Informal Caregivers' Thoughts on the Design, Functioning and Acceptability of Assistive Robots in Home Care

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Abstract: Informal care provided by family members, friends or acquaintances for individuals with chronic diseases, disabilities or age-related limitations is becoming increasingly significant in aging populations. Providing informal care over the long-term may burden not only the caregiver but also the society due to its impact on caregivers' health, quality of life and work productivity. Innovative, artificial intelligence-based systems and assistive robots may offer partial solutions for home care; however, little is known about their acceptability and users' preferences regarding specific features.

The aim of this explorative pilot research was to explore informal caregivers' ideas about assistive robots for use in home care. Structured interviews were performed in a cross-sectional study involving 18 informal caregivers in Hungary. The Negative Attitudes Towards Robots Scale (NARS) was applied and care-related quality of life was assessed with the CarerQoL questionnaire. Results indicate a significantly positive attitude of informal caregivers towards robots in general and towards the application of assistive robots in home care. All participants expressed a willingness to incorporate robotic assistance into their caregiving duties. The most important mentioned assistive robot features were ease of use, safety features, and functionalities such as movement support and assistance with daily household tasks. The interviews provided novel insights into informal caregivers' impressions and preferences, particularly concerning emotional aspects associated with the appearance and voice of the robot. Our findings offer valuable guidance for the design, development, implementation and management of assistive robots, underscoring the need for a balanced approach that addresses functional requirements while considering the psychological aspects of human-robot interaction.

Keywords: informal care; quality of life; robot; design; function; acceptability; innovation management

1 Background

Globally, a significant proportion of the population lives with life-limiting diseases, chronic or age-related conditions that necessitate permanent or temporary care and support to perform every day activities [1, 2]. This demographic trend is influenced by several factors, including population aging and the increasing prevalence of chronic diseases. Despite the presence of universal healthcare systems in many countries, challenges persist in terms of accessibility and quality of care, particularly for geriatric and rural populations [2]. Consequently, there is a substantial reliance on family members, called as informal caregivers in the literature, who play an essential role in complementing formal care services and mitigating the burden on health and social care systems.

Informal caregiving is defined as a non-professional, mostly unpaid care provided by family members, friends, neighbours, or other individuals to those who need assistance with daily activities [3]. This type of care is typically provided outside of formal healthcare or social services frameworks. The time of informal care can range from a few hours a week to continuous support, encompassing various activities, such as personal care, household chores, medical care, emotional support and companionship, accompaniment to medical appointments and supervision. Research has demonstrated that informal carers often experience physical, emotional, and financial burdens, as well as social isolation [4-8]. To effectively support informal caregivers in their responsibilities, preserve their mental and physical well-being and productivity in their paid job, it is imperative to recognize the challenges they face and provide appropriate support mechanisms and resources.

The rapid advancements in digital health technologies and robotics present significant potential to revolutionize informal caregiving, enhancing its efficacy and reducing the burden on caregivers and on health financing [9]. There are considerable opportunities for the utilization of assistive robots, either to support the daily activities of patients and caregivers or to potentially replace certain aspects of informal care [10]. The robots can be used in many areas, including physical assistance, rehabilitation support, household chores and even mental health support by facilitating patient's connection with the external environment.

The adoption of novel technologies is often slow and heterogeneous, particularly among specific populations such as the elderly [11]. The key to successful implementation of new technologies, like assistive robots, lies in understanding the needs and drivers of utilization. The acceptance and perception of assistive robots are significantly influenced by general attitudes towards robotics [12]. However, the adoption rate of such technologies can be enhanced through the application of knowledge regarding the specific needs and preferences of the target population. The development of assistive robotic systems can be effectively guided by a comprehensive investigation of the task-specific prerequisites, robotic attributes, and generalized attitudes towards particular use cases. Questionnaires and interviews are commonly used techniques for outcome evaluation to assess the acceptance of assistive technologies [13].

The potential applications of assistive robots are not yet widely recognized, and their usage has remained limited, while it is looked upon as one of the prominent domains within medical robotics [14]. Increasing number of studies investigate the potential of companion robots to support adults in their home environments [15, 16] and exploring important characteristics for different user needs [17, 18]. However, these studies primarily focus on the patient perspective, while the perspective of informal caregivers remains a less researched and mostly qualitatively assessed area.

The primary objective of this explorative pilot study is to gather information from informal caregivers regarding their thoughts on assistive robots, including their expectations, the functions they deem important, and the tasks they would find acceptable for a robot to perform. This study supplements a comprehensive online cross-sectional survey conducted across two countries [19, 20]. Results from this study could also support the designing of assistive robots and planning of further public research related to home care robots, as well as the evaluation of their results.

