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Study protocol: a survey exploring patients' and healthcare professionals' expectations, attitudes and ethical acceptability regarding the integration of socially assistive humanoid robots in nursing

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ABSTRACT

Introduction Population ageing, the rise of chronic diseases and the emergence of new viruses are some of the factors that contribute to an increasing share of gross domestic product dedicated to health spending. COVID-19 has shown that nursing staff represents the critical part of hospitalisation. Technological developments in robotics and artificial intelligence can significantly reduce costs and lead to improvements in many hospital processes. The proposed study aims to assess expectations, attitudes and ethical acceptability regarding the integration of socially assistive humanoid robots into hospitalised care workflow from patients' and healthcare professionals' perspectives and to compare them with the results of similar studies.

Methods/design The study is designed as a cross-sectional survey, which will include three previously validated questionnaires, the Technology-Specific Expectation Scale (TSES), the Ethical Acceptability Scale (EAS) and the Negative Attitudes towards Robots Scale (NARS). The employees of a regional clinical centre will be asked to participate via an electronic survey and respond to TSES and EAS questionaries. Patients will respond to TSES and NARS questionaries. The survey will be conducted online.

Ethics and dissemination Ethical approval for the study was obtained by the Medical Ethics Commission of the University Medical Center Maribor. Results will be published in a relevant scientific journal and communicated to participants and relevant institutions through dissemination activities and the ecosystem of the Horizon 2020 funded project HosmartAI (grant no. 101016834).

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Strengths and limitations of this study

- The study sample will include only subjects from Slovenia, which may lead to cultural bias and limit the generalisability of our results.
- Data will be collected using self-report questionnaires only, which may lead to random or systematic misreporting.
- A large and diverse study sample of patients and healthcare professionals, including physicians and nurses, will be recruited.
- The questionnaires that will be used in our study have previously been validated and used in several languages. Previous studies suggest that they are valid and reliable.
- Our study will provide a broad assessment of attitudes, expectations and aspects of ethical acceptability related to the use of socially assistive humanoid robots during hospitalisation.

INTRODUCTION

Healthcare systems worldwide are striving to rise to the challenges that result from an ageing population, the growth in chronic disease prevalence, the appearance of new viruses, burgeoning technical possibilities and a rise of public expectations.[1] With the increasing economic burden of modern health, the Organization for Economic Co-operation and Development estimates that up to 20% of health spending in Europe is spent on services that either do not deliver benefits or are even harmful, as they create additional costs and could be avoided by substituting them with (cheaper) alternatives with identical or greater benefits.[2] Technological developments in robotics and artificial intelligence could lead to improvements in many hospital processes. In fact, the robotic systems are being increasingly used to improve accuracy,[3] to improve diagnosis and enable remote treatment,[4] in supporting mental health and daily tasks[5 6] and in complementing the

human workforce in auxiliary services.[7] Nursing and care, in particular, could gain much from the artificial systems' capacity to assist people and decrease the workload. Namely, nursing and care staff are a critical part of healthcare and make up the largest section of the health profession. According to the World Health Statistics Report, there are approximately 29 million nurses and midwives in the world,[8 9] while current estimates suggest that additional 5.9 million nurses are needed worldwide.[10] However, there are multiple concerns related to integrating advanced technologies and assistive technologies in the healthcare sector. The more recognised ones include technical barriers and technological limitations, fairness and sustainability, accountability, acceptance, and negative preconceptions.[11]

Socially assistive humanoid robots (SAHR) have long been posited as a promising response to a chronic nursing shortage in the EU and the US health systems.[12] As physically and socially interactive technologies, SAHR present new opportunities for embodied interaction and active and passive sensing in this context. They have also been shown to psychologically impact individuals, affect group and organisational dynamics, and modify our concepts and experiences of work, care and social relationships.[13] Although the systems exhibit robust, autonomous capabilities and initial concerns regarding physical safety around people have been at least partially addressed, the uptake of the technology is arguably slow. In addition to ethical considerations[14] related to decreased social contact, there are additional barriers related to acceptance, such as patients' stigmatisation and fear of the dehumanisation of society. The former is mostly related to non-acceptance from end users[15] and the latter mostly to non-acceptance from healthcare professionals, nurses in particular.[16 17] In general, both relate to oversimplifying the complexity of nursing and care context. 'The implementation of a robotic system in nursing care must be seen as a complex intervention due to the number of involved stakeholders and their behaviours, the variability and number of outcomes and various interacting components.'[15] Oversimplification in design may lead to unhelpful features, creating inconveniences and frustrations, preventing patients and professionals from recognising the added value.[18] In some cases, robots may even be perceived as a local threat to their independence due to unfamiliarity and technical inexperience.[19–21] Previous research suggests that such negative perceptions are more common among certain subgroups of the population, such as those that are older and less educated.[22 23] Furthermore, although healthcare professionals are facing high workloads and tend to recognise the potential value of care robots as an aid in 'measuring/monitoring' (eg, assessment of vital signs), 'mobility/activity' (eg, movement assistance) and 'safety of care' (eg, fall prevention),[24] they are still challenged in fully understanding, prioritising, and integrating the robotic units into fundamental aspects of care.[25 26]

