Human-Robot-Collaboration in the Healthcare Environment: An Exploratory Study

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Abstract. There is an existing shortage of skilled personnel in the healthcare environment. The growing need for healthcare professionals due to the increasing number of elderly people represents a sociopolitical and economic challenge. It is expected that human-robot collaboration in healthcare will rise in the near future because it could be a great advantage to relieve healthcare professionals with technical systems. To promote the acceptance of such technical systems and digital aids, it is important to involve the health care staff from the very beginning. Therefore, the aim of this study was to examine differences in the acceptance of and the general attitude towards robots in the healthcare sector. In focus was the difference between people working in the health care environment and those who don't. An exploratory study was conducted to find out if - and if yes how - the attitude of people towards robots in the healthcare sector differ and whether the type of robot has an influence on the attitudes towards robots. The results show that participants working in the healthcare sector have a less positive attitude towards robots than those not working in the healthcare sector. Furthermore, significant differences can be shown regarding the assessments of the different robots in the different scenarios. The results of the study should help to understand how people working in the healthcare sector evaluate the potential use of different robots in healthcare.

Keywords: Human-robot collaboration · Healthcare environment · Acceptance

1 Introduction

The proportion of elderly people in the population is increasing around the world. This results in more people needing care [1]. Consequently, there is a growing need for healthcare professionals, which represents a sociopolitical and economic challenge. This challenge exists because the healthcare sector already has a long history of staffing problems, such as staff shortages and turnover rates [2]. Which in result can affect the quality and safety of care [3]. To relieve the burden on professional healthcare workers and make work processes more effective, digital and technical systems are introduced [4]. Those technical systems are not only computer systems but also robots. An interaction

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between a robot and a human being is called human-robot interaction [5]. As of now human-machine interaction in healthcare is primarily used to help patients improve or monitor their health. It is expected that human-machine interaction in healthcare will rise in the near future. In in-home and inpatient care as well as in hospitals, robotic systems are already increasingly being used as support for control, routine, and logistical activities [6]. By incorporating interacting robots, the healthcare sector can improve the quality and accessibility of healthcare services, which in turn may improve the patients' health outcomes for example due to more close monitoring [7]. In addition, the support of robots will increase the time for patients by the healthcare staff itself. This could also improve the well-being of the patients. However, despite the great need for support, human-robot interaction in the healthcare environment faces several challenges. These range from ethical aspects (e.g. awareness of the patients intimate space [8]) and design issues to safety, utility, acceptance, and appropriateness.

Another challenge occurred when in December 2019, the virus SARS-CoV-2, also known as the coronavirus, was discovered in China and developed into a worldwide pandemic [9]. According to the Robert Koch Institute [10] the course of the disease varies. There are cases that remain completely asymptomatic as well as cases where the infection can lead to severe pneumonia with lung failure and death. This disease resulted in major challenges for society as a whole and especially for the staff in the healthcare environment [11]. To protect oneself and keep the virus from spreading one of the main measures for the public is social distancing [10]. For people working in the healthcare environment applying physical distancing is – in many cases - not a valid option. In this regard, the use of robots can have benefits in terms of health and safety for patients and healthcare staff [12].

Yang et al. [13] addressed the question of whether robots could be effective tools in the fight against COVID-19. Today, robots can already be used in many areas of healthcare and serve as support. They have the potential to disinfect, distribute medicines and food, measure vital signs, and keep someone company. With the escalation of a pandemic such as the one caused by Sars-CoV-2, the potential role of robotics is becoming increasingly clear. Since coronavirus viruses can persist for days on inanimate surfaces, the cleaning of surfaces is highly relevant. To prevent the spread of diseases, so-called UV-surface disinfection robots can be used in the hospitals [14]. These are UV-light-devices that are completely robot-controlled and contact-free. They are used to clean contaminated surfaces and thus effectively reduce contamination. Evaluations show that compared to standard room disinfection, non-contact technologies reduce residual contamination more effectively. Furthermore, such systems are able to save costs, perform rapidly and reduce the risk of infection for cleaning staff who are directly exposed to viruses while cleaning, which could be prevented by using these systems [13]. A robot that is used for the disinfections of rooms and surfaces is one of the robots that does not necessarily have to have direct contact to patients when it is used. Examples for such robots are the "Laska" and "Yezhik UVD Robots" by Aitheon [15]. Another robot that is already being used and tested in the healthcare environment today the robot "Moxi" from the company Diligent Robotics [16]. "Moxi" is a one-armed robot for assistance in hospitals. Normally, it does not have direct patient contact. It is designed to assist nurses

by performing routine tasks that do not require direct interaction with the patient. For example, its tasks include fetching supplies and lab results.

