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Designing Care Robots for Sustainable Healthcare Work

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***Abstract*— Compassionate care is widely acknowledged as a fundamental component of high-quality healthcare, closely linked to positive outcomes for both patients and their families. The increasing incidence of burnout and compassion fatigue among healthcare professionals represents a critical obstacle to maintaining this standard of care. Elevated stress levels, emotional exhaustion, and compassion fatigue can significantly impair professionals' capacity to offer empathetic and patient-focused support. This paper explores whether integrating care and assistive robots into healthcare environment can mitigate these challenges. By automating routine tasks and providing support, robots may contribute to creating a more sustainable work environment, thereby reducing stress, and burnout. To achieve this, we propose adopting a Value-Sensitive Design (VSD) approach which ensures that robots are not only technologically advanced but also ethically designed. VSD incorporates moral and social values throughout the design process, emphasizing that care robots must align with persons' needs and values. This approach highlights the importance of a value-based framework in shaping innovative robotic solutions.**

***Keywords*—patient-centred care, healthcare professionals, value sensitive design, robot ethics.**

Introduction

The increasing complexity of healthcare systems—characterized by chronic understaffing, heightened patient demands, and growing administrative responsibilities—has placed considerable strain on healthcare professionals [1], [4]. These structural conditions have been widely recognized as key contributors to burnout, emotional exhaustion, and compassion fatigue, which not only affect the psychological well-being of caregivers but also compromise the quality, continuity, and safety of care delivery [5]. In such a context, ensuring the sustainability of healthcare work has become a pressing concern. Addressing the needs of healthcare professionals requires the development of innovative and systemic strategies capable of relieving their workload without diminishing the quality of care. One promising avenue in this regard is the integration of robotics into healthcare environments, particularly as a means of supporting professionals in routine, repetitive, or resource-intensive tasks.

This paper explores whether integrating care and assistive robots into healthcare environments can contribute to reducing cognitive and emotional strain among healthcare professionals. By delegating repetitive, logistical, or administratively demanding tasks to robotic systems, these, robotics entities may help alleviate the pressures that often lead to burnout and compassion fatigue.

However, developing technologies which are truly capable of responding to professionals' need calls for a design approach that is attentive to the ethical, relational, and contextual dimensions of care work. To this end, we propose the adoption of a Value Sensitive Design (VSD) framework [6], which offers a methodological basis for embedding human values into technological development.

II. The Role of Robotic Assistance in Supporting Health Professionals

A. *Transforming Healthcare Practices Through Robots*

Robots have assumed an increasingly prominent role over the past decades, being deployed in hospitals in a wide range of contexts—from logistics and clinical assessment to rehabilitation and emotional companionship. For example, in the field of surgery, robotic systems such as the da Vinci Surgical System have become emblematic of the technological shift toward precision, minimal invasiveness, and enhanced control. These systems support surgeons in performing complex procedures with greater accuracy, contribute to better clinical outcomes and shorter patient recovery times, and reduce physical strain on healthcare professionals [7].

In the field of telemedicine, robotic entities have transformed patient-physician relationship, thereby expanding access to care while reducing the burden on healthcare infrastructures. For example, the Remote Presence Virtual + Independent Telemedicine Assistant (RP-VITA), a robot designed to facilitate remote consultations by connecting patients with physicians across distances, has proved effective in improving continuity of care, by enabling timely interventions while reducing the need for physical visits [8].

B. *Mitigating Burnout and Compassion Fatigue*

These advancements encourage to view robots not as merely substitutes but as valuable allies in the care process [6]–[11]. However, their potential extends far beyond these domains [12], encompassing roles that directly impact the caregiving process [13].

A compelling argument for robotic integration is its potential to address burnout and compassion fatigue among healthcare providers. These conditions not only compromise the well-being of professionals but also adversely affect the quality of care [14], [15]. By offloading routine–such as distributing meals, beverages, and medications–and administrative responsibilities, robots can alleviate the physical and emotional burdens experienced [16]. For instance, robotic medication delivery systems such as Pyxis automation system [17] or HOSBOT, developed within the ODIN – Open-Digital-Industrial and Networking pilot lines using modular components for scalable production Project (H2020 – 2024) [18] (from now on, ODIN Project), can ensure a timely and accurate administration of drugs, reducing a substantial source of stress for nurses and pharmacists.

Furthermore, in the domain of assistive and psychosocial care, pet-like robots such as PARO, AIBO, and iCat can provide emotional comfort and sensory stimulation to patients. This can minimize the need for repeated staff interventions allowing healthcare professionals to focus on more urgent or complex tasks. Moreover, such robots can facilitate a form of virtual presence, enabling caregivers to extend their support without being physically present at all times. Similarly, humanoid robots such as Pepper, Care-O-bot, and TIAGo have shown promise in reducing social isolation and promoting engagement among individuals with cognitive impairments, patients with dementia or recovering from stroke, and children on the autism spectrum. These robots support interaction and communication with healthcare personnel, favour a form of remote presence, while also reducing the overall healthcare burden [19].