2 Methods

2.1 Study Design

Structured, in-person interviews were conducted in Hungary in the year 2024. Interviews were carried out by three interviewers (IM, PF, KZ), all of them were physicians specialized in rehabilitation and working in hospital-based rehabilitation ward. Participants for the interviews were recruited from the informal carers of patients attending one of the 3 centres of the National Institute of Locomotor Diseases and Disabilities (out of which two centres now belong to the Rehabilitation Clinic of Semmelweis University). The aim of including more centres was to increase the heterogeneity of the sample. Informal carers were invited to participate if they met the following criteria: they were at least 18 years old, they had provided informal care for a minimum of 1 month in the home of the care recipient, and they consented to sign an informed consent form. Ethical approval was obtained from the Medical Research Council, Hungary (Ref: BM/5946-1/2024).

2.2 Interviews

The survey instrument and guide for the structured interviews was designed by our research group. This included standard validated, self-completed health- and care-related quality of life measurement tools, along with a range of multiple-choice and free-text questions, organized into four distinct modules.

Module 1: Respondent's main social and demographic characteristics (gender, age, education, marital status, employment).

Module 2. Core component of the survey, where respondents' attitudes toward domestic robotic applications were evaluated. Participants were given a brief explanation about what “robot” refers to in the context of the research. They were asked to indicate whether they have ever met any robot. Survey questions consisted of the following.

- Acceptability of distinct robot characteristics (e.g., appearance, size, functions, other) for an assistive robot to be used their care recipient’s home (Yes/No; if a characteristic/function was not acceptable for the carer, they were asked about the reason in an open-ended question).
- Open question on whether the respondents would be willing to use robots to support informal care and why.
- Rating exercise: participants were asked to rate the importance of various robot characteristics on a 4-point scale (1 - not important at all, 4 - very important); participants were asked to add any items to the list that were missing but they considered important.

- Ranking exercise: participants were asked to select and rank the five most important robot characteristics from the list provided in the rating exercise.
- Using the care-related quality of life instrument's descriptive system (CarerQoL-7D), respondents were asked to select all the domains where an assistive robot could potentially improve their care-related quality of life. Participants could add any missing aspects as a free text response.
- Suitability of care recipient's home to implement an assistive robot (Yes/No).

Module 3: The caregiving situation: care-related quality of life (CarerQoL) of the informal caregiver; the health status of the patient; caregiving tasks; the digital proficiency of caregivers and care recipients, and the digital tools they used.

Module 4: The situation of the informal caregiver at the time of the survey, including their digital skills and their use of digital technology, attitude towards robots (NARS scale), health status (MEHM), and general characteristics of their household.

2.3 Measurement Tools

2.3.1 Negative Attitudes towards Robots Scale (NARS)

The Negative Attitudes towards Robots Scale (NARS) is a psychological measurement tool designed to assess people's negative attitudes towards robots and human-robot interactions [21]. The scale consists of 14 items and divided into three subscales:

Subscale 1: Situations of Interaction with Robots (6 items, score range 6-30).

Subscale 2: Social Influence of Robots (5 items, score range 5-25).

Subscale 3: Emotions in Interaction with Robots (3 items, score range 3-15).

Responses were evaluated on a 5-point Likert scale (from strongly disagree = 1 to strongly agree = 5). S3 subscale items are reverse scored to ensure consistency in the direction of negative attitudes. For each subscale the score was calculated by summing the scores of the items belonging to that subscale and the total NARS score by summing all 14 items (possible range 14-70). Higher scores indicate more negative attitudes towards robots.

2.3.2 Minimum European Health Module

The Minimum European Health Module (MEHM) is a brief standardized instrument used to collect comparable data on health status across European countries [22]. The first component inquires about respondents self-perceived health and scored on a 5-point Likert scale (from very good = 1 to very bad = 5). The second question on chronic morbidity evaluates the percentage of respondents reporting chronic morbidity (yes/no). The last component on activity limitation uses a 3-level scale (severely limited, limited, not limited at all) and indicates the percentage of population reporting any limitation and the percentage of population reporting severe limitations.

2.3.3 CarerQoL-7D

The CarerQoL-7D is a validated instrument designed to measure and assess the quality of life of informal caregivers [23]. This tool encompasses seven distinct dimensions that capture various aspects of the caregiving experience, and each dimension is evaluated on a three-point scale, allowing for a detailed assessment of the caregiver's situation.

2.3 Data Analysis

Interviewers recorded responses on paper. Quantitative data and responses to the open-ended questions/free text responses were entered manually into an electronic database developed in IBM SPSS Statistics 25 software.

Descriptive statistics (mean, standard deviation) for quantitative questions were derived. No in-depth statistical analyses were conducted due to low sample size. Responses provided on the open-ended questions were reviewed and synthesized by AV and MP.

3 Results

As the main focus of our study is on informal caregivers’ perceptions and attitudes towards the use of assistive robots in home care, we briefly summarize the relevant background information, including the main characteristics of the study sample and caregiving situations in the next section. Detailed data are provided in electronic supplementary (ESM) material.