A robot that can socially interact also seems to be very useful and supportive especially in times of a pandemic where people have very few social contacts because of physical distancing and isolation [17]. It is well known that quarantine and isolation have a significant impact on the mental health and the psychological well-being of people [18]. This is where social robots can be useful.

A study by Aymerich-Franch and Ferrer [11] examined the implementation of social robots in real settings during the COVID-19 pandemic. The results showed that during the crisis an expansion of social robots occurred due to their advantages of facilitating the social distance and palliating the effects of isolation. One example is the "Care-O-Bot" by the Fraunhofer Institute [19]. The "Care-O-Bot" is a mobile robot assistant that is used to actively support humans, for example, it assists them with tasks such as monitoring vital functions or reminders. In addition, the robot "Pepper" by the company Softbank Robotics is already in use [20]. Pepper can recognize people and reacts individually to its environment. It also recognizes moods and things like body posture and facial expressions, which qualifies it for contact with people [21]. Within the healthcare sector pepper is already used, to entertain elderly people needing care.

An important factor in implementing robots into the workplace is the subjective perception of the interaction between humans and robots by the users who get in contact with the robots, in this case the healthcare staff and patients themselves [22]. Since they are supposed to interact directly with the corresponding systems, the attitude, perception, and acceptance of the interacting humans is crucial for the introduction of a successful human-robot interaction. That's why it is important to involve the healthcare staff as well as potential patients from the very beginning when thinking about the implementation of a robot within a healthcare system. In this context, people's opinions and attitudes differ. For example, attitudes towards robots in the different areas of everyday life, work and care were investigated in a former studies of our research group [23, 24]. The results show that attitudes towards robots in everyday life and work are neutral to positive, whereas in the care sector they are neutral to negative. Following Wagner-Hartl et al. [24] the results in the care sector are valid for two different scenarios: To let a robot take care on oneself as well as to let a robot take care on relatives. Furthermore, the results show significant differences regarding the assessment of the need and acceptance of a robot that assists people in different care relevant tasks. For example, the help of a robot was assessed significant better for tasks like transportation or the relocation of patients than tasks like support with body care, assistance with feeding or entertainment. This is also in line with [25] who show that elderly people indicate the help of a robot for tasks like body washing or companionship as not useful.

Aim of the Study

The aim of this study was to examine differences in general attitude towards and the acceptance of robots in the healthcare sector. In the focus was the difference between people working in the healthcare environment and those who don't. An exploratory study was conducted to find out if - and if yes how - the attitude of people towards robots in the healthcare environment differ and whether the type of robot has an influence

on the acceptance of robots. Consequently, the following research questions will be investigated:

1. To what extent do the attitudes towards robots in the healthcare environment differ between persons, who work in the healthcare environment and among those who don't?
2. Does the acceptance (usefulness and satisfaction) of different types of robots used within the care sector, differ between persons, who work in the healthcare environment and among those who don't?

2 Method

2.1 Participants

Overall, 115 women and 78 men ($N = 193$) aged between 18 and 74 years ($M = 32.83$, $SD = 14.52$; 2 participants did not report their age) participated in the online study. 33 of the participants work in the healthcare environment and 160 participants work in other occupational fields. Following the results of a t-test, no significant difference regarding age can be shown for the two different working environment groups, $t(190) = 1.42$, $p = .157$ (participants that work in healthcare environment: $M = 36.09$, $SD = 14.48$; participants that do not work in healthcare environment: $M = 32.15$, $SD = 14.49$). All participants provided their informed consent at the beginning of the online study.

2.2 Study Design and Materials

An exploratory study was designed as an online survey with a within-subject design. Overall, the participants needed 10–15 min to complete the questionnaire. The first part of the questionnaire focused on sociodemographic data and possible personal linkages to the work in the healthcare sector as well as general attitudes and previous knowledge about human-robot interaction. In this context, the participants had to assess their general attitude towards robots on a 5-point rating scale [negative (−2) – rather negative (−1) – neutral (0) – rather positive (+1) – positive (+2)].

