Empowering future care workforces: scoping human capabilities to leverage assistive robotics

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ABSTRACT

How and what health and care professionals do will be changed by the use of robotics technologies in their workplaces. This paper reports provisional results of a 12-month scoping project in which we explained to people working in care sectors what emerging robotics and autonomous systems (RAS) in health and social care look like at present and how they are designed to work. With participants such as nurses, physiotherapists and occupational therapists we explored how RAS might develop in ways that empower professionals and are safe, trustworthy, legal and ethical. Our research shows a diversity of tasks are valued by professionals and a range of human capabilities are required throughout care organisations in order to support them. Our findings have implications for how health and care professionals and operators might develop training programmes that best align the use of emerging RAS with practices of care, and how robotics systems might be responsibly designed to meet the needs of diverse professionals and service users. Today's professionals told us that in the future they will want to continue doing what they signed up for. Responsible robotics research will ensure that technology enables and empowers them to do this as needed.

CCS CONCEPTS

• **Social and professional topics → Employment issues**; **Assistive technologies**.

KEYWORDS

robotics and autonomous systems in care, assistive robotics, human capabilities, responsible research and innovation

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TAS '23, July 11–12, 2023, Edinburgh, United Kingdom

ACM ISBN 979-8-4007-0734-6/23/07.
https://doi.org/10.1145/3597512.3600210

ACM Reference Format:
Cian O'Donovan, Praminda Caleb-Solly, Praveen Kumar, Siabhainn Russell, Linda Sumpter, and Robin Williams. 2023. Empowering future care workforces: scoping human capabilities to leverage assistive robotics. In *First International Symposium on Trustworthy Autonomous Systems (TAS '23), July 11–12, 2023, Edinburgh, United Kingdom.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3597512.3600210

1 INTRODUCTION

Health and care professionals (HCPs) deploy a diverse set of capabilities in fulfilling their role [9, 11]. They feel empowered and engaged where they can utilize skills and pursue goals they value. For instance, being able to undertake their care tasks safely and with empathy; being able to manage their own time so they feel in control; having confidence in their own judgments and having prospects to advance in their career. Robotics and autonomous systems (RAS) in care settings are often valued and promoted precisely for their potential to strengthen the human capabilities [6, 10] that underpin these tasks. This paper reports provisional findings from a 12-month co-design project that scoped what knowledge, skills and human capabilities are required to empower care professionals to use physically assistive robotics in ways that are safe, trustworthy, and meet the legal and ethical standards of their profession. We discuss implications of these findings for training needs in care sectors and prospective strategies for responsible research and innovation that build on our capabilities framework.

For RAS to be safe, trustworthy, and accountable, their design and operation must be assured through dynamic and ongoing verification and validation processes, underpinned by specific human-digital capabilities. Understanding what capabilities matter and how to cultivate them is especially important in care settings because of the complex, unstructured, dynamic and unpredictable nature of these locations, and because the conditions of care recipients are often in flux (e.g. because of ageing or changing health conditions). However, there is currently a gap in considering the full extent of the impact these technologies may have on training needs [13]. We wanted to address this gap by understanding the skills, knowledge and capabilities required by professionals to use RAS effectively. In other words, what kind of human capabilities will professionals themselves need in order to work alongside robotics systems in the future, and what kind of hopes and concerns might they have about their future jobs?

To answer these questions, we convened participant groups of professionals such as occupational therapists, nurses, physiotherapists along with service uses and family members. Thinking about the skills, expertise and experience that underpin the appropriate use of RAS amongst care professionals, we were interested in who does what, when and how often. Building on prior research by some of the team that identified skills and training needs of health and care professionals [13], we asked what tasks are required to use RAS in dynamic care settings? For instance, tasks such as using the system as intended, assessing safety, configuring the initial system, updating or repairing the system or to handle data appropriately.

A highlight of the research project is the production of six sets of human capabilities valued by HCPs in pursuit of doing their jobs. We produced these sets through systematic analysis of the data and iterative testing of findings with participants. We believe such capability sets have the potential to be used analytically in evaluating how well RAS are contributing to staff and service user empowerment. For instance, by mapping the human capabilities valued by staff and service users in specific care settings, and assessing the degree to which these capabilities are actually realised by the use of robotics systems in practice.