Another compelling example can be found in the domain of rehabilitation. Robots such as Robear exemplify the potential of assistive technologies to support both patients and caregivers. These robotic systems are designed to assist in lifting and transferring individuals with reduced mobility, facilitate physical exercise and rehabilitation, and minimize the physical burden on healthcare staff—all while preserving patient autonomy and ensuring safety [20].

Additionally, robots equipped with artificial intelligence can streamline administrative and bureaucratic processes, enhancing operational efficiency across healthcare settings. Documentation, scheduling, and coordination of care are essential yet time-intensive tasks that often divert healthcare professionals from their core responsibilities. Systems capable of managing these operations can free up significant amounts of time for providers, allowing them to focus on patient care [21]. Beyond these logistical functions, care robots can also be programmed to support the well-being of healthcare workers by providing reminders for self-care activities or facilitating mindfulness-based interventions. Taken together, these capabilities offer a promising avenue for mitigating burnout and compassion fatigue, while fostering a healthier and more sustainable work environment.

III. Rethinking Value Sensitive Design for Robotics Entities in Healthcare

The examples provided underscore the importance of designing technologies that are not only technically effective but also capable of addressing the ethical needs encountered by healthcare professionals. However, this does not occur spontaneously or naively; rather, it follows clearly defined ethical pathways grounded in a robust framework of values.

This entails on one hand, strengthening healthcare professionals' capacity to understand their own needs and limitations [22]–[24]. On the other hand, it involves developing robotic designs that are responsive to these very needs through the integration of ethical values [6]. Consequently, adopting a Value Sensitive Design (VSD) approach becomes crucial.

VSD operates on the premise that new technologies are not value-neutral and can be defined as a theoretically grounded design methodology that systematically integrates ethical and social values into the development of technology, starting from early conceptual stages through to implementation [25].

Recent work by Umbrello and colleagues has adapted this framework to the field of care robotics, proposing a model that incorporates care-centred values, ethical considerations specific to AI, and broader normative aims such as the United Nations Sustainable Development Goals (SDGs). This contribution moves beyond approaches focused exclusively on traditional care-related moral qualities—such as those theorized by Joan Tronto, including attentiveness, responsibility, competence, and responsiveness [26]—as seen in the foundational work of authors like van Wynsberghe [27], [28]. Umbrello and colleagues instead advance a broader set of values, capable of addressing the ethical complexity of contemporary care environments.

Integrating this design framework into the development of care robots would enable engineers to create systems that centre on human needs and values. By doing so, VSD ensures that robotic solutions are not only technologically advanced but also ethically grounded, fostering trust and alignment between technology and those it serves. Figure 1 outlines a general structure that engineers can adopt when initiating investigations within a design process. The proposed framework offers a comprehensive guide to ensure that key dimensions—contextual, conceptual, and technical—are adequately addressed throughout the development cycle.

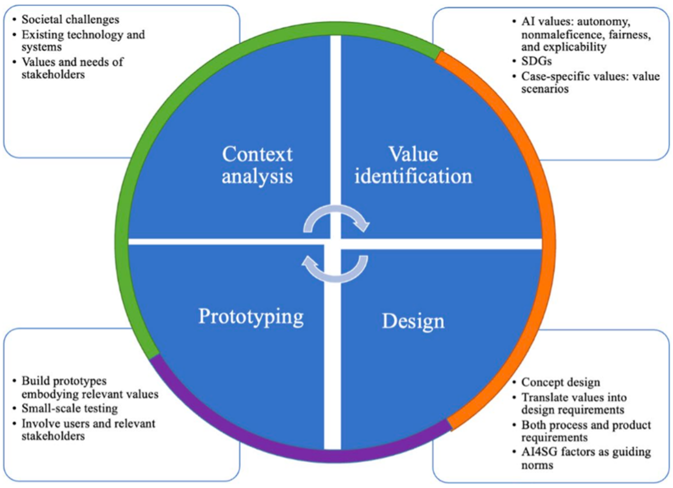

Fig. 1: AI4SG-VSD design process; Green: empirical investigation; orange: conceptual inv.; purple: technical inv. [29]

Let us now explore how this can be implemented in practice. A first step involves translating abstract values into observable behaviours, performative actions, and communicative-linguistic modalities that reflect and enact the selected values. For instance, consider a hospital ward where care professionals are simultaneously confronted with bureaucratic, administrative, managerial, and direct caregiving responsibilities. In such a setting, healthcare professionals often experience administrative and bureaucratical tasks as a source of significant stress and anxiety.