In the main part of the questionnaire, the participants assessed four different robots with four different uses (scenarios). The different robots were an assistance robot (Moxi) [16], a disinfection robot (by Aitheon) [15], a care robot (Care-O-Bot) [19] and a social robot (Pepper) [20]. The robots were embedded in a scenario, which should help the participants to understand their possible usage in the context of the healthcare environment. The scenarios contents were adapted from the specific manufacturer websites of the different robots [15, 16, 19, 20]. For each scenario the activity of the robot was described textually (see Table 1).

For a better visual imagination, two additional pictures of each type of robot were presented together with the text to the participants. The pictures used were requested from the specific companies and were used with their consent. One of each pictures showed the robots in a healthcare environment while the other picture showed the robot by itself with a neutral background.

Table 1. Description of the four different scenarios, representing the four different robots in a healthcare environment

Scenario 1: Assistance robot	"Moxi" is an assisting robot in nursing [16]. It helps hospital staff with tasks that are not performed directly on the patient. These include tasks such as delivering bed linen to the patient's room or transport laboratory samples to the laboratory where it is analyzed
Scenario 2: Disinfection robot	Aitheons disinfection robot is used to disinfect rooms [15]. It moves through the room fully automatically and irradiates each surface to be disinfected with UV light. The germs are killed by this process, which prevents the spread of bacteria, viruses, etc. via surfaces
Scenario 3: Care robot	The "Care-O-Bot" is a mobile robot which can provide support in hospitals [19]. Its tasks include monitoring patient monitors, providing information to doctors and triggering alarms in case of an emergency
Scenario 4: Social robot	"Pepper" is a robot that is used in many ways. In the hospital, "Pepper" is a contact point for social contact [20]. For the most part, he serves as a contact person for patients. He cheers them up, entertains them and fulfils their wishes

After each scenario with one of the robots the participants rated their subjectively perceived acceptance using the acceptance scale of Van der Laan et al. [26]. In the acceptance scale nine items (5-point semantic differentials; ranging from -2 to $+ 2$) represent two subscales of acceptance: Usefulness and satisfaction.

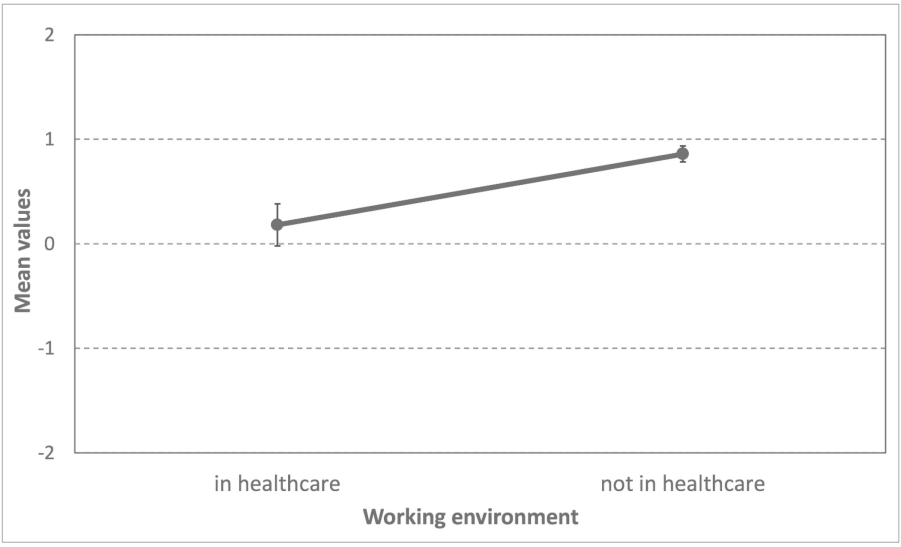
2.3 Statistical Analysis

The software IBM SPSS Statistics was used for the statistical analysis. *T*-tests and analyses of variance with repeated measures were used as statistical procedure. The evaluation was based on a significance level of 5%.