3.1 Sample

A total of 18 informal caregivers participated in the survey, with 6 respondents representing each of the three centres involved. The characteristics of the participants are outlined in ESM Table S1 (https://osf.io/t9qvx). Mean age of the participants was 63 years (SD: 14; min: 38; max: 83) and 11/18 were female, 9/18 had a degree and 12/17 lived in Budapest. Half of the respondents provided informal care while simultaneously working either full-time or part-time. Seven participants had some level of health education degree. The first component of the

MEHM (general health status) had a mean score of 2.6 (SD: 0.6). In the second component, 12 participants indicated they had a chronic condition. For the third component 7 participants reported activity limitations, but none of them had severe limitations.

The data on informal caregiving and various aspects of the care provided are presented in ESM Table S2 (https://osf.io/t9qvx). On average, informal caregivers spent 31.5 hours per week (SD: 27.9; min: 2; max: 100) with the caregiving tasks. One response was excluded from the analysis as it indicated 1420 hours/week were spent on caregiving. The average age of the care recipient was 76 years (SD:14; min: 31; max: 90). Most caregivers (13/18) had been providing care for more than a year, while smaller proportions had been caring for 7-12 months (3), 2-6 months (1), or less than 2 months (1). Over half of the caregivers (10) do not expect any improvement in the health status of their patients, four expect improvements, and another four either don't know or prefer not to disclose their expectations. The caregivers were most commonly caring for their parents (8) or partners (6), while others caring for siblings, friends, or acquaintances. The care recipients were slightly more often female (10) than male, with half of the caregivers living in the same household, and the rest were either living alone (3) or not in the same household.

From the various tasks listed in the survey, the main task performed by the informal carer (ESM Table S3. https://osf.io/t9qvx) was accompanying the patient for medical visits or leisure activities, reported by 15 participants. Tasks associated with aid in housework such as cleaning and shopping were performed in 14 cases. Moving the patient or assisting in movement and helping with administrative tasks were both reported by 13 participants, while entertaining the patient through conversation or reading was part of the caregivers' duties in 11 cases. Three respondents provided free text responses that included medication administration, gardening and "doing what the patient requests".

Caregivers were asked about the digital activities frequently performed by patients and informal carers; results are presented in ESM Table S4 (https://osf.io/t9qvx). The most common activity among both patients and carers was reading, watching videos, playing games, or looking for information on the internet (reported by 17 caregivers and for 11 patients). Nearly all (16) carers and 6 patients used the internet for communication. Online shopping or online administration was also common (reported by 16 carers and for 5 patients). A notable number of patients (8) were not engaged in any of the mentioned digital activities. In contrast, only four informal carers reported not participating in the listed digital activities (however, three of them selected other digital activities as well from the list; therefore, the actual number of caregivers not involved in digital activities is only one).

Data on the usage of different digital devices and technologies currently used by the patient are presented in ESM Table S5 (https://osf.io/t9qvx). Mobile phones and television were the most commonly used devices (16). Emergency systems, including both an emergency call system and an emergency call button, were used in 7-7 cases. Smart watches were only used in three cases. Surveillance tools like cameras and motion sensors were used in two cases. The use of tracking devices as well as automatic calendars/reminders, electronic medication dispensers, and various sensors were not reported to be used by any of the participants. Window/door alarms were the only sensors reported to be used in three cases. Notably, only three participants mentioned using the internet resources/social media groups/applications to support them with informal caregiving. Additionally, one participant reported using "Gondosóra", a Hungarian alert system that enables elderly people to rapidly contact a designated person during emergencies via a simple device and mobile app.

3.2 Distribution of NARS Results among Informal Carers

The overall mean NARS score was 39.0 (SD: 9.4). The Sub-scale 1 on the Negative Attitudes toward Situations and Interactions with Robots resulted in a mean score of 14.5 (SD: 5.5). Sub-scale 2 on the Negative Attitudes toward Social Influence of Robots provided a mean score of 15.2 (SD: 4.2). In sub-scale 3, the scale scores were reversed and resulted in a mean score of 9.3 (SD: 2.1). The NARS responses are outlined in Table 1.