In future work, this kind of human capability mapping might help guide the specification of technical requirements for robotics and autonomous systems in care, and inform decisions about what tasks and decisions should be automated in order to ensure that human values remain at heart of robotics solutions. As such, further co-design will be needed to tune requirements and configuration specifications

2 METHODS AND MATERIALS

The project established a diverse 14-person stakeholder co-design steering group which included experts in national policy, practising professionals, clinical researchers as well as interdisciplinary robotics researchers. Two steering group workshops held at the start of the project reflected on research from previous projects [5] and guided us in creating an initial set of participant engagement protocols. The research progressed through two rounds of online and hybrid workshops. In the first rounds, 33 participants joined seven 90-minute online workshops with one further workshop organised at UWE Bristol's Schools of Health and Social Wellbeing for people for whom real world engagement was more appropriate. In the second round, 19 participants joined us at two hybrid workshops in the University of Nottingham's Cobot Maker Space and the National Robotarium in Heriot-Watt University respectively. At the second-round workshops participants had an opportunity to see some of the robotics platforms being used for research. Both events were run in conjunction with the EPSRC EMERGENCE Network for Tackling Frailty.[1] These hybrid workshops allowed us to ask participants what tasks they valued in their jobs already and then test and advance theories of human capability building demonstrating real robots in settings that were designed to account for real life care contexts.

Workshops were recorded, transcribed, and coded using NVIVO software. Two members of the research team independently coded transcripts from the first set of workshops at references to tasks and practices valued by participants and the underlying skills, knowledge and capabilities that supported these tasks. Codes were compared and discussed with the wider team producing a list of representative sets of human capabilities. These capability sets were then iteratively tested and discussed during follow-up workshops. We engaged and tested work at a special project workshop for industry and global robotics researchers at the global robotics conference IROS 2022 [2] and amongst physiotherapists at the annual conference of the Association for Chartered Physiotherapists in Neurology. We also verified results at two events hosted by the TAS Governance Node and University of Edinburgh as part of outreach during the 2023 Edinburgh Science Festival: a knowledge café workshop involving care professionals and an expert-led round-table public talk. In all, the project hosted 12 research engagements with over 100 participants including more than 60 health and care professionals.

3 FINDINGS

Participant responses were diverse. First people told us about relevant capabilities they valued having in their jobs today. For instance, having people skills, communication skills, patience and empathy, coaching skills, being able to help service users navigate technology and structure it into their everyday lives, and analytic skills that help them assess service users' ability to function and manage daily life. They told us that common sense, experience and interpersonal skills are crucial. Participants also voiced a wide range of questions about potential changes to front line staff tasks – for instance caring for service users in care homes or clinics – and about broader organisational and institutional concerns, for instance procurement, legal and regulatory skills needed. For example, questions included: is the robotics system registered as a medical device? Will it fit through a narrow doorway or work on an uneven carpet? Will the system understand accents, dialects and speech impediments? How do we keep tabs on the value the system is creating and how do we evidence its efficacy?

Often participants framed their responses using questions about what robotic systems might do: Will the system accurately report its own faults? Will it self-maintain? Will it function with poor wi-fi access? Will robotic systems be able to recognise the many different carers it will likely encounter. Indeed, this tendency for participants to frame questions we were asking about human skills in terms of robotic functionality is an intriguing methodological issue in itself, one that hints at powerful currents of technological determinism built into how participants already think about embedding technology in everyday situations. One important area for future research will be investigating trade-offs between choices of robotic system design on the one hand and cultivating staff capabilities through training on the other.

In all, these data show the breadth of tasks valued by HCPs and the huge range of skills, knowledge and capabilities required throughout care organisations needed to support them. Today's professionals told us that in the future they will want to continue

[1]See https://www.emergencerobotics.net/

[2]See https://www.emergencerobotics.net/events/iros-2022-workshop/workshop-organisers

doing what they signed up to do. Developers of robotics systems should ensure that the technology enables and empowers them to do this as needed.

3.1 The skills, knowledge and capabilities required by HCPs, patients and carers for effective use of RAS

The study revealed six sets of capabilities valued by health and care professionals for working alongside robotics and autonomous systems (RAS) in health and care settings. These are:

(1) For HCPs to have confidence in their ability to use robots (self-efficacy).
(2) For all stakeholders to be involved in learning from interactions with RAS, and be empowered to implement lessons.
(3) For roboticists to recognise and respond to a diversity of values and needs.
(4) For organisations to ensure that RAS are fairly procured, distributed and accessible across patient pathways and places.
(5) For HCPs to have the ability to control infrastructure and environment in which RAS are embedded.
(6) For all stakeholders to ensure design and implementation is responsible.