3 Results

3.1 General Attitudes Towards Robots

The results of an independent samples *t*-test show significant difference in the general attitudes towards robots between persons, who work in the healthcare environment and those who don't, $t(191) = -3.53$, $p = .001$ (see Fig. 1). Persons who don't work in healthcare ($M = .86$, $SD = .97$) have a significantly more positive general attitude towards robots than people working in healthcare ($M = .18$, $SD = 1.16$).



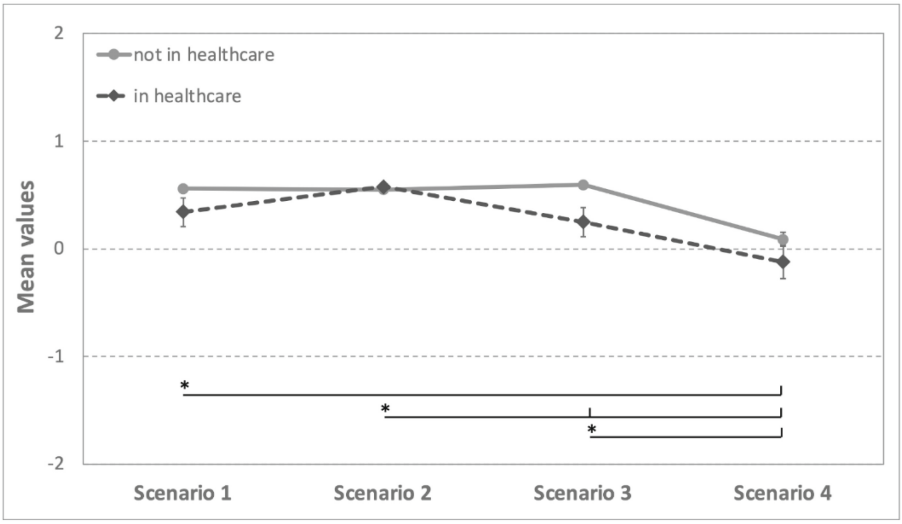
Note. 5-point scale: Negative (-2) – positive (+2); I … standard error of mean

Fig. 1. General attitudes towards robots – Differences of the two different working environment groups

3.2 Acceptance Regarding Different Robots

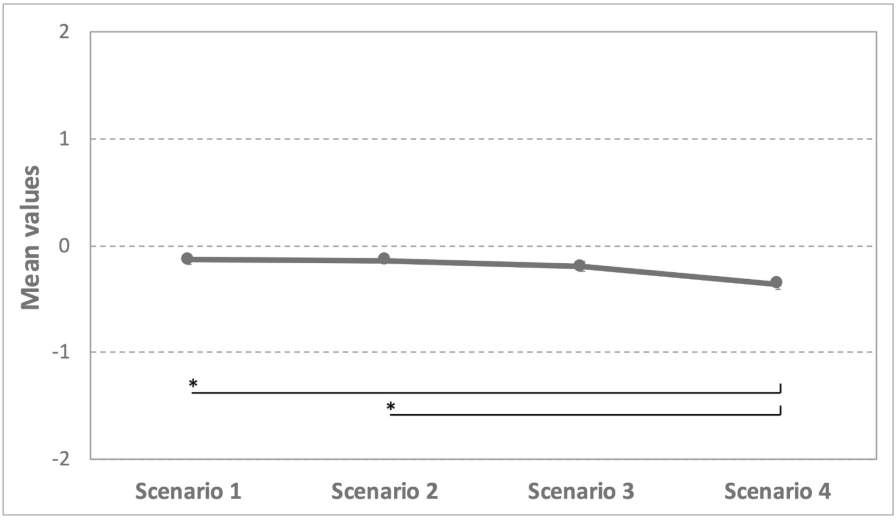
Usefulness. Following the results of an analyzes of variance with repeated measures, the different scenarios describing different types of robots (see Table 1) were assessed as significantly different regarding their usefulness, $F_{GG}(2.12, 393.41) = 22.38, p \leq .0001$, $\eta^2_{\text{part}} = .107$ (see Fig. 2). The interaction scenario x working environment group, did not reach the level of significance, $F_{GG}(2.12, 393.41) = 2.70, p = .065, \eta^2_{\text{part}} = .014$. Post-hoc analyses (Sidak) showed that Scenario 1 describing the use of the an assistance robot like the robot "Moxi" [16] ($M = .52, SD = .50; p \leq .0001$), Scenario 2 (disinfection robot [24]; $M = .56, SD = .29; p \leq .0001$) and Scenario 3 representing the usage of a care robot like the "Care-O-Bot" [19] ($M = .53, SD = .54; p \leq .0001$) were assessed as significantly more useful by the participants than Scenario 4 describing a social robot like the well-known robot "Pepper" [20] ($M = .07, SD = .82$). In addition, Scenario 2 was assessed significantly more useful than Scenario 3 ($p = .035$). Furthermore, a significant effect of the working environment group can be shown, $F(1, 186) = 5.37$, $p = .022, \eta^2_{\text{part}} = .028$. Overall, participants working in the healthcare environment assessed the different robots as significantly less useful than participants who don't work in healthcare environment.