SAHR in nursing can have a significant impact on the workload of nurses and the quality of hospital services. However, the barriers and challenges related to medical ethics (autonomy, beneficence, non-maleficence and justice), as well as other expectations and attitudes, have yet to be fully addressed and understood.[11 27] A more anticipatory and contemporary position towards technology in nursing must be established with all stakeholders, especially healthcare professionals and patients.[28] Most existing studies focus on long-term (elderly) care or partial substitution of nursing activities rather than SAHRs as complimentary service. The most frequently reported barriers fit in socioeconomic and ethical domains and are focused on the implementation outcomes domain. The quality of reporting and quality of evidence were low in most studies.[25] The proposed study will investigate (1) general attitudes of patients towards SAHR in the setting of nursing, (2) ethical acceptability among healthcare professionals and (3) functional (technological) expectations of healthcare professionals and patients. The goal is to gain a detailed and comprehensive insight into the current state of attitudes, expectations and ethical acceptability regarding the use of SAHRs in the Slovenian public healthcare context where the implementation of digital tools is riddled with challenges.[29] This will allow us to develop implementation strategies aligned with patients' and professionals' preferences. Moreover, the study could reveal potential misconceptions about SAHRs and point to specific myths or fears that should be addressed with future educational programmes. Lastly, the results of the proposed study will also reveal which patients and subpopulations of providers, based on their demographic characteristics, may need additional information regarding the safety and potential benefits of SAHRs.

OBJECTIVES AND HYPOTHESES

The main objective is to assess expectations, attitudes and ethical acceptability regarding the integration of SAHRs into the nursing and care workflow at the regional clinical centre. With this study, we will evaluate the prevalence of generally recognised barriers that could hinder the integration of SAHRs in the targeted institution. We will gain crucial knowledge on how such SAHRs should be designed to match the complexity of the environment and preferences of the target end users (before their actual implementation). Overall, the study will address the following research questions:

R1: What do healthcare professionals expect from SAHRs in hospital care?

R2: What do patients expect from SAHRs in hospital care?

R3: To what extent do healthcare professionals find the use of SAHRs in hospital care ethically acceptable?

R4: What is the general attitude of patients towards SAHRs in hospital care?

R5: How do healthcare professionals and patients differ in their expectations regarding the use of SAHRs in hospital care?

R6: Which demographic characteristics of healthcare professionals (ie, gender, age, education, occupation) are related to their expectations and ethical acceptability regarding the use of SAHRs in hospital care?

R7: Which demographic characteristics of patients (ie, gender, age, education) are related to their expectations and attitudes regarding the use of SAHRs in hospital care?

Moreover, based on previous literature,[22 23] which investigated the role of age, education and other variables in the acceptance of SAHRs in different contexts, we have formed the following hypotheses, which concretise our expectations regarding the two correlational research questions (R6 and R7):

H1: Patients' attitudes towards SAHRs in hospital care are negatively related to their age, meaning that older participants exhibit less favorable attitudes.

H2: Patients' attitudes towards SAHRs in hospital care are positively related to their level of education, meaning that participants with higher education level exhibit more favorable attitudes.

H3: Healthcare professionals' opinion on ethical acceptability of SAHRs in hospital care is negatively related to their age, meaning that older participants find their use less acceptable.

H4: Healthcare professionals' opinion on ethical acceptability of SAHRs in hospital care is positively related to their level of education, meaning that participants with higher education finder their use more acceptable.

METHODS

Design and setting

The study is a cross-sectional survey evaluating expectations, attitudes and ethical acceptability related to the integration of SAHRs, as perceived by healthcare professionals and patients.