3.2 Why these capabilities are useful

These are useful additions to existing lists of digital skills, capabilities and competency frameworks, examples of which have been published by the government and professional bodies [1, 3]. They extend the skills, knowledge, and capabilities we know are valued by professionals themselves. To our knowledge, they are the first list of capabilities explicitly built around robotics and autonomous systems in UK care settings rather than more general-purpose digital technologies. What sets these capabilities apart from other lists is their attention to complexity and scale. For instance the complex and dynamic environments in which care takes place, constantly changing as service users' conditions improve or deteriorate; as care professionals progress through careers; or as built infrastructure such as wards, clinics and homes change with the times. Discussing these settings, participants also mentioned pragmatic concerns about getting machines to work in everyday settings as well as issues of maintenance, troubleshooting and repair. Also, we expect the degree to which these capabilities are valued by specific care professionals to vary depending on local arrangements of technology and culture. Future analysis will explicate these capability sets in further detail and comment on how they might be cultivated in specific real-life care settings.

3.3 Empowering care organisations: organisational capabilities and learning

Our second finding is at the level of organisations. Participants told us that people throughout the care system need to be empowered to use and make decisions about the use and role of robotics. This is something of a departure from existing digital capabilities frameworks that focus on building skills amongst specific staff such as data analysts or nurses [3, 7]. Our analysis indicates a more comprehensive, yet nuanced approach to workforce training is required. Beyond front-line staff, legal teams, procurement officers, safeguarding and risk officers and regulatory gatekeepers all have a stake in how robots are embedded in care systems. The need for a diverse range of human capabilities throughout the care system tells us that training is not simply important for staff and unpaid carers on the ground but needed by stakeholders throughout organisations.

3.4 Methodological challenges remain, user requirements are still ambiguous

Health and care professionals also bring their own practical understandings of settings of care - flagging issues (e.g. wi-fi connectivity) that might be overlooked by designers in development settings. They are likely to be in the front line in terms of issues of embedding, configuration, maintenance, and fault-detection. Working with HCPs and service users though co-design methods revealed that often robotics designers don't fully understand what technological functionality would most satisfy stakeholder needs. We think part of the problem is this: in the design of RAS outlier safety cases often dominate design decisions in order to make sure the very worst doesn't happen but neglecting more tailored functionality for everyday uses and regular staff. However, getting to the root of this issue presented methodological challenges for us in the workshops. When we were supposed to be talking about human capabilities needed to work alongside RAS, participants were still telling us what they wanted the systems to do. Sometimes it wasn't clear to participants what the intention of specific robots was, or what features were built in to support its intended use. In other situations, they noted that technical features such as what data was captured and how it was made available for their use, were insufficient for their needs.

4 DISCUSSION OF IMPLICATIONS

4.1 Training robots and levels of autonomy – robotic functionality vs human empowerment

An important issue that emerged through our analysis was uncertainty regarding where decisions about appropriate levels of autonomy are made, who is designated to do this, and what skills and knowledge will be required. These kinds of decisions will dictate not only how the robotic system is expected to work, but also what the health and care professional is expected to do and how. For instance, consider the set-up process for a first-time RAS implementation in a care home. The robotic system will need to get data from somewhere to learn and be trained in terms of the baseline of how the system is to operate. Who provides that training? Who ensures the quality, relevance and veracity of the data? This issue of training data and systems goes beyond the training this project envisioned for staff and falls into the realm of designing trustworthy AI systems. Sticking with the same example, further questions arise. Should the system do predictive maintenance using its own sensors, or should staff do this independently, or should this be a mixture of both? These questions have implications for how staff need to be trained and how baselines are compiled, and the issue of who gets to answer these questions has further implications for governance and accountability in the sector.