Table 1

NARS results

	Strongly disagree (score 1)	Disagree (score 2)	Neutral (score 3)	Agree (score 4)	Strongly agree (score 5)
	N (%) of total participants				
S2 - I would feel uneasy if robots really had emotions.	4 (22.2%)	2 (11.1%)	8 (44.4%)	1 (5.6%)	3 (16.7%)
S2 - Something bad might happen if robots developed into living beings.	2 (11.1%)	3 (16.7%)	6 (33.3%)	1 (5.6%)	6 (33.3%)
S3 - I would feel relaxed talking with robots. * (missing: N=1)	2 (11.1%)	1 (5.6%)	7 (38.9%)	6 (33.3%)	1 (5.6%)
S1 - I would feel uneasy if I was given a job where I had to use robots	2 (11.1%)	6 (33.3%)	8 (44.4%)	1 (5.6%)	1 (5.6%)
S3 - If robots had emotions, I would be able to make friends with them. *	3 (16.7%)	2 (11.1%)	8 (44.4%)	5 (27.8%)	0 (0.0%)
S3 - I feel comforted being with robots that have emotions. *	5 (27.8%)	1 (5.6%)	10 (55.6%)	2 (11.1%)	0 (0.0%)

S1 - The word "robot" means nothing to me.	4 (22.2%)	9 (50.0%)	3 (16.7%)	1 (5.6%)	1 (5.6%)
S1 - I would feel nervous operating a robot in front of other people. (missing: N=1)	5 (27.8%)	6 (33,3%)	2 (11,1%)	3 (16,7%)	1 (5.6%)
S1 - I would hate the idea that robots or artificial intelligences were making judgments about things	2 (11.1%)	6 (33.3%)	3 (16.7%)	3 (16.7%)	4 (22.2%)
S1 - I would feel very nervous just standing in front of a robot.	4 (22.2%)	9 (50.0%)	3 (16.7%)	0 (0.0%)	2 (11.1%)
S2 - I feel that if I depend on robots too much, something bad might happen.	2 (11.1%)	5 (27.8%)	4 (22.2%)	5 (27.8%)	2 (11.1%)
S1 - I would feel paranoid talking with a robot.	4 (22.2%)	10 (55.6%)	3 (16.7%)	0 (0.0%)	1 (5.6%)
S2 - I am concerned that robots would be a bad influence on children.	2 (11.1%)	6 (33.3%)	6 (33.3%)	3 (16.7%)	1 (5.6%)
S2- I feel that in the future society will be dominated by robots.	1 (5.6%)	2 (11.1%)	8 (44.4%)	5 (27.8%)	2 (11.1%)

S1=Subscale 1: Situations of Interaction with Robots; S2=Subscale 2: Social Influence of Robots; S3=Subscale 3: Emotions in Interaction with Robots

*Reverse items (with reverse scoring of responses: 1=5, 2=4, 3=3, 4=2, 5=1)

3.4 Importance Rating and Ranking of Specific Robot Characteristics

Participants were asked to rate the importance of various characteristics of an assistive robot on a four-point Likert scale. The analysis of the responses revealed that the 'Voice' of the robot (mean 3.6, SD: 0.5) was the most important characteristic among the appearance attributes, followed by 'Appearance', 'Size' and lastly 'Movement'. Features related to the functionality of the robot, such as 'Having an emergency call system' was rated the highest. 'Moving the patient, help in walking' and 'Helping with everyday tasks and chores', 'Helping to maintain health status' were all rated above 3.0, signifying that participants found these functionalities fairly important. Amongst the other characteristics listed on the questionnaire, 'Safety' was deemed to be the most important (mean 3.9) with a low standard deviation of 0.3, indicating a general consensus on its importance. Similarly, 'Ease of use/assistance in use' and in equal numbers 'Data security' and 'Price' also received high importance ratings (Table 2).

Table 2
Importance of the robot characteristics

Category	Robot characteristics / function	Mean* (scale 1-4)	SD
Appearance	Appearance	3.1	0.7
	Size	3.0	0.6
	Movement	2.8	1.0
	Voice	3.6	0.5
Function	Helping with everyday tasks and chores	3.3	1.0
	Helping to maintain the health status of the patient	3.3	0.8
	Helping to maintain/improve the mental health	3.1	1.0
	Helping to get involved in social life	2.9	1.1
	Communication with the patient	3.2	1.0
	Moving the patient, helping with walking	3.6	0.6
	Emergency call system	3.7	0.6
	Remote monitoring of the patient	3.2	0.9
Other characteristics	Ease of use/assistance in use	3.8	0.4
	Recommendation from doctor/ health professional	3.2	0.9
	Safety	3.9	0.3
	Data security	3.7	0.5
	Price	3.7	0.5

*N=17

In the free-text response section, participants identified 12 additional characteristics of a healthcare robot according to their perceived importance, categorizing them as "Important" or "Very important." Key functionalities such as ‘the ability to send an error message in the event of a failure’, ‘the submission of daily self-check results’, ‘energy efficiency, ‘operating time’, ‘patient acceptance’, customization to patient needs were all ranked as "Very important." Additional characteristics considered "Important" included ‘the robot's portability by car’, ‘service background’, ‘memory for data retrieval’, and ‘cleaning/disinfection processes’. The feature ‘Ability to take the patient for a walk’ was mentioned but was not given an importance rating.