Satisfaction. The results of an analyzes with variance with repeated measures showed significant difference regarding the perceived satisfaction of the different robots represented in the four different scenarios, $F_{HF}(2.71, 503.46) = 6.46, p \leq .0001, \eta^2_{\text{part}} = .034$ (see Fig. 3). A significant interaction scenario x working environment, $F_{HF}(2.71, 503.46) = 1.47, p = .224, \eta^2_{\text{part}} = .008$, as well as an effect of the working environment groups,



Note. 5-point scale: Negative (-2) to positive (+2); * … $p \leq .05$; I … standard error of mean

Fig. 2. Perceived usefulness of different robot scenarios.



Note. 5-point scale: Negative (-2) to positive (+2); * … $p \leq .05$; I … standard error of mean;

Fig. 3. Perceived satisfaction of different robot scenarios.

$F(1, 186) = 2.35$, $p = .127$, $\eta^2_{\text{part}} = .012$, cannot be shown. Post-hoc analyses (Sidak) showed that Scenario 1 (assistance robot [16]; $M = -.13$, $SD = .48$; $p = .031$) and Scenario 2 (disinfection robot [15]; $M = -.14$, $SD = .35$; $p = .001$) were assessed as significantly more satisfying by the participants than Scenario 4 (social robot [20]; $M = -.36$, $SD = .71$).

4 Discussion

Following the results, the first research question "(1) To what extent do the attitudes towards robots in the healthcare environment differ between persons, who work in the healthcare environment and among those who don't?" can be answered as follows: The results show significant differences regarding the general attitude towards robots between participants working in the healthcare environment and participants who do not work in this working environment. Persons who don't work in healthcare showed a significantly more positive general attitude towards robots than people working in the healthcare environment.

Furthermore, significant differences can be shown regarding the assessments of the different robots in the different scenarios. Therefore, research question 2 can be answered with: the acceptance (perceived usefulness and satisfaction) of different types of robots used within the care sector, differ between persons, who work in the healthcare environment and among those who don't. The results show that regarding the perceived usefulness of the different robots described in the four scenarios, the social robot was assessed as significantly less useful than all other robots (assisting robot, disinfection robot and a care robot). Furthermore, the disinfection robot was assessed as significantly more useful than the care robot.

In addition, regarding the perceived satisfaction of the participants the social robot was also assessed as significantly less satisfying than the disinfection robot and the assistance robot described within the different scenarios.

Differences due to the two working environment groups can only be shown for the perceived usefulness but not for the perceived satisfaction of the different robots. Therefore, participants who did not work in the healthcare environment assessed the different robots presented in the four different scenarios significantly more useful than participants who work in the healthcare environment.

Following the results, health care professionals seem to be more critical when thinking about working together with robots within their working environment than people not working in this specific working field. One limitation of the study must be considered: Due to the online questionnaire the participants did not really "work" with the robots presented within the different scenarios but only got to imagine how it would be if the robot would support them within the different tasks. From our point of view, it would be important to expand the research. Health care professionals as well as patients and potential future patients should have the possibility to experience to work and actually interact with a robot within the healthcare environment. This would have the benefit of measuring their feeling within this framework.

To sum it up, the results of the study should help to understand how people working in the healthcare sector relate to different robots in healthcare environments. The results emphasize the importance of including this particular group in future research, as the introduction of robots would change their personal workspace. Only if the people who will work with the robots are also convinced that the interaction can support them in their daily work, a good cooperation will succeed.

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Author's Statement. The authors state no conflict of interest. Informed consent has been provided from all participants of the study. The study was approved by the ethics committee of the Furtwangen University.

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