Comparison of Nursing Personnel's User Experiences of Four Types of Assistive Robots: Challenges Include Knowledge and Safety Issues

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***Abstract*— The interest to employ service robots in the care context is increasing due to the aging population. Many studies have examined robot acceptance from various angles, but reports of actual robot usage and the user experiences of professional personnel are scarce. Via an online user experience questionnaire, this study targeted nursing personnel who have used assistive robots in their work. Ten statements, modified after the Almere questionnaire, concerned the respondents' acceptance of robots which they had used. Four different types of robots (robotic therapy animal; rehabilitation/recreational robot; telepresence robot; and patient lifting robot) were each covered separately. Most of the reported robot usage was with the seal robot Paro, and regular use of any robot was rare. The intentions to use and the attitudes towards each type of robot were generally positive. The patient lifting robots were most positively received regarding their usefulness, whereas the interaction with the robotic therapy animals was rated pleasant. Fewer respondents had used the rehabilitation/recreational robots and telepresence robots, which received lower scores than the others regarding many of the studied user experience aspects. In general, more knowledge is needed to make good use of the robots. Furthermore, it seems there are some concerns of the safety of using them. These results show that the initial steps towards employing robots in care work have been taken. There is a lot of underexplored ground between the simple-to-use therapy animal robots and functional patient lifting robots, and the potential and acceptance of those robots is yet to be seen. These results give a baseline for monitoring the service robot acceptance of nursing personnel based on actual robot usage.**

Keywords-human-robot interaction; service robots; acceptance; user experience; nursing.

I. INTRODUCTION

Robots have been suggested as a partial solution to tackle the challenge of aging population and the increased need for care services. For instance, it has been estimated that there will be a shortage of 380 000 caregivers by 2025 in Japan [1], and in Finland, the demand for care labor will increase by more than 100 000 persons by 2030 [2]. Robots could relieve the physical burden of care tasks (e.g., lifting and transfer of patients), increase the efficiency of care work (e.g., by improving rehabilitation of persons, or taking secondary care tasks, such as fetch and delivery tasks, from care workers) and increase the quality of life of the elderly themselves (e.g., by increasing their mobility or helping to keep in contact with their social networks) so that they would need less help from care workers.

The public opinion of robots has been studied consistently in Europe for several years. The Eurobarometer 2017 [3] shows that 61% of Europeans have a positive view of robots and artificial intelligence, and 30% a negative view (in Finland, the respective figures were 71% and 23%). On the other hand, the opinions are less positive for "having a robot to provide them services and companionship when infirm or elderly," and a comparison between the last two Eurobarometers (years 2014–2017) shows that exceedingly more people feel uncomfortable having robots perform these tasks [3]. Regarding gender differences, men have typically more positive attitudes towards robots than women [3][4] although the opposite has been reported for the seal robot Paro [5].

In the care context, the attitudes of elderly people towards service robots have been studied extensively (see, e.g., reviews [6][7]), and a lot of technical development is done towards assisting the elderly people at their homes (see e.g., reviews [8][9]). Although the views of the elderly and their relatives provide good input to the research and technical development of assistive technology, Saborowski & Kollak raised the importance of taking into account the care professionals' needs [10]. Specifically, they pointed out that new technology and robotics have started to change the relation between care workers and technology, and already the care workers need to have the knowledge to help people use assistive technology. Their interviews revealed that the care staff had encountered several technology-related issues, such as malfunctioning devices and lack of competence and training [10]. In rehabilitation context, barriers to adopt new technologies were similar [11]. On the other hand, in the rehabilitation context, the acceptance and use of new technologies was most strongly affected by the perceived usefulness of the technologies, while the effort to use them or social pressure were not significant factors. Current use of new technologies was affected by behavioral intention and facilitating conditions, such as institutional support [11].

The care personnel's general opinion towards robotics has been studied to some extent. Compared with the opinion of the general population, healthcare professionals had more negative attitudes towards robots [12]. However, the

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healthcare professionals would be comfortable with robots aiding in moving heavy materials, patients or other items, and in sorting and shelving [12]. In addition to those, other tasks that have been suggested for robots in the care context include laundry, food and medicine distribution, patient monitoring, help with forgetfulness and falling, motivation and activation, and companionship [13]–[15].

A literature review showed that the concerns the health professionals have regarding robots include the fear of the robot's unreliability in clinical situation, privacy of patients, unemployment, and decrease of face-to-face contact with patients [13]. In the same article, 39% of surveyed nurses thought they may need service robots at work. The reasons for needing robots was not affected by perceived high physical workload; however, aspects such as making the work lighter, increasing the meaningfulness and quality of work, and time savings affected the need for robots [13].