In the ranking exercise, the most respondents selected ‘Ease of use’ as the most important characteristic, followed by the function ‘Moving the patient and helping with walking”. The function ‘Helping with the everyday tasks and chores” was chosen as the third most important feature, followed by ‘Safety” and finally the function ‘Helping to maintain the health of the patient”. (Fig. 1)

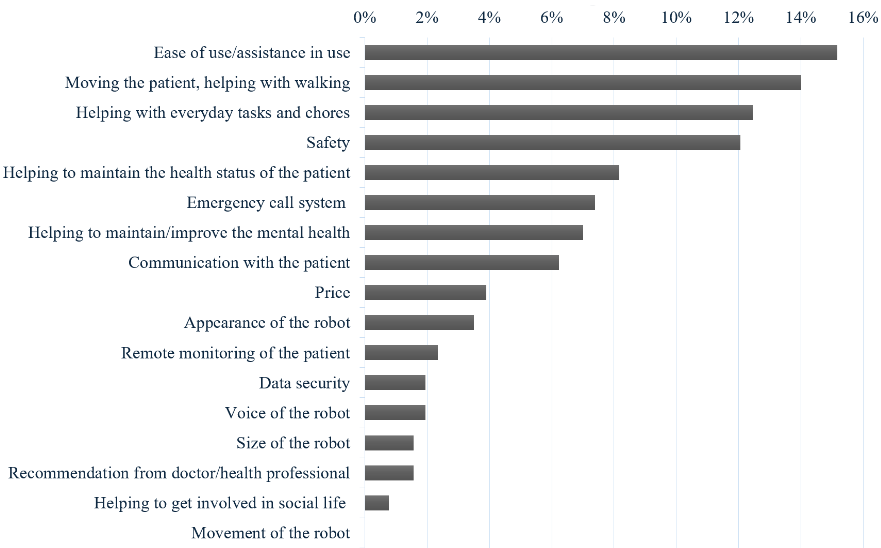

Figure 1

Ranking of robot characteristics by their importance

The sum of all responses received per characteristic, weighted by the ranking (5 if ranked first; 1 if ranked fifth), divided by the total number of cases

3.2 Acceptability of Specific Robot Characteristics and Functions

The survey included questions on the acceptability of specific attributes of assistive robots. Results are presented in Table 3. Although this self-completed part of the survey held a substantial amount of missing data, the findings deserve consideration. Ten out of the 18 participants considered a humanoid appearance acceptable. For respondents who selected the 'not acceptable' response option, a follow-up open-ended question was included to gather explanations for their decision. Among participants who did not consider a humanoid appearance acceptable, two participants specifically noted that robots resembling animals or living creatures could potentially evoke feelings of fear or cause discomfort among patients. One participant stated that "The robot is not a living being, so I don't think it should look like it". Conversely, three responses indicated a preference for more lifelike appearances. One respondent noted, "A human-looking robot with a pleasant face and soothing voice is more acceptable." Another commented, "In my opinion, it is easier to accept or ask for the help of a machine that can be personalized." Only one respondent indicated that any appearance for the assistive robot would be acceptable.

Regarding the size of the robot, the majority of respondents (11) expressed a preference for a medium-sized device. The free-text responses revealed perceived issues with both excessively small and overly large devices, such as: “A robot that is too small is not suitable for certain tasks. On the other hand, I would feel that a big robot is more difficult to handle” or “The small, approx. 60 cm tall robot might be too small for everyday use, it wouldn't even reach patients’ beds.”

Among the everyday activities listed on the questionnaire, all respondents indicated that they would accept a robot performing minor tasks at home, such as switching on lights, closing blinds/curtains, and controlling heating/air conditioning. A significant proportion of the participants found it acceptable for an assistive robot to do the vacuum cleaning, send reminders or lift smaller objects. The least accepted tasks were to manage administrative tasks or do the shopping (not accepted by half of the carers). Four respondents specifically added free-text comments stating that preparing food or cooking is not required from a helper robot, with one noting, "I don't trust it would make good quality, tasty food." Three comments were received explaining why respondents did not accept the robot performing shopping or administration. The reasons given were: “These are personal matters” and "I can't imagine administrative duties being done by a robot at all." In two comments, it was not clearly indicated which task they were referring to. The comment "I don't want a robot to think for me" could be associated with the negative response for making shopping lists or performing administrative tasks.

Three potential nursing tasks were listed on the questionnaire and all but one of the respondents found it acceptable for a robot to perform blood pressure, pulse, and blood sugar measurements. Medication administration was acceptable to 14 of the 18 respondents. One of the reasons not accepting this option indicated in the free-text section was, "Even a small mistake when administering medicine can lead to big trouble. I trust myself more than a machine." Eleven of the 18 participants would accept a robot administering injections (into a muscle). The explanations for not accepting this task included: "Administering or receiving an injection is better with personal contact," and "The (robot) hand movement is not so refined."