Discussion with participants revealed ambiguity and uncertainty about what level of autonomy systems should be working at and how this might need to differ based on the functionality of the robot and the cognitive, sensory, and physical capability of the service user. This issue has profound implications for embedding RAS that can sense environmental change and adapt to those changes without human intervention. So, for instance, should robotics researchers spend increasingly expensive time and resource driving towards ever higher levels of autonomy, when what's really important for many healthcare professionals is having a clear idea about what they want to do in terms of setting the system up and checking the system is working correctly, particularly in relation to their legal and ethical responsibilities in various roles, and organisational commitments to trustworthiness?

4.2 Beyond technology push - Roles are shifting, new framings of robotic assistance are needed

Public discussions and media framings of future care often centre on technology push: they present the emergence of robots from labs into everyday life as inevitable and they privilege stories of how robots will replace human staff and tasks. Consequently, there tends to be a focus in policy on adapting workforces to emerging technology rather than engaging professionals in meaningful ways to steer innovation. However, our discussions with participants tell us that visions of future care work that hinge on the substitution of professionals by robots are often beside the point. Our participants were clear that staff in the future will need new skills, knowledge, and capabilities to work alongside RAS. For instance, roles that require core skills in manual handling and intimate touch may in the future require additional capabilities to assess the safety of robotic equipment and collate data for ongoing monitoring. New ways of discussing working alongside RAS are critical for staging deliberative fora where staff, service users and technologists might together discuss the direction robotics might proceed in and the impact RAS will have on changing care pathways and organisational cultures.

4.3 System-wide training is necessary for empowering health and care professionals - but it's not sufficient

Participants told us that while training important, it is also expensive, imposes burdens on time-poor staff and that one size training rarely fits all staff across organisations. Given social care is already understaffed and underfunded, these issues represent large challenges and call for huge investments in social, human, as well as technological capital.

Training, even when provided to everyone who will benefit from it, is only one side of the story. The job of cultivating skills, knowledge and human capabilities is also dependent on features and affordances of technology design (such as user interfaces), infrastructure (and how they are configured around new technologies) and organisational culture. Future research on integrating robotics in the health and social care sectors might extend this approach and more comprehensively investigate the trade-offs and tensions within the triad of i) the functional design of robotic systems, ii) aspirations, skills, knowledge and capabilities of staff and iii) organisational culture.

5 IMPLICATIONS FOR RESPONSIBLE ROBOTICS RESEARCH AND INNOVATION

These results are partial and provisional. Work remains, for instance systematically comparing these results against the findings of scholarship in areas of human computer interaction [2, 5, 14]. Nevertheless, we think our capabilities approach offers a useful analytic tool that might augment existing strategies for supporting responsible research and innovation in situations where there is genuine desire to distribute agency (empowerment) amongst researchers, designers, and end-users through collaborative innovation processes such as co-design, co-creation and co-production. Doing the kind of interdisciplinary innovation work that is central to robotics research requires that certain human capabilities exist within research teams [4] [13]. It follows that processes of RRI, constitutive of certain kinds of practices – for instance practices of anticipation, engagement, reflection and action (AREA); or practices of listening, to working across disciplines, and ensuring open collaboration (TAS) – require their own subset of innovation capabilities [12]. Our approach allows us explicitly map and understand how values like trustworthiness, responsibility, anticipation and reflexivity exist amongst care professionals in the first instance, and also amongst robotics researchers. The approach builds on frameworks that identify multi-disciplinary researcher capabilities [8]. In this project, we sought to understand what kind of 'RRI capabilities' for verifying safety and performance of assistive robotics in dynamic care contexts might be valued. Unfortunately, investigating the extent to which these capabilities were realised in practice was beyond our scope.

We see two potential applications for further developing and implementing this approach. First in terms of evaluating what kind of diverse practices of responsible innovation might be valued in the context of specific co-design, co-production or interdisciplinary research projects, perhaps mitigating against risks of instrumental capture faced by process orientated governance frameworks such as RRI – however well intentioned. Second in terms of formatively evaluating the capabilities for responsible innovation fostered at the level of research programmes. Our framework may attend not only measuring to individual research capabilities within projects, but broader capacities for RRI across entire programmes [12]. In this regard, as elsewhere, further development work remains.

ACKNOWLEDGEMENTS

This research was funded by UKRI TAS, grant number: EP/V00784X/1. We thank our research partners ACPIN and Bristol After Stroke, our project co-design steering group and our participants, without whom this kind of research would not be possible.

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Received 22 March 2023; revised 19 May 2023; accepted 26 May 2023