Envisioning how a robotic entity could serve as a resource in this context, we might consider a care robot designed to assist professionals supporting task recall throughout the day, prioritizing tasks according to urgency and relevance. This robot could function as an intelligent assistant, organizing and managing routine duties, thereby alleviating cognitive load and allowing healthcare providers to focus more on patient-centred activities. This functionality may embody the value of attentiveness, as articulated by Tronto, by demonstrating a form of care and attention to the needs of others.

As this example illustrates, any value-informed design must begin with a close reading of the context and the individuals who inhabit it. This requires the structuring of the design process around a community of care in which the professional is seen as a co-pilot of the design phase and includes a careful identification of the needs and the corresponding ethical values that the robot should embody.

Once proposed actions are conceptualized, they should be shared with engineers and computer scientists, allowing for an assessment of technical feasibility and the refinement of implementation strategies. For these reasons, VSD must be situated within the broader paradigm of ethics by design, which acknowledges that technological innovation is not solely a matter of engineering or computational competence. Rather, it demands ethical reflection, deep listening to the users who will engage with the technology, and the active involvement of all relevant stakeholders.

IV. Bio-Engineering Challenges

The considerations we have outlined not only open up ethical and social dimensions but also highlight significant bio-engineering challenges. Hospitals across Europe, especially during the COVID-19 pandemic, have struggled to adapt to unprecedented demands, such as increasing the capacity of intensive care units. To address these challenges, the EU-funded ODIN project has identified several hospital care issues that can be tackled by combining robotics, IoT, and AI. By deploying autonomous and collaborative robots, hospitals can reduce the workload of overstretched staff while introducing services that range from clinical assistance to logistical support. This approach aims to facilitate a transition toward data-driven healthcare procedures and management, aligning with the VSD principles of centring technology on human needs.

Despite these advances, the widespread adoption of robotic technologies highlights key bio-engineering challenges. Ensuring the reliability of robots operating in shared human environments and prioritizing user safety remain critical issues, particularly for mobile platforms capable of autonomous navigation. Standardized evaluation protocols for hospital-based robot navigation are still lacking, creating a gap in ensuring consistent and reliable deployment of these technologies.

The ODIN project [30] aims at addressing this limitation by introducing a structured benchmarking protocol that includes standardized tests designed for conditions of increasing complexity, alongside a set of quantitative performance metrics. This methodology has been applied in real-world settings to assess the capabilities of two robotic platforms, HOSBOT and TIAGo, each designed with distinct technical features for different clinical applications. Preliminary results highlight the potential of these systems to improve efficiency and adaptability in healthcare environments [18].

The ODIN project sheds light on the possibilities as well as the complexity of introducing emerging technologies in hospital environments, with particular attention to issues such as reliability, safety, spatial control, logistical flow optimization, and data collection. While grounded in a specific case, these challenges are common to many healthcare innovation efforts, suggesting the need for a generalizable approach that integrates engineering capabilities with ethical and organizational guidance.

V. Conclusion

Extending the principles of VSD to the implementation of robotic platforms opens new possibilities for addressing workload challenges in healthcare while ensuring alignment with human values. This emerging partnership between healthcare professionals and care robots presents a new frontier of ethical, social, and engineering challenges. Tackling these challenges within an integrated framework informed by VSD would be critical to fostering trust and ensuring that healthcare robotics not only meet technical requirements but also uphold the values and priorities of the professionals and patients they serve.

By automating routine tasks, streamlining administrative processes, and enhancing healthcare professional-patient interactions, robots can create a more sustainable and compassionate healthcare system. Beyond their functional roles, robotic systems have the potential to re-humanize healthcare by enabling providers to focus on empathetic and personalized care. The goal is to think of a professional-patient relationship not inhibited by robots but facilitated by their presence and proactive interaction. However, achieving this vision requires more than technical advancements alone, as we have emphasized throughout this paper. A VSD approach is essential to ensure that robotics aligns with the values central to care practices. By embedding specific ethical principles into the design and implementation of robotic systems, VSD provides a framework that bridges the human and technological dimensions of caregiving.

How can VSD open new possibilities? One of the most significant contributions of the VSD approach lies in its promotion of interdisciplinary collaboration, which counters the fragmentation of knowledge often observed in technological development. Rather than isolating technical, ethical, and social considerations, VSD fosters an integrated design process that results in technologies not only robust from a technical standpoint, but also ethically sound and socially responsive. This holistic orientation allows for the development of systems that are increasingly aligned with societal needs, and that place users at the very centre of the design process.

In this sense, VSD creates the conditions for technologies capable of delivering not only material and technically effective forms of care, but also a more comprehensive, person-centred care—attuned to the needs, desires, and preferences of the user. By integrating ethical reflection into every stage of design, VSD enables the creation of robotic systems that contribute meaningfully to human well-being in all its dimensions.

Future research should prioritize the development of VSD methodologies tailored to healthcare robotics, fostering innovations that balance technical progress with ethical responsibility. This approach will ensure that robots advance healthcare efficiency while remaining aligned with the fundamental ethical principles of caregiving.

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