Regarding patient movement, movement support, and body care, all listed tasks were deemed acceptable by a high number of respondents. Transportation of smaller objects was acceptable to all respondents. The least acceptable task from the list (13 respondents) was supporting patients in drinking and feeding. Three free-text comments highlighted the importance of personal contact for these tasks. For example, one respondent stated, "I believe that people need personal presence and care, and I can't imagine it with emotionless machines." Another noted that "Cared person need to feel the love" during the performance of these tasks.

Regarding tasks related to companionship and communication, respondents were generally very accepting. For the three questions in this category, only five "not acceptable" answers were received. One free-text response indicated, "My care recipient does not like talking to a machine or communicating on the computer."

Among the listed patient monitoring tasks, all participants deemed it acceptable for the robot to function as an emergency call device. A high number of participants also found it acceptable for robots to collect patient data. However, the least acceptable task for a robot, was to work as a professional monitoring system to remotely monitor patients at home (indicated by 13 carers). Four free-text comments were provided, all of which highlighted potential privacy issues. For example, one respondent stated, "I refrain from this because of potential hacking risks. Criminals could gain access to the homes and everyday lives of elderly people and could use the information for malicious purposes".

All 18 carers expressed a willingness to utilize an assistive robot within the residence of the care recipient, despite, 13 of them reported no prior in-person interaction with a robot. Two comments were provided: "I can imagine it because there are tasks that do not require close human contact" and " It could assist with tasks that primarily require physical strength."

The last question in this section inquired whether respondents thought the home of the cared personnel would currently be suitable for an assistive robot to move around in (considering obstacles such as thresholds, stairs, etc.). Altogether 10 of the carers deemed the homes suitable, while 8 considered them unsuitable.

Table 3
Acceptance of various robot characteristics and functions

Category	Robot characteristics / function	Acceptable	Not acceptable
		N (% of total participants)	
Appearance	humanoid (missing: N=6)	10 (55.6%)	2 (11.1%)
	animal-like (missing: N=9)	3 (16.7%)	6 (33.3%)
	robotic appearance (missing: N=6)	9 (50.0%)	3 (16.7%)
Size	small sized (~60 cm) (missing: N=10)	2 (11,1%)	6 (33.3%)
	medium sized (~110 cm) (missing: N=3)	11 (61.1%)	4 (22.2%)
	large sized (approx. 160 cm) (missing: N=7)	7 (38.9%)	4 (22.2%)
Everyday activities	lifting smaller objects (missing: N=1)	15 (83.3%)	2 (11.1%)
	sending reminders (missing: N=1)	16 (88.9%)	1 (5.6%)
	making a shopping list (missing: N=3)	11 (61.1%)	4 (22.2%)
	vacuum cleaning	17 (94.4%)	1 (5.6%)
	shopping (missing: N=3)	9 (50.0%)	6 (33.3%)
	performing minor tasks at home	18 (100.0%)	0 (0.0%)
	supporting in administration (missing: N=2)	9 (50.0%)	7 (38.9%)
	preparing food, cooking (missing: N=1)	10 (55.6%)	7 (38.9%)
Nursing tasks	medication administration (missing: N=1)	14 (77.8%)	3 (16.7%)
	blood pressure, pulse, blood sugar measurement	17 (94.4%)	1 (5.6%)

	injection administration (into a muscle) (missing: N=2)	11 (61.1%)	5 (27.8%)
Movement support, and body care	supporting in standing up and walking	17 (94.4%)	1 (5.6%)
	rehabilitation exercises with the patient	16 (88.9%)	2 (11.1%)
	transporting smaller objects	18 (100.0%)	0 (0.0%)
	repositioning the patient in bed (missing: N=1)	16 (88.9%)	1 (5.6%)
	supporting in personal care (e.g., bathing) (missing: N=1)	14 (77.8%)	3 (16.7%)
	drinking and feeding the patient (missing: N=1)	13 (72.2%)	4 (22.2%)
Companionship and communication	communicating with the patient	17 (94.4%)	1 (5.6%)
	reading, playing music to maintain/improve mental health	17 (94.4%)	1 (5.6%)
	supporting the social life of the patient (e.g., making video calls)	15 (83.3%)	3 (16.7%)
Patient monitoring	functioning as an emergency call device	18 (100.0%)	0 (0.0%)
	a remote monitoring system for the caregiver	17 (94.4%)	1 (5.6%)
	a remote monitoring system for health care professionals (missing: N=1)	13 (72.2%)	4 (22.2%)
	collecting patient data for the caregiver	16 (88.9%)	2 (11.1%)
	collecting patient data for the doctor	17 (94.4%)	1 (5.6%)

3.3 CarerQol Areas where Robots could Assist in Providing Informal Care

Carers were asked which specific care related quality of life domains a robot could potentially improve. The results (Table 4.) indicate the most important area chosen by 15 respondents was the 'Fewer problems combining care tasks with my daily activities'. The CarerQoL survey indicated that the same participants reported to experience some or many problems in this area. 'More support with carrying out my care tasks when I need it' and 'Fewer problems with my own physical health' were identified as the subsequent most significant elements, both demonstrating equivalent results (9-9 respondents). The corresponding CarerQoL items indicated that 12 and 14 carers faced some or many challenges in these two areas. The subsequent important factor, selected by 8 participants, was 'Fewer problems with my own mental health', a concern that affected 15 of the 18 informal carers based on the CarerQoL results.

