Guidelines for the Development of Care Robotics: A Human Factors Perspective

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SUMMARY

This mixed-methods study seeks to address the complex challenge of integrating robotics within adult social care by developing evidence-based design and implementation guidelines. Using a participatory design approach, the research combines public sentiment analysis, healthcare worker surveys, carer interviews, cognitive work analysis and expert review. The findings here highlight the importance of human-in-the-loop automation, unambiguous appliance-like design and integration with existing care systems and infrastructure. The resultant guidance offers actionable insights for designers, manufacturers, and policymakers to ensure safe, ethical, culturally sensitive and effective deployment of care robotics.

KEYWORDS

Human-robot interaction, aged care, participatory design, emerging technologies

Introduction

The UK's adult social care faces a dual challenge: an ageing population and a shrinking workforce providing vital frontline work. By 2060, the old-age dependency ratio is projected to rise to 52%, while the working population age declines. An additional one million care workers will be needed to fulfil this demand over the next decade. Robotics is often proposed as a solution to either alleviate the workload for carers or replace some roles entirely. Potential for this vision is further propelled by recent advancements in battery technology, materials science, computing networking, psychophysiological sensors and intelligent software. However, real-world deployments have largely failed due to technical, ethical and organisational barriers therefore meaningful integration of robotics in the aged care sector is yet to be seen. This project aims to bridge that gap by first identifying barriers and opportunities for sustainable implementation then creating a set of human-centred guidelines for care robotics grounded within a sociotechnical systems and end-user focused perspective.

Method

A participatory design (PD) approach was employed, gathering both qualitative and quantitative data from a variety of stakeholders. The study involved various methods: content analysis of 8,500 social media comments on contemporary robotics, a questionnaire with 40 healthcare workers evaluating robot acceptability, trust, adaptability and privacy concerns, semi-structured interviews with 10 frontliner carers, cognitive work analysis of the UK residential care system and expert review using a modified Delphi method.

Results

Public sentiment favoured robots with clear, bounded roles and appliance-like designs over anthropomorphic or general-purpose platforms. A significant correlation appeared between

perceived intelligence and trustworthiness (ρ = .71, p = .009). Healthcare workers expressed openness to robotics for domestic and repetitive tasks where timesaving and safety benefits could be found. They were more cautious about the use of robotics for intimate, sensitive care or situations which involves ethical quandaries surrounding mental capacity and data privacy. Interviews revealed six key themes:

Theme 1. Agency, Dignity & Consent – The potential to help patients maintain dignity and restore individual agency but also represents concern for a robot's ability to understand mental capacity and consent.

Theme 2. Workforce, Skills & Work Design – Impact on staff role, efficiency, workload and skills. Automation of domestic, repetitive and time-consuming tasks may facilitate a better care environment.

Theme 3. Data Privacy, Monitoring & Control – Concerns on data privacy and how ethical lines may be drawn differently depending upon circumstance.

Theme 4. Safety, Reliability & Accountability – The need for care robots to have clear liability frameworks, safety testing and context-dependent deployment.

Theme 5. Human Connection vs Automation – Increased automation is likely to reduce opportunities for social connections between patients and carers.

Theme 6. Implementation, Economics & Infrastructure – Cost, procurement and infrastructure needed to scale and support robotics including maintenance programs and parts availability

The work domain analysis identified administration, information management and monitoring as areas with high potential for automation. Expert feedback emphasised the need for standardised parts, lifecycle maintenance plans, safe and hygienic materials, accessible user-interface and sensitive alarm system design as well as rigid governance and strict operational parameters.

Combined, these stakeholder engagements form the following groups of guidelines: Behaviour & HRI (human-robot interaction), Legal & Ethics, Physical Design, Work & Systems Integration, Training and Maintenance. These consist of the following examples shown in Table 1, notably for the purposes of this paper this is limited to just one per group.

Table 1 - Limited Example Guidelines

Group	Guideline	Proposal	Supporting Evidence
Behaviour & HRI	1.2 Make behaviours predictable, transparent and calming to minimise cognitive load and startle.	Design and communicate robot behaviours to reduce cognitive load for both staff and service-users: pre-announce actions with short plain-language prompts and light cues, keep interaction patterns consistent, avoid ambiguous states, provide a single, predictable recovery path after errors, and summarise next steps on-screen/voice. Offer a 'low stimulus' mode (slower motion, fewer prompts) when residents appear fatigued or distressed while keeping staff views concise and actionable.	Theme 5 & 3, ISO 13482, HTM-08-01 acoustics, NICE NG97, Dautenhahn (2007a)

Group	Guideline	Proposal	Supporting Evidence
Legal & Ethics	2.1 Evidence and record decision-specific mental capacity and consent for any robot-enabled activity.	Implement consent models suited to capacity and context: offer dynamic consent with granular toggles per capability, tiered consent for high-risk functions, proxy/Lasting Power of Attorney where applicable, and assent/best-interests' workflows when capacity is time-varying. Record consent decisions with timestamps, responsible staff, expiry/review dates, and easy withdrawal.	Theme 1 & 2, WDA: Respect for Personhood & Capacity Mental Capacity Act 2005, SCIE best-interests guidance, BMA mental capacity toolkit Ghallab (2019)
Physical Design	3.2 Engineer inherently safe motion and contact.	Limit speed/torque by design, use compliant/soft interfaces, round edges. Guard against pinch points, put in place PFL (power and force limiting) and SSM (speed and separation monitoring) when relevant. Verify with risk assessment and physical testing with simulated skin and limbs.	Theme 4, ISO 13482, ISO 12100, ISO/TS 15066, Samadikhoshkho et al. 2025
Work & Systems Integration	4.3 Dynamic task assignment with carers being able to assign robots to patients, rooms or tasks.	Define autonomy boundaries: specify when the robot may self-initiate tasks, safety pre-conditions, priority rules and how conflicts are resolved, require human-in-the-loop for higher-risk actions, provide an immediate human override, and log all autonomous decisions for traceability.	Theme 6 and 2, ISO 9241 ISO 13482 Greenhalgh et al. 2017
Training, Maintenance & Economics	5.2 Build and design for user-serviceability and regular maintenance.	Provide a maintenance matrix, daily/weekly user checks (cleaning, visual inspection, consumables), monthly/annual manufacturer servicing. Maintain logbooks, lockouts for overdue service. Determine unsafe-to-use conditions. Provide parts catalogue, lifetime production guarantees, instruction sets and tools.	Theme 6 and 2, PUWER L2 (inspection/maintenance), CQC Reg. 15 (equipment)

Conclusions

This work investigates the perspectives of multi-level stakeholders to understand where the robots can be used successfully. Incorporation of the views of these parties seeks to forge practical and contextually sensitive solutions for a problem which has yet see significant progress. Further opportunities lie within intelligent software, multi-modal psychophysiological sensing and adaptive robotics which may see more responsive systems. However, this piece of work consolidates the voices of caregivers and public sentiment into a set of pragmatic requirements and guidance for future development and design of care robots.