The participating healthcare professionals employed in the clinical centre in Maribor (Slovenia) will be asked to respond to a questionnaires' battery in a digital format, consisting of questions on their demographic characteristics, namely age, gender, education level and occupation. To collect information regarding the SAHRs, we will use two widely used questionaries.[30] The healthcare professionals will be asked to fill out the Technology-Specific Expectation Scale (TSES),[31] which was developed to measure users' expectations prior to encountering and interacting with a robot and which is often used as one of the indicators of acceptability. It can also offer insight into unrealistic ideas regarding the capabilities of robots. The scale consists of 10 items answered using a 5-point Likert scale (1—very low expectation, 5—very high expectation). These items belong to two subscales, namely 'capabilities' (eg, 'I think I will be able to interact with the robot') and 'fictional view' (eg, 'I think the robot will have superhuman capacities'). Both subscales generally exhibit good internal consistency (coefficient $\alpha \geq 0.75$).[31] Moreover, the healthcare professionals will also fill out the Ethical Acceptability Scale (EAS),[30] first developed to assess ethical issues in the use of robot-enhanced therapy with children with autism. In its original form, the scale consists of 12 items answered on a 5-point Likert scale (1—strongly disagree, 5—strongly agree); approximately half of the items are directly focused on children with autism, and others are general. For the purposes of the proposed study, items specifically related to autism will be modified slightly to be applicable in the more general healthcare context (only small modifications are needed, as the items capture ethical reservations regarding SAHRs that exist in various contexts). Structurally, the scale consists of three subscales: ethical acceptability for use (five items; eg, 'it is ethically acceptable that social robots are used in healthcare'), ethical acceptability of human-like interaction (four items; eg, 'it is ethically acceptable to make social robots that look like humans') and ethical acceptability of non-human appearance (three items; eg, 'it is ethically acceptable to make social robots that look like objects'). All subscales generally exhibit good internal consistency (coefficient $\alpha \geq 0.72$).[32] Additionally, a few additional dichotomous questions will be posed to participants as well (eg, 'do you think the robot could answer patient's questions about treatment?). The questionnaires will be digital, distributed to the healthcare professionals by the researchers.

The study will also involve inpatients from the clinical centre in Maribor. Patients will be asked to answer questions on their demographic characteristics, namely age, gender and education level. Similarly to healthcare professionals, they will also respond to TSES.[31] However, since EAS is rather specific, as it tackles complex ethical issues, it is not as suitable for patients, who are less involved in the ethical aspects of SAHRs implementation. As such, EAS will be substituted in the patients' sample with the Negative Attitudes towards Robots Scale (NARS)[33]—a widely used and cited measure of negative attitudes towards robots, which was developed based on the analysis of participants' open responses regarding the robots. The scale consists of 14 items answered on a 5-point Likert scale (1—strongly disagree, 5—strongly agree). The factor analyses revealed that NARS consists of three subscales, namely: negative attitudes toward situations of interaction with robots (six items; eg, 'I would feel uneasy if I was given a job where I had to use robots'), negative attitudes toward social influence of robots (five items; eg, 'I would feel uneasy if robots really had emotions') and negative attitudes towards emotions in interaction with robots (three items; eg, 'I would feel relaxed talking with robots'). Psychometric evaluations of

Table 1 Outline of the study design

Healthcare professionals	
Design	An electronic survey among healthcare professionals
Cohorts	No a priori cohorts; instead, employees will be divided according to their gender and occupation in the analyses
Desired sample size	500
Inclusion period	Until the desired sample size is reached (max. 4 months after the beginning of the study)
Exclusion criteria	None
Inclusion criteria	Employees of participating medical institution, between 18 and 65 years of age
Questionnaires	EAS and TSES, demographic data, additional questions related to acceptance
Other requirements	Willingness to participate
Patients	
Design	An electronic survey among inpatients. Staff collects the responses using tablets. If needed, support of hospitals' staff will be provided
Cohorts	No a priori cohorts, instead, patients will be divided according to their gender in the analyses
Desired sample size	500
Inclusion period	Until the desired sample size is reached (max. 4 months after the beginning of the study)
Exclusion criteria	Patients hospitalised at the paediatric clinic, department of psychiatry and the clinic for gynaecology and perinatology
Inclusion criteria	Hospitalised patients in the participating medical institution at the time of the survey, capable of signing the informed consent
Questionnaires	NARS and TSES, demographic data, additional questions related to acceptance
Other requirements	Willingness to participate

EAS, Ethical Acceptability Scale; NARS, Negative Attitudes towards Robots Scale; TSES, Technology-Specific Expectation Scale.