Table 4
CarerQoL and areas where robots could support with informal care

Care-related quality of life of the informal caregivers assessed with the CarerQoL, N (%) of total participants					Areas the informal caregivers think a robot could improve, N (%) of total participants	
	no	some	a lot of			
I have	1 (5.6%)	6 (33.3%)	10 (55.6%)	fulfilment from carrying out my care tasks.	More fulfilment from carrying out my care tasks.	4 (22.2%)
I have	9 (50.0%)	5 (27.8%)	2 (11.1%)	relational problems with the care receiver.	Fewer relational problems with the care receiver.	6 (33.3%)
I have	3 (16.7%)	10 (55.6%)	5 (27.8%)	problems with my own mental health.	Fewer problems with my own mental health.	8 (44.4%)
I have	3 (16.7%)	9 (50.0%)	6 (33.3%)	problems combining my care tasks with my daily activities.	Fewer problems combining my care tasks with my daily activities.	15 (83.3%)
I have	12 (66.7%)	4 (22.2%)	0 (0.0%)	financial problems because of my care tasks.	Less financial problems because of my care tasks.	4 (22.2%)
I have	6 (33.3%)	5 (27.8%)	7 (38.9%)	support with carrying out my care tasks, when I need it.	More support with carrying out my care tasks, when I need it.	9 (50.0%)
I have	3 (16.7%)	10 (55.6%)	4 (22.2%)	problems with my own physical health.	Fewer problems with my own physical health.	9 (50.0%)

Free text answer, N=1: The robot could "replace" the physiotherapist. The patient reacts differently to the instructions of a "stranger" and carries them out without any comment.

4 Discussion

Our research explored the attitudes and preferences of informal caregivers regarding the use of assistive robots in informal care. All respondents expressed their willingness to incorporate robotic assistance in their caregiving duties despite the notably low adoption rate of innovative digital devices in general and the lack of previous personal experience with any type of robots. The NARS results also indicated a generally positive attitude towards robots among informal caregivers. Participants reported favorable dispositions towards situations and interactions with robots, while maintaining a neutral stance concerning the social influence of robots and emotions in interaction with robots. Attitudes and acceptance of robotic devices exhibit considerable variation. Our findings underscore a clear willingness to integrate robotic technologies in caregiving practices. However, eight out of the 18 respondents reported that the home environment of the care recipient is currently not suitable for a robot to navigate effectively, highighting that besides human factors, further barriers may remain in the implementation of assistive robots in home care.

Acceptance of robot functions varied largely. We found interesting that all informal caregivers would accept a robot performing minor tasks such as switching on lights or controlling heating. These tasks could be handled effectively by smart home systems. However, such systems in the elderly population's homes in Hungary are usually not available. The perceived importance of various robot characteristics was more homogenious (with average scores varying between 2.8 and 3.9 on a 1-4 scale). (Table 2) Nonetheless, when respondents were asked to select the five most important robot characteristics from the same list, responses showed greater differentiation (Figure 1). Ease of use-emerged as the most significant feature, with the majority of participants emphasizing its importance. Movement support was identified as the second most critical characteristic, with high acceptance levels for tasks such as assisting in standing, walking, repositioning patients in bed, and supporting rehabilitation exercises. This finding underscores the potential value of assistive robots in enhancing mobility and physical support for care recipients. Support for daily chores and household tasks ranked third in importance. Subsequent survey questions revealed a strong need for various supporting activities, such as lifting objects, sending reminders and performing minor tasks at home. While also highlighted areas of reluctance for robots helping with administrative tasks or preparing food or cooking. Safety was ranked fourth among important robot characteristics. While stringent safety standards are governing assistive robots, further research is necessary to gain insights from the target population regarding specific features, characteristics, and design elements that would effectively demonstrate the robot's safety to users. The fifth important characteristics was support in maintaining the health of the care recipient, including tasks such as medication administration and various measurements. However, an analysis of acceptance levels of various nursing tasks and the free-text responses revealed that despite high acceptance of robot-performed tasks, caregivers still have concerns with trusting a robot with specific procedures.