There are relatively few studies that have reported of the care personnel's experiences of actual robot usage at work. Focus group discussions about professional caregivers' experiences with the seal robot Paro showed that the emotional and social impact of the robot were perceived as positive, while there were difficulties in taking the full advantage of the robot due to the lack of information and availability of the robot, and the caregivers were worried about the robot's hygiene and about breaking the robot [16].

A bathtub robot was initially rejected by nursing staff due to temporal and financial investments, but it was later accepted, because it supported the staff's values on patient well-being and integrity, even though the robot did not bring significant ergonomic benefits nor save labour [17].

In the context of a mobile self-navigating greeting robot in a care-hospital, the personnel raised issues, such as the fear of making mistakes with the robot, the fear of being replaced by robots, the inability of robots to replace human care, and irritation caused by the robot's presence. On the other hand, the robot was seen as a source of support for staff and it elicited a positive atmosphere [18].

With telepresence robots, the personnel's primary concern of the elderly users' negative reactions was not realized in practice. The personnel approved that the robot enabled the residents to interact with their families remotely, and despite technical problems, the personnel believed that with adequate training and assistance, the use of the telepresence robot would be feasible in the future [19]. In two other telepresence studies, care workers experienced robot trials positively although issues, such as the privacy and integrity of the patients, and the need for common rules, were raised [20][21].

To summarize the studies related to robots in the care context, the elderly perspective is well represented in the literature, but it seems the studies on professional personnel's attitudes, needs and concerns remain on a general level and are based on expectations rather than on actual robot usage. Therefore, there is a research gap between expectations of robots and the actual usage experiences among the professionals in the healthcare sector, especially when different robots and larger user groups are considered. The aim of this paper is to compare the nursing personnel's user experiences of four different kinds of robots which they have actually used in their work (Figure 1). These results give a baseline for monitoring the acceptance of service robots by professional nurses and help us identify needs for future development, which is important if robots are to be the future co-workers of the care personnel.

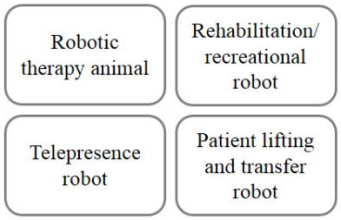

Figure 1. The four types of robots that were in the focus of this research.

The rest of this paper is organized as follows. Section II describes the methods. Section III reports the results and Section IV discusses them. Section V and the acknowledgements conclude the paper.

II. METHODS

As part of a research project concerning the use of robotics in welfare services, Finnish nursing personnel were asked to participate in an online questionnaire concerning their attitudes towards robots and their robot usage at work [12]. In addition to user experience questions, the online questionnaire included 127 general multiple-choice questions concerning demographics, occupational details, and attitudes towards technology and robotics. The online questionnaire was distributed between October and December 2016 through two major trade unions, The Union of Health and Social Care Professionals in Finland and The Finnish Union of Practical Nurses (most of the Finnish nurses are unionized [22]). The final aggregate data included the responses of 3 800 respondents who had completed at least the first page of socio-demographic information and a question concerning their interest in technology (reported elsewhere [12]). The average response time was 19 minutes. 458 respondents (12% of total) had had first-hand experience with robots, and their responses are reported in this paper.

The respondents with first-hand experience with robots (n=458) were prompted to answer a user experience (UX) questionnaire regarding each of the types of robots they had used. They were aged 19–70 (mean 46.8; standard deviation 11.46), and 95% of them were native Finnish speakers. By profession, 62% were practical nurses, 34% registered nurses, and 4% were physiotherapists, instructors, and assistants.

The UX questionnaire covered the robot usage of four different types of robots, which were introduced using generic terms and example photos as follows:

- Robotic therapy animal (image of the seal robot Paro)
- Rehabilitation/recreational robot (image of the humanoid robot Nao)
- Telepresence robot (image of Double)
- Patient lifting and transfer robot (images of RoboticBed and Riba bear).

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The respondents with first-hand usage experience with any of the types of robots listed above were prompted for more questions regarding the frequency they had used the type of robot in question (used once or twice; a few sporadic times; in regular use for less than one month; in regular use for one or two months; in regular use for several months); followed by ten items concerning their user experience (5-point Likert scale, totally disagree – totally agree), adapted from the Almere questionnaire [23]. The Almere model is an extension of the Unified Theory of Acceptance and Use of Technology (UTAUT)[24], and it was developed to test the acceptance of social robots. The Almere model uses constructs (e.g., anxiety, trust, perceived ease of use) to predict the user's intention to use a robot. In the Almere questionnaire, each of the constructs is represented by 2-5 statements evaluated using the Likert scale [23].

