., "Vulcan") are equipped with an area-detecting intelligence they can be perceived as semi-autonomous. They are ultimately controlled by a human sitting in the wheelchair, but at the same time they are self-reliant in their intelligent navigation. Social, humanoid robots (e.g., Pepper) are being developed as assistants to people. They have been used tele-operated for physical and cognitive activation of residents in elderly care (Johnson et al. 2016; Melkas et al. 2016). One exception to robots and automatons with a very limited range of features is a multifunctional, communicating, serving, and autonomously navigating robot assistant called Care-O-bot (Fraunhofer 2017).

Today, especially in elderly care, service robots are used as monitoring and communicative devices (Sharkey & Sharkey 2012), yet they are gradually evolving from tele-operated equipment into more self-reliant and intelligent systems (Goeldner et al. 2015). Artificial intelligence is predicted to create a new generation of assistive tools (Henry et al. 2015), since hospitals have both assistive equipment and information systems that can afford to be more autonomous and easy to use. Successful capitalization of service robotics, however, involves skilled and motivated employees who are willing to use equipment with advanced automatism or artificial intelligence.

Robot acceptance has been approached here by drawing from the theory of planned behavior (TPB), which combines individual attitudes, social norms, and perceived behavioral control (Ajzen 2002; Heerink 2011; Malhotra & Galletta 1999). According to empirical studies, positive attitudes toward robots are correlated with personal experiences with robots or technology in general (Heerink 2011; Katz & Halpern 2014; Nomura & al. 2006). Also, social norms influence technology acceptance (Malhotra & Galletta 1999) and resistance to technological change (Chen 2016).

Perceived behavioral control—the most substantial aspect of this study—is paralleled here with the concept of self-efficacy, which has been found to moderate acceptance of technological innovations (Maillet et al. 2015; Malhotra & Galletta 1999; Moore & Benbasat 1991).

General self-efficacy, based on social cognitive theory, denotes individuals' universal beliefs in their ability to cope with challenging situations (Bandura 1977; 1986), whereas specific self-efficacy measures confidence in particular tasks or contexts. Technology-specific self-efficacy indicates individuals' confidence in mastering a form of technology (Ajzen 2002). Supporting the idea of self-efficacy as a component of cognitive motivation (Bandura 1986), technology-specific self-efficacy is correlated with the level of interest in technology (Niederhauser & Perkmen 2008). In other words, where there is motivation to use robots there is also more likely confidence to master this form of technology. Employees, then, who are self-efficient adopt novel environments easily during organizational changes (Chen et al. 2001).

Psychological variables such as extraversion (Judge & Ilies 2002) and change fatigue (Bernerth & al. 2011) correspond with work-related self-efficacy. Furthermore, general self-efficacy has a correlation with healthcare technology self-efficacy (Rahman et al. 2016). Although information technology self-efficacy instruments have been employed before (Compeau & Higgins 1991; Moore & Benbasat 1991), specific measures for service robot usage have not been developed.

There is a need for a very short, potentially repeatable questionnaire (Schroeders et al. 2016) concerning the staff's perceived self-efficacy when implementing robots and artificial intelligence to healthcare organizations. Repeated measures are highly recommendable in health organizations where new technology is gradually being implemented. It is crucial to acknowledge the staff's point of view in technological change (Koistinen & Lilja 1988) and especially to identify any perceived deficiencies or shortcomings regarding technology use (Ajzen 2002).

The aim of this study was to develop a measure of robot use self-efficacy in healthcare work (RUSH) and evaluate the validity of its three- and six-item Finnish-language versions. Studying RUSH is important for understanding how to improve technology adaptation in health care work. We hypothesized that RUSH's convergent validity would be confirmed by at least mild associations ( $r_s > .21$ ) with general self-efficacy, extraversion, change fatigue, interest in technology, and use of technological assistive devices at work.

## **2 Data and methods**

### *2.1 Samples*

This study is based on three samples collected in 2016. Sample 1 was gathered from Finnish homecare workers aged 19–65 ( $M = 43.2$ ,  $SD = 11.8$ ; 93.5% female) in five municipalities throughout Finland. In two municipalities ( $n = 114$ ; response rate 58%), data were collected in paper form during a staff development event. An electronic questionnaire was used in the other municipalities ( $n = 86$ ; response rate 9%). The share of practical nurses in the data was 59.5 percent, and the share of registered nurses was 22.5 percent.

Sample 2 included members of the Finnish Union of Practical Nurses ( $n = 2,218$ ) aged 17–68 ( $M = 45.5$ ,  $SD = 12.1$ ; 89.8% female). Through cooperation with the trade union, we used its register database to form a population of members currently working in elderly services. Every second member of the population (age  $M = 43.0$ ; 94% female) was randomly selected for the sample and sent a link to the online questionnaire. The response rate was 11 percent.