The importance of personal contact was repeatedly emphasized by the informal caregivers across various tasks. The perception of both patients and caregivers can be significantly influenced by carefully designed robot characteristics. For instance, implementing a remote monitoring system for caregivers in conjunction with a patient monitoring device that transmits vital signs data [24] could enhance the perception of proper feedback and ensure that robot-performed tasks are executed correctly and safely. Notably, these functions were deemed acceptable by most respondents. It is also noteworthy that there was a greater opposition to remote monitoring by professionals compared to caregivers, despite the fact that cybersecurity risks exist regardless of data access authorization. This contradiction suggests a misunderstanding of cybersecurity principles or a conflation with issues of trust. This finding highlights the need for better cybersecurity education and robust security protocols in all remote monitoring systems.

From the patient's perspective, as indicated in free-text responses, a humanoid robot with a pleasant appearance and soothing voice might be more acceptable to care recipients and could positively impact their mental health. Conversely, a robot resembling a living creature might potentially evoke fear or discomfort among other patients. The survey has also revealed that voice and appearance were selected to be the most important physical characteristics by the caregivers, therefore the most influencing factors for a positive perception of a robot companion. Considering emotional needs of care recipients ('Cared person need to feel love') and understanding how assistive technologies can support emotional needs is a potential direction for future research.

Similarly, literature research has shown that users' preferences for robot appearance are multifaceted and sometimes contradictory. According to research, healthy adults are generally receptive to domestic robotic integration [25], and older adults demonstrate a higher acceptance for a robot compared to their caregivers and relatives [26]. While some studies report a preference for humanoid features [27], others indicate an inclination towards more abstract or non-anthropomorphic designs [28, 29] and some even accepting of both human and object like looks [25]. The respondents' discomfort with human-like robots aligns with the uncanny valley phenomenon, a well-documented concept in human-robot interaction literature. Recent research suggests that the uncanny valley effect may manifest only under specific conditions, particularly when there is an incongruence between artificial and human attributes, rather than being a universal response or influenced by movement as originally proposed [30]. This dichotomy underscores the importance of considering diverse user preferences in robot design.

Regarding functionality, recent studies on user preferences for assistive robots have reported a need for more complex and diverse functionalities to enhance independence. Users express a need for robots capable of performing a wide range of tasks, including fetching and carrying objects, emergency communication, medication delivery, rehabilitation/ fitness assistance and sending reminders [31, 32]. However, there's a notable reluctance towards robotic assistance in intimate activities such as bathing, feeding and dressing. In general, users show a preference for human assistance in personal care and leisure activities, while favoring robotic help for household chores and object management [26, 33-36]. It is essential to recognize that variations in requirements may arise from the fact that our findings pertain to informal caregivers, while the literature primarily focuses on patients.

The advancement of Natural Language Processing is projected to enhance robot-human communication capabilities, potentially altering the acceptance and significance of various functionalities. The COVID-19 pandemic has demonstrated that during critical periods, methodologies previously underutilized (such as telemedicine) can rapidly gain widespread adoption. These factors may necessitate a reevaluation of existing paradigms on the implementation of robotics across diverse applications [37, 38].

This study's significant strength lies in its comprehensive data collection from the perspective of informal caregivers, complementing existing research that primarily focuses on patient attitudes and expectations. The extensive free-text responses provide valuable insights into the complex phenomena of perceptions, needs, and expectations regarding assistive robots, offering a more holistic understanding of how these technologies can support both patients and caregivers.

However, some limitations must be acknowledged when interpreting the results, such as the relatively small sample size and the study's limitation to a single country. Furthermore, the majority of respondents and their care recipients reported low levels of engagement with novel technologies and devices. While attitudes primarily drive the intention to use new technologies, greater experience with health technology devices could potentially provide more appropriate judgments and more precise expectations from the target population [18]. Additionally, the survey did not include detailed questions pertaining to specific robot characteristics that respondents identified as very important, such as ease of use, safety, voice of the robot. To address these limitations and expand upon the current findings, future research is recommended. Such studies should incorporate a broader population, including participants with more extensive experience with technology. Moreover, these should focus specifically on robot characteristics not covered in detail in this study. This approach would provide a more comprehensive understanding of user needs and expectations regarding the assisitive robot technologies. Despite the recent advances in medical robot standards and ethical development practices [39], assessing social acceptance of such critical technology components remain a significant challenge [40].

Conclusions

Our study provides valuable insights for the design and development of assistive robots in home care contexts. Our research outcomes, complemented by the existing literature, suggest that while there is growing acceptance of assistive robots, their design and functionality should be carefully tailored to respect user preferences. A balanced approach is needed that addresses functional requirements while considering the psychological and emotional aspects of human-robot interaction in caregiving scenarios. The emphasis should be on enhancing independence in practical, everyday tasks while maintaining human involvement in more personal aspects of care.

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