The questionnaire items are listed in Table 1 (translated from Finnish; order reorganized to facilitate reporting). In the UX questionnaire, the questions were answered separately for each type of robot the respondents were experienced with. Compared with the Almere questionnaire, the items #1, #6 and #10 deviate most from the original items whereas the other items are mainly about re-phrasings of the original ones to suit all four types of robots and to reflect the literal translations from the Finnish language. The Almere model has two items for Trust, but they reflect trust for the robot's advice (the studied robots do not generally give advice), and therefore item #6 was generated to measure the overall perceived reliability of the robot and its safety.

Regarding the non-social robots, item #10 measures "Perceived operating friendliness" instead of "Perceived sociability" to reflect the smoothness of interaction instead of social characteristics. Moreover, the Almere item for Perceived sociability in the context of telepresence robots could have been misinterpreted to mean the interaction between two humans communicating through the robot. The UX composite variables showed good inter-item consistency: Rehabilitation/recreational robot (α = .787), robotic therapy animal (α = .846), telepresence robot (α = .819), and patient lifting robot (α = .781).

The participants were instructed to answer the questionnaire as follows: "Please answer the following questions thinking that the same robot that you are already experienced with would be taken into use at your workplace by the personnel."

There were several reasons for adapting the set of questions from the Almere questionnaire. Firstly, the number of questions had to be limited to keep the overall answering time manageable: using the whole Almere questionnaire would have made the whole online questionnaire [12] too burdensome, and therefore only ten items were included. Secondly, to the best of our knowledge, there are no human-robot interaction questionnaires available that would suit all four kind of robots. For example, many available questionnaires are targeted at the social characteristics of robots (e.g., [27]), which would not make sense in the context of telepresence or mechanoid lifting robots. The Almere construct "Social presence" was dropped for a similar reason. Thirdly, we wanted to use constructs that are compatible with technology acceptance models (e.g., [24][26]), but would reflect at least some of the characteristics related to robots specifically (e.g., safety and interaction). The Almere constructs have also been used in a review [7] and as a part of a study focusing on telepresence robots [28].

The data were fitted into the Almere model to see if the nine questionnaire items (items #2–9 in Table 1) could predict the Intention to use (item #1 in Table 1) according to the model [23]. However, the small sample size did not produce statistically significant results among all the robot types and explanatory factors. Wanting to present results

TABLE I. UX QUESTIONNAIRE FOR THE FOUR TYPES OF ROBOTS. EXCLUDING ITEM #10, THE PHRASES WERE THE SAME FOR ALL FOUR TYPES OF ROBOTS, WITH THE [ROBOT] REPLACED BY EACH TYPE OF ROBOT. THE RESPECTIVE ITEMS AND CONSTRUCTS IN THE ALMERE QUESTIONNAIRE [23] ARE SHOWN ON THE RIGHT.

#	Questionnaire item	Respective item in Almere	Construct in Almere
1	If the [robot] was available, I would use it[a]	I'm certain to use the robot during the next few days	Intention to use
2	I think it's a good idea to use the [robot]	I think it's a good idea to use the robot	Attitude towards technology
3	I think the [robot] would be useful in my job[b]	I think the robot is useful to me	Perceived usefulness
4	I think I can use the [robot] without any help	I think I can use the robot without any help	Perceived ease of use
5	Working with the [robot] would be pleasant	I enjoy doing things with the robot	Perceived enjoyment
6	I would be worried about the safety of using the [robot] [c]	–	Trust
7	I think the [robot] can be adapted to what I need	I think the robot can be adaptive to what I need	Perceived adaptivity
8	I know enough of the [robot] to make good use of it	I know enough of the robot to make good use of it	Facilitating conditions
9	I would be afraid to make mistakes with the [robot].	If I should use the robot, I would be afraid to make mistakes with it	Anxiety
10	I find the {Robotic therapy animal; Rehabilitation/recreational robot} pleasant to interact with In my experience, controlling the {Telepresence robot; Patient lifting robot} goes smoothly[d]	I find the robot pleasant to interact with	Perceived sociability (Perceived operating friendliness)[d]

[a] "If the robot was available, I would use it." was used in [25].