Sample 3 included nurse ( $n = 1,701$ ) and physiotherapist ( $n = 81$ ) members of the Union of Health and Social Care Professionals in Finland aged 19–70 ( $M = 47.5$ ,  $SD = 10.4$ ; 89.0% female). From among the population of nurses and physiotherapists (age  $M = 43.7$ ; 94% female), an invitation to an online questionnaire was sent to every nurse and physiotherapist who was currently working in elderly services, and to every third randomly selected member working at a health center or hospital. The response rate was 9 percent.

## 2.2 Questionnaires

The first questionnaire for sample 1 contained a total of 83 questions, and the 49 statements regarding robots were all Likert-type scale items. The questions were related to the respondents' background, home care work in general, attitudes toward robots and care robots and views on the introduction and use of care robots in home care.

An identical questionnaire for samples 2 and 3 included multiple-choice questions about the respondents' background, personality, experiences with low-technology and high-technology tools in healthcare, and views on robots. The definition of robots used to prime the questions was as follows: "A robot is defined as a machine which can assist humans in everyday tasks without constant guidance or instruction, e.g. as a kind of co-worker helping on the factory floor or as a robot cleaner, or in activities which may be dangerous for humans, like search and rescue in disasters. Robots can come in many shapes or sizes and some may be of human appearance. Traditional kitchen appliances, such as a blender or a coffee maker, are not considered as robots" (Special Eurobarometer 382 2012).

The study complies with the regulations of the Finnish Advisory Board of Research Integrity (2009) and more broadly with the Declaration of Helsinki. All of the participants were informed about the aims of the study and had the right to decline participation. The data handling was designed to ensure the participants' complete anonymity.

### 2.3 RUSH measure

Robot use self-efficacy in healthcare work (RUSH) refers to care workers' beliefs in their ability to use robots. RUSH-6 is a technology-specific self-efficacy indicator that includes six statements on general views of technological skills (item 1), confidence in learning how to use robots (items 2, 3, and 4), and confidence in guiding others in robot use (items 5 and 6):

1. Generally speaking, I consider myself technologically competent.
2. I'm confident in my ability to learn how to use care robots if they were to become part of my unit.
3. I believe that it would be easy for me to learn how to use the care robots that may be used in home care in the future.
4. I'm confident in my ability to learn simple programming of care robots if I were provided the necessary training.
5. I'm confident in my ability to learn how to use care robots in order to guide others to do the same.
6. I believe that teaching elderly people how to use care robots would not be difficult for me.

The RUSH items are framed in the motivational "Would you be able to" format (Rhodes & Courneya 2004), and they have been professionally translated into English for this article. The responses were given on a scale from 1 = *totally disagree* to 5 = *totally agree*. Three items (2, 4, and 5) were later selected for the short version of the indicator, namely RUSH-3.

### 2.4 Corresponding measures

General self-efficacy was measured using the short-form questionnaire GSE-6 (Romppel et al. 2013):

1. If someone opposes me, I can find means and ways to get what I want.
2. It is easy for me to stick to my aims and accomplish my goals.
3. I am confident that I could deal efficiently with unexpected events.
4. Thanks to my resourcefulness, I know how to handle unforeseen situations.
5. I can remain calm when facing difficulties because I can rely on my coping abilities.
6. No matter what comes my way, I'm usually able to handle it.

The Finnish translations were retrieved from the full GSE questionnaire (Härköpää 1995; Schwarzer & Jerusalem 1995). The six statements with four-point-scale responses resulted in Cronbach's alphas between .75 (Sample 3) and .78 (Sample 2), which are close to the original validation measurements (2013:  $\alpha = .79-.88$ ).

Extraversion was measured with a double-item variable validated by Gosling et al. (2003). The variable includes a direct question on extraversion ("I see myself as extraverted, enthusiastic") and introversion ("I see myself as reserved, quiet"). The two questions with five-point-scale responses resulted in alphas between .69 and .74, which are close to the original measurement (2003:  $\alpha = .68$ ).

Change fatigue was measured with a question on whether the respondent felt change initiatives are too frequent regarding information technology or other work methods (McMillan & Perron 2013; Reineck 2007). Responses were given on a scale from 1 (*Not at all true*) to 4 (*Exactly true*) ( $M = 2.6$ ,  $SD = .89$ ).

The extent of technological assistive device use was measured as a sum of 16 different automatons and devices the participant had used in care work. The composite variable formed a 0–16 scale (Sample 2:  $M = 3.56$ ,  $SD = 1.99$ ; Sample 3:  $M = 3.36$ ,  $SD = 2.36$ ).