NARS are rather extensive and support its use in various contexts.[34] Patients will respond to the questionnaires in a digital format. The questionnaires will be distributed by the hospital's staff using the hospital's tablets. Additional support will be offered if needed.

In both cases, a non-probability sampling method will be followed, that is, all the eligible participants from the participating institution will be invited to participate. The cross-sectional study is planned to begin in December 2021 and the data collection will last until the targeted sample sizes are reached for both populations. If we will not be able to reach the target sample size due to unforeseen challenges, the study will be closed after 4 months. Table 1 summarises the study design.

Participants

We plan to recruit 500 healthcare professionals between 18 and 65 years of age (although more than 1000 will probably have to be invited to reach this number). Besides the age requirement, another inclusion criterion for the healthcare professionals is that they need to be employed in the participating medical institution. There are no exclusion criteria for the healthcare professionals.

We estimate that more than 1000 patients will be invited to fill out the questionnaires, leading to the final sample size of about 500 patients aged 18 years or above. The inclusion criteria for the patients are that they need to be hospitalised in the clinical centre during the study period, that they are willing to participate and able to sign the informed consent. The patients hospitalised at the paediatric clinic, department of psychiatry and the clinic for gynaecology and perinatology will not be invited to participate. No information through which individuals could be identified will be collected; in other words, the study will be completely anonymous. Participants will be informed that participation is completely voluntary, and they can terminate their involvement at any time without any consequences. They will also receive the relevant information explaining the intent of the survey, its procedure, foreseen analyses and dissemination strategy.

Ethical, legal and regulatory aspects

Ethical approval for this study was obtained from the Medical Ethics Commission of the University Medical Center Maribor (UKCM-MB-KME-40/21). The study will not collect sensitive data (eg, data revealing racial or ethnic origin, sexual orientation, religious beliefs, etc). Data will be anonymised on collection. Patients participate on a voluntary basis and sign the consent. The study group will be fully committed to respecting the highest ethical and legal standards.

Data storage and privacy

The study will not collect any personal identifying information, meaning that the data will already be anonymised at the collection point. The results of the study will be

published, and data made available in digital form on reasonable request. However, as a general rule, respect for fundamental rights to privacy and personal data is of paramount importance to all partners and to the project.

In view of this presumption and considering the different modes of flow of personal data (including those categories of personal data that fall under sensitive data, as set out in Article 9 of the General Data Protection Regulation (GDPR), the following compliance rules and management policies will apply. Among personal data, we will collect information on gender, age and level of education of patients, and for employees, additional information on their occupation. The time span of the survey will be used and not the exact date of the completed survey for the individual. Data will be processed using descriptive statistics and appropriate inferential statistical tests.

Management and reporting of adverse reactions

We do not expect any adverse effects in the study. The only adverse event could be the unwillingness of patients and staff to participate.

PATIENT AND PUBLIC INVOLVEMENT

Healthcare professionals of the participating medical institution were involved in the study design (eg, selection of relevant variables and questionnaires, method of data collection) via multidisciplinary workshops and electronic communication. Patients were not involved in the study design. The results of the study will be disseminated to the participants and public via publication of open access research papers and relevant dissemination channels. These include local and social media, website posts and blog posts.

OUTCOMES

This study will examine the research questions and hypotheses to determine the prevalence of various expectations, attitudes and ethical reservations in two subsamples—patients and employees. We are also interested in the relationship between expectations and attitudes of patients and their age, gender and education. Similarly, we are interested in the relationship between expectations and ethical acceptability of employees, and their age, gender, education and occupation. Table 2 summarises the expected outcomes related to correlations and differences between subcohorts.

DATA ANALYSIS AND STATISTICS

Sample size determination

The sample size was determined based on various information sources, namely the observed sample sizes in previous similar studies, our selected tools, research questions and hypotheses (ie, expected results), as well as the ratio between population and sample size.

The sample sizes in previous studies normally vary between 50 and 300 participant[35–38]. However, some of these studies explicitly mention that the generalisability of their results is limited due to a relatively low number of participants. As such, our goal is to overcome this limitation.