[b] "I would find [.....] useful in my job" was used originally in [24][26].

[c] The item reflects the Almere definition of Trust "The belief that the system performs with personal integrity and reliability".

[d] Perceived sociability was replaced by "Perceived operating friendliness" for the non-social robots.

separately for every robot type, we therefore focus on a descriptive analysis of the UX. Additionally, the general opinion towards robots among these respondents was asked using the same phrase as in the Eurobarometer survey ("Generally speaking, do you have a 'very positive' (4); 'fairly positive' (3); 'fairly negative' (2); or 'very negative' (1) view of robots?").

III. RESULTS

The number of respondents having used robots was a) 201 (44%) for a robotic therapy animal; b) 59 (13%) for a rehabilitation/recreational robot; c) 63 (14%) for a telepresence robot; and d) 79 (17%) for a patient lifting robot; the total number of respondents reporting of first-hand robot usage was 458 (some participants chose not to answer all questions). Figure 2 shows that most respondents had used the robots only once or twice whereas regular use was much less common.

The effect of the frequency of usage on the questionnaire items was not significant. Looking at all the robot types combined, Intention to use correlated the most with Attitude ($r=.695$; $p<.001$) and Perceived enjoyment ($r=.626$; $p<.001$). Regarding opinions towards robots in general, 61% of respondents had a positive and 26% a negative opinion towards robots, and the rest were indecisive (mean = 2.73; SD .68; scale 1–4). The user experience viewed as an aggregate variable of average questionnaire items did not correlate with age or working years of the respondent. Regarding the experiences of the robotic therapy animal, women had more positive views than men ($F(1)$ 4.546; $p<.05$). The other robot types did not show gender differences. Earlier experiences of care technologies correlated positively with the questionnaire items, yet only with the users of telepresence robots ($r = .362$; $p < .01$) and the robotic therapy animal ($r = .242$; $p < .05$).

There were big differences between the UX questionnaire data for the different types of robots (see the error bars indicating the standard error of the mean in Figures 3–5). The UX questionnaire for each robot was answered only by nursing personnel with actual user experience of the robot in question. On average, the questionnaire items (Figures 4–5) were towards the positive end of the scale except for the items for the Facilitating conditions (sufficient knowledge about the robot) and Trust (worrying about the safety) for which three types of robots received lower ratings. Overall, looking at the average of all 10 questionnaire items, the

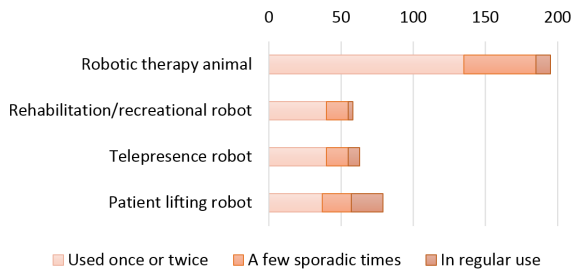

Figure 2. Number of nurses with experience of robot usage for each robot type. The legend indicates the frequency of usage.

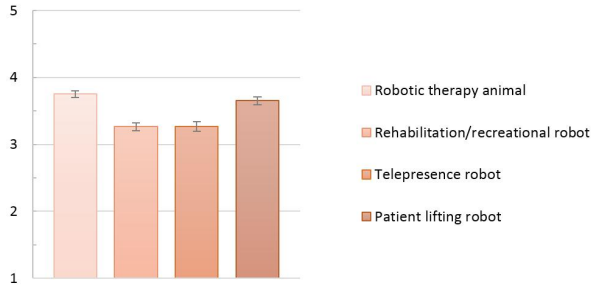

Figure 3. Average of the ten questionnaire items by robot type. Higher values indicate a more positive attitude towards robot usage (5=totally agree, 1=totally disagree).

robotic therapy animal (open field answers indicated most respondents had used the Paro seal) was most positively received, followed by the patient lifting robot (Figure 3). On the other hand, Intention to use, Attitude, and Perceived usefulness of patient lifting robots were higher than those for the robotic therapy animal (Figure 4). With the robotic therapy animal, interaction and work were rated pleasant, the robot was easy to use, and the respondents were not afraid to make mistakes with it.

The rehabilitation/recreational robot (open field answers indicated most respondents had used the Zora robot) and the telepresence robot received more cautious ratings. The respondents had less experience with these robots and they did not have enough knowledge of them. The pleasantness and smoothness of interacting and working with them was rated close to neutral, but lower than with the other two robots, and they were not considered as useful. Nevertheless, Intention to use and Attitude were positive. The responses did not identify robot brands for telepresence and patient lifting robots.