Technological interest level was measured with a validated question modified from Special Eurobarometer 382 (2012): “Are you *very interested* (3), *moderately interested* (2), or *not at all interested* (1) in technology and its developments?” (Sample 2:  $M = 2.03$ ,  $SD = .48$ ; Sample 3:  $M = 2.11$ ,  $SD = .50$ ).

## 2.5 Data analysis

The RUSH-6 data were first examined using principal axis factoring. This is a method within exploratory factor analysis in which variables are loaded into different, non-correlating factors. The method can also be used in situations in which the assumption of normality is not fulfilled; therefore, it is usable for Likert scales.

Internal consistency was estimated with Cronbach’s alpha ( $\alpha$ ) to ensure that all items were reliably measuring the same concept of RUSH. When developing RUSH-3, it was essential to focus on the structure of the measure instead of a naïve strategy of deleting items based on the highest “alpha” alone (Schroeders et al. 2016). Finally, convergent construct validity was examined by Spearman’s rho ( $r_s$ ), classifying correlations from .21 to .40 as mild (Deyo et al. 1991).

## 3 Results

### 3.1 Reliability

For an instrument to be reliable, the items should all measure the same concept. The instrument should also give consistent results independent from the sample drawn from the same population. Factor analysis revealed all six questions of RUSH loading into one scale. This indicated that there was a unified frame for RUSH. The internal consistency for the responses to RUSH-6 proved to be excellent ( $\alpha = .901$ ; see Table 1). The confidence in learning robot use construct (3 items) had an internal consistency of  $\alpha = .875$ . The confidence in guiding others in robot use construct (2 items) had an internal consistency of  $\alpha = .778$ .

Three questions were selected for RUSH-3 to be used in broad surveys in November 2016. From the confidence in learning robot use construct, we selected item 2 for non-specific learning (loading .802) and item 4 for programming-specific learning (loading .835). Item 3 (loading .848) was excluded because of its contextual specificity

on home care. From the construction of confidence in guiding others in robot use, we selected item 5 (loading .879) over item 6 (loading .691). RUSH-3's internal consistency remained high (Sample 1:  $\alpha = .873$ ; Sample 2:  $\alpha = .862$ ; Sample 3:  $\alpha = .837$ ), implying the reliability of the three-item questionnaire.

### 3.2 Validity

By the validity of the RUSH instrument we refer to its ability to cover the concept of robot-use self-efficacy. In the development phase, the content of the measure was certified by basing the questionnaire statements on previous research on technology-specific self-efficacy. In addition, an important starting point for the research was the careful study of home care facilities in one Finnish municipality. Before preparing the questionnaire, eight focus group interviews were held in home care facilities. The aim of this round of employee interviews (eight groups and 40 interviewees) was to conceptualize the work in home care, particularly the ways in which time is spent. The developed questionnaire, including RUSH-6, was psychometrically pre-tested among nursing students ( $n = 15$ ) to establish its face validity. Only some minor changes related to the layout and wording were made after the pre-testing.

The construct validity was further analyzed using correlative analysis among RUSH-3, general self-efficacy, extraversion, change fatigue, interest in technology, and use of technological assistive devices at work. The RUSH items corresponded with other measured concepts in the anticipated direction. The correlations varied from .12 to .33 (Table 2).

## 4 Conclusions

The aim of this study was to develop and validate a measure for robot-use self-efficacy. We evaluated the reliability of the six- and three-item measures for RUSH, and both emerged as consistent instruments. The convergent construct validity was confirmed through acceptable correlations with general self-efficacy and interest in technology.

Technological interest had the strongest association with RUSH, mirroring prior findings (Niederhauser & Perkmen 2008). Yet, change fatigue—another motivational factor—did not quite reach an acceptable correlation. RUSH was moderately correlated with general self-efficacy, as in prior studies on general and healthcare technology self-efficacy (Rahman et al. 2016). This implies that while the two constructs have a positive relationship, they are two separate constructions.

The RUSH questionnaire works as a theoretical tool to measure perceived self-efficacy in a time where robots are only just arriving to healthcare. The measure has a general and broad approach to robot use self-efficacy. As a



limitation, there is uncertainty regarding the future robot use and the skills actually required from care workers. For example, is there a need for nurses to know how the robot works in a programming level or not?

The high level of RUSH is notable in our data. Care workers are confident in their ability to learn how to use care robots – even at a programming level. High-level RUSH supports the importance of including staff in the technology-selection processes early on. The staff's high confidence in their own skills of using robots is a constructive starting point for the process of acquiring new technologies. The history of technological implementations within workplaces shows that a successful use of technology requires consensual adaptation (Koistinen and Lilja 1988; Ornston 2012). Further studies will analyze the associations between robot-related self-efficacy and robot acceptance. Also, studies should perhaps profile care workers with the most self-efficacy and motivation to use robots to indicate the potential change agents among healthcare staff.