Moreover, based on the selected tools, research questions and hypotheses, we need a large enough sample to be able to detect relatively weak correlations between the measured constructs. For example, Heerink[22] has found that the correlation between age and education and attitudes towards the application of the robot are approximately ±0.15. Hence, the sample size calculation in the G*Power V.3.1.9.7 software (two-tailed test, correlation=0.15, $\alpha=0.05$, $1-\beta=0.80$) suggests the recruitment of

Table 2 Expected differences and correlations between sociodemographic variables and attitudes, expectations, and ethical acceptability regarding SAHRs among employees and patients

Employee categories	Expected results	Measuring tool
Age	Younger employees are more open to the idea of implementing an SAHR into nursing care.	TSES and EAS Questionnaires (electronic form)
Gender	No expected difference in these groups.	
Education	We expect that employees with higher levels of education will be more open to the idea of implementing an SAHR into nursing care.	
Occupation	Outcome uncertain.	
Inpatient categories	**Expected results**	**Measuring tool**
Age	Younger patients are more open to the idea of implementing an SAHR into nursing care.	TSES and NARS Questionnaires (electronic form)
Gender	No expected difference in the two groups.	
Education	We expect that patients with higher levels of education will be more open to the idea of implementing an SAHR into nursing care.	

EAS, Ethical Acceptability Scale; NARS, Negative Attitudes towards Robots Scale; SAHR, socially assistive humanoid robots; TSES, Technology-Specific Expectation Scale.

at least 346 employees and 346 inpatients to achieve statistical significance (p value) equal or below 0.05.

Lastly, we want our sample to be as representative as possible (but data collection also needs to be feasible). For example, the main participating hospital employs approximately 3360 medical and non-medical staff members (approximately 600 medical doctors and 1500 healthcare workers). Using Israel's table[39] of sample sizes necessary for given combinations of population size, precision, confidence levels and variability, this would suggest the recruitment of about 333 (given the ±5% precision) to 714 (given the ±3% precision) employees. The population of patients is also quite large; the primary participating hospital is a 1316-bed facility and approximately 60 000 patients are treated annually.

Considering all the factors described above, we argue that approximately 500 employees and 500 patients should suffice for statistical inference as well as adequate generalisability of results.

Analysis

We will use the R V.3.4.2 and IBM SPSS Statistics V.26 programmes for statistical analysis. Results with a p value below 0.05 will be considered statistically significant. In the first steps, the missing values will be replaced (according to the logic of multiple imputation or using the 'missForest' procedure). In addition, we will perform basic psychometric analyses, namely factor analysis and analysis of reliability as internal consistency (coefficient alpha). With a sufficient sample, the measurement invariance of the questionnaires used will also be checked. In accordance with the results of these preliminary analyses, the values of the parent dimensions (factor scores) will be calculated.

Following that, basic descriptive analyses will be performed (calculation of M and SD), and the normality of the distribution of the included variables and other assumptions of statistical tests, outlined below, will be checked. Since normality tests (such as the Kolmogorov-Smirnov test) are generally too sensitive in case of a relatively large sample size (and our hypothesised sample size may be considered as large), we will mostly rely on visual inspection, skewness and kurtosis. Specifically, a general rule of thumb that suggests the use of parametric tests if skewness and kurtosis are between –2.00 and 2.00 will be applied. Additionally, basic correlation analyses (Pearson's r) will be used to provide insight into the associations between variables. In cases where hypotheses assume the comparison of two or more independent groups, t-tests for two independent samples (eg, to identify gender differences) and one-way analysis of variance analysis (ANOVA for independent groups, eg, to identify differences between occupational groups) will also be used. In cases of correlation of the studied dependent variables, the MANOVA test (multivariate analysis of variance) will be used instead of the ANOVA test for independent groups.

Non-response

People tend to be more inclined to answer the questionnaire when they are familiar with the current subject. This situation might skew the prevalence estimates (regarding expectations, attitudes, ethical acceptability) found in our sample in case of substantial non-response. To evade considerable non-response among the patient population, healthcare professionals will inform patients regarding their value in the study even though they do not have experience with SAHRs. Moreover, when necessary, the healthcare professionals will provide further assistance and explanation.

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Contributors All authors conceptualised the study. IM and AB were in charge of the study design and wrote the original draft and the draft version of primary and secondary endpoints. VF, NK, TK and MM were in charge of the inclusion/exclusion criteria and defined how the study would be carried out. US and NP were in charge of the definition of the data analysis methodology and the statics, including sample size calculations. All authors contributed to background research. AB, VF, NK, TK and MM were in charge of the ethics approval process. All authors contributed to the revision of the study. All authors read and approved the final manuscript.

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Competing interests None declared.

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