IV. DISCUSSION

The Finnish nursing personnel with actual experience of robot usage at work had a more positive attitude towards robots than the Finnish nursing personnel in general (cf. [12]). However, their attitude remains slightly more negative than the opinion of the general population in Finland (Eurobarometer data)[12]. On the other hand, the general acceptance of robots is higher in Finland than in many other European countries [3], and the Finnish nursing personnel's acceptance comes close to the recent European average. Robot acceptance at work (as opposed to the general acceptance) has been found stronger among those healthcare professionals who have used robots in their work [12], and therefore first-hand experiences with robots at work are important in molding the ground for robots in care work.

Regarding gender issues, whereas men are typically more positive towards robots than women [3][4], these results indicated higher acceptance of the robotic therapy animal among women in the care context, which is consistent with an earlier evaluation of the same robot by exhibition visitors from different countries [5].

Most of the robot usage was with a robot therapy animal, or the Paro seal. The Paro seal is easy to use, and it can help in creating a positive atmosphere toward care robots, and

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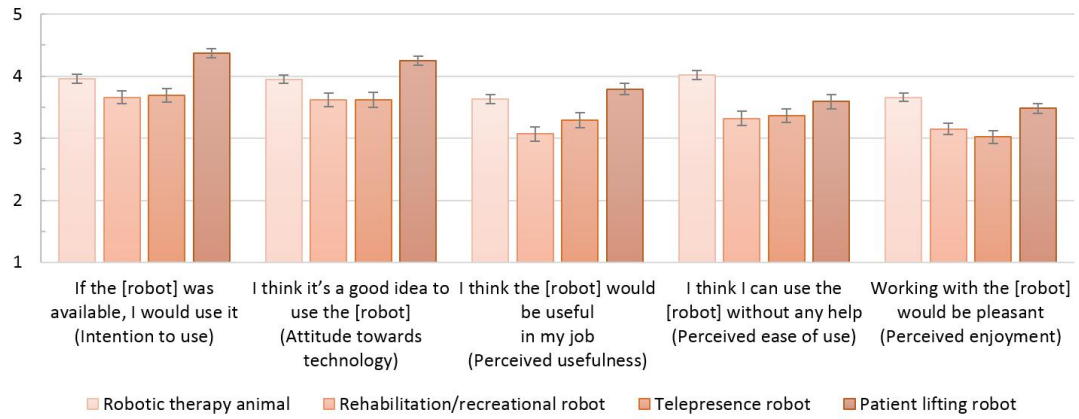

Figure 4. Mean responses to the questionnaire items #1–5. Higher values indicate a more positive attitude towards robot usage (5=totally agree, 1=totally disagree).

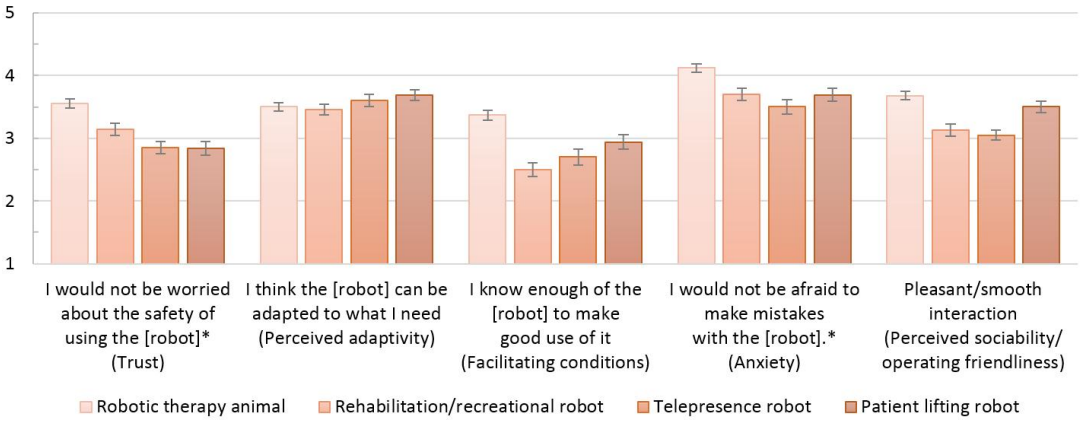

Figure 5. Mean responses to the questionnaire items #6–10. Higher values indicate a more positive attitude towards robot usage (5=totally agree, 1=totally disagree; the items marked with an asterisk * are inverted; see Table 1 for the used phrases).

therefore facilitate the adoption of other robots as well [16]. Assistive robots, however, include many more possibilities than just the social, companionship types of characteristics.