The confidence among care workers regarding robot use in their work might reflect Finland being one of the most technologically oriented countries globally. For example, Finland is among the few countries in the world to use electronic prescriptions nationwide (Lämsä et al. 2017). Even nursing education in Finland emphasizes eHealth knowledge, skills, and competence (Ahonen et al. 2016). Arguably, this kind of technological orientation creates an environment where novel devices or systems do not cause stress but are rather perceived as things that can be managed and mastered over time (Bandura 1977).

The RUSH measure provides opportunities to investigate differences between countries and occupational groups. Although this study focused on Finland, the results have broader implications, and upcoming studies should continue this analysis of RUSH. In Finland, the reason for collaborating with trade unions was because a high majority (90%) of nurses are unionized (Kilpeläinen 2010). This and the random sampling conducted (Scholz et al. 2002) support the representative nature of the data. Comparing the age and gender structure to the population statistics indicates that male and older respondents were slightly overrepresented in the data. These differences were minor and do not compromise the generalizability of the findings.

RUSH can be recommended as a tool to measure the self-efficacy of staff members when implementing different kind of robots in healthcare. We encourage researchers to use and validate this instrument in other cultural settings as well, since the questionnaire statements themselves do not require a certain technological skill level, for example. Using RUSH in other languages should pose no problems either because questionnaires drawing on TPB have been successfully validated before (Ohlyanski et al. 2007).

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Table 1. Items of the RUSH measure (scale 1–5), means and standard deviations per question, per sample, and Cronbach's alpha if the item is deleted from Sample 1.

<b>Robot use self-efficacy in healthcare work</b>			<b>Sample 1 (n = 200)</b>			<b>Sample 2 (n = 1,889)</b>		<b>Sample 3 (n = 1,554)</b>	
<i>Item no.</i>	<i>Finnish version (validated)</i>	<i>English translation</i>	<i>M</i>	<i>SD</i>	<i>α if item deleted</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
1	Yleisesti ottaen pidän teknologiavalmiuksiani hyvänä.	Generally speaking, I consider myself technologically competent.	3.29	1.13	.904				
2	Luotan siihen, että oppisin hoivarobottien käytön, mikäli asia tulisi yksikössämme ajankohtaiseksi.	I'm confident in my ability to learn how to use care robots, if they were to become part of my unit.	4.03	1.01	.881	4.20	0.89	4.35	0.78
3	Uskon, että kotihoidossa mahdollisesti tulevaisuudessa käytettävien hoivarobottien käytön opettelu olisi minulle helppoa.	I believe that it would be easy for me to learn how to use the care robots that may be used in home care in the future.	3.57	1.11	.874				
4	Luotan siihen, että oppisin hoivarobottien yksinkertaista ohjelmointia, mikäli saisin siihen koulutusta.	I'm confident in my ability to learn simple programming of care robots if I were provided the necessary training.	3.83	1.12	.876	4.10	0.95	4.22	0.86
5	Uskon pystyväni tarvittaessa helposti opettelemaan hoivarobottien käytön siten, että pystyn opastamaan myös muita.	I'm confident in my ability to learn how to use care robots in order to guide others to do the same.	3.49	1.20	.868	4.05	0.93	4.24	0.80
6	Uskon, että hoivarobottien käytön opettaminen ikääntyneille ei tuottaisi minulle vaikeuksia	I believe that teaching elderly people how to use care robots would not be difficult for me.	3.04	1.19	.896				

Table 2. Correlations (all  $p < .001$ ) and effect sizes between Robot use self-efficacy in healthcare work (RUSH) and general self-efficacy, extraversion, change fatigue, technological assistive tool use, and technological interest.

<b>RUSH-3</b>	<b>Sample 2 (n = 1,889)</b>		<b>Sample 3 (n = 1,554)</b>	
	<i>r<sub>S</sub></i>	<i>Z<sub>r</sub></i> (95% CI)	<i>r<sub>S</sub></i>	<i>Z<sub>r</sub></i> (95% CI)
General self-efficacy	.239	.244 (.19–.29)	.261	.267 (.21–.32)
Extraversion	.169	.171 (.13–.22)	.130	.131 (.08–.18)
Change fatigue	.196	.199 (.15–.25)	.186	.188 (.14–.24)
Technological assistive tool use	.136	.137 (.09–.18)	.118	.119 (.07–.17)
Technological interest level	.295	.304 (.26–.35)	.329	.342 (.29–.39)