A minority of the respondents had used any robot regularly (Figure 2). Therefore, the answers may be based on projected expectations of how robots could aid the care work in the future. On the other hand, there was no significant difference between the responses of those with very little and those with regular experience of robot usage. Earlier research has shown that even meeting a robot may result in more favorable attitudes [29], although direct experiences with robots have not always affected acceptance ratings [25]. Repetitive testing for determining acceptance has been suggested [7][23], and therefore the robot UX of the nursing personnel should be monitored repetitively.

The lack of knowledge of the robots (Facilitating conditions) was clearly the aspect that needs most improvement although the evaluations for each type of robot can reflect different things. For example, using the Paro seal requires understanding of the therapeutic possibilities of the robot (see also [16]) whereas operating the Nao (or Zora) robot requires also some technical skills. Others have also raised the knowledge of how to use and adapt the technology as an important topic [10]. In this study, most of the respondents believed the robots could be adapted to their needs, but a future question is whether it is the nursing personnel or specialized persons who do the adapting, or if the robot is self-adaptive. Furthermore, the users may also have to adapt to the needs of the robots [30]. In the rehabilitation context, training needs have been identified as a barrier for using new technology, and similarly, Facilitating condition (institutional support and knowledge) has been found to be the strongest construct for current use of new technologies by rehabilitation professionals [11], and therefore the issue of knowledge should be emphasized in the future.

The nurses' low level of trust in the safety of the robots is slightly alarming, because the robots the nurses had used are presumably commercial products. On the other hand, the ratings were near the middle of the Likert scale, which can also mean that the respondents were indecisive or had mixed feelings towards the questionnaire item. Furthermore, as with the knowledge issues, safety can take different meanings with different robots, which should be examined further. For example, telepresence robots may seem wobbly and pose

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security and privacy issues [20], and patients may be harmed if an extremity is squeezed by the robot's joints.

The attitudes were most positive for the patient lifting robots. Additionally, the intention to use and perceived usefulness for the patient lifting robots were also higher than for other robots, which can reflect that their purpose of use can be easier to see than for the other robots. A weakness to the study design is that the respondents did not have to specify which kind of lifting robots they had used.

The UX questionnaire worked as a basis for a descriptive analysis of the different robot types. With especially the rehabilitation/recreational robots, however, the questionnaire leaves some ambiguity regarding the interaction with the robot (e.g., pleasantness of interaction, ease of use, fear of making mistakes). The questionnaire did not specifically state whether the interaction was only about the social interaction, or was the programming of the robot also considered a form of interaction. In a similar vein, the robot classification in questionnaire item #10 was done based on the presumption that the interaction with robots with social characteristics would be more natural and that they would not need "controlling" as the more mechanical robots do. Categories of physical or social assistance [31], or companion or service type of assistance [23] could facilitate in assigning the constructs. The question of who will be programming and controlling the robots, and adapting their behavior, is a relevant issue for the future working practices and education of nursing personnel on a larger scale.

The limitations of the study include the small number of the UX questionnaire items and the previously discussed ambiguity related to the questionnaire, the low frequency of use, and the uncertainty related to the extent to which the respondents had interacted with the robots. Moreover, the exact versions of the robots and the ways the robots had been used are not known, and therefore the results should not be considered as user experience evaluations of specific robot models or interfaces.

In addition to the four types of assistive robots considered in this study, there are also other robots that can support care work, such as exoskeletons, indoor logistics, and surgical robots. Compared to the robots' future tasks that have been conceived by care personnel [12]–[15], none of the latter kind of robots fulfil those needs, and neither do the robots included in this study meet those needs in full. Currently, there is little or no experiences of actual robot usage of robots that can perform those tasks, and it will be interesting to see how the acceptance of that kind of autonomous and possibly multitasking robots relate to the types of robots reported in this paper.

V. Conclusion and Future Work

This study provides a baseline for monitoring the acceptance of different types of service robots by professional nurses. Because service robots are still scarce in the health sector, these results are novel in that they show the comparison of four different types of robots and they are based on actual robot usage instead of expectations. The results showed that Finnish nursing personnel have a relatively positive attitude towards using robots in general and the robots they are most experienced with, but more effort is needed to improve the personnel's knowledge of robots, the understanding of the robots' potential use applications, and the trust towards the safety of using the robots.

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