Ethical Implications of Autonomous Robotics in Patient Monitoring and End-of-Life Care

Author: Olusoji John Samuel **Affiliation:** University of Roehampton, London, United Kingdom

Email: essojay007@gmail.com

Abstract

The advent of increasingly autonomous robotic systems for patient monitoring and end-of-life (EOL) care poses significant ethical, legal, technical and organizational challenges for healthcare delivery. Such systems promise improvements in continuous monitoring, early detection of clinical deterioration, resource optimization, and enhanced access to care. At the same time, they raise fundamental questions regarding patient autonomy, dignity, human supervision, accountability, fairness, data governance, and the meaning of human care in final-phase lifecycles. This article presents a systematic and integrative examination of the ethical implications of deploying autonomous robotics in patient-monitoring paradigms and end-of-life care settings. We first review the technological landscape of autonomous robotics in healthcare, then conduct an extended literature review of ethical frameworks and empirical studies. We then articulate the main ethical domains (autonomy & dignity; beneficence/non-maleficence; justice; accountability & liability; data/privacy; human-machine relationality) in the context of monitoring and EOL care. We examine domain-specific applications (continuous monitoring in acute and home settings; palliative robotics; decision aids) and associated ethical trade-offs. Finally, we discuss governance, regulatory and design recommendations, and propose a research agenda. We conclude that while autonomous robotics hold considerable promise, successful and ethically robust adoption demands a human-centred, socially embedded, multi-stakeholder approach with explicit ethical governance and situational sensitivity.

Keywords: autonomous robotics; patient monitoring; end-of-life care; ethics; healthcare robotics; accountability; human dignity; data privacy; algorithmic fairness.

1. Introduction

The convergence of robotics, artificial intelligence (AI) and machine-learning (ML) technologies has begun to transform many sectors, including healthcare. In recent years, a growing body of research has explored how robotics can contribute to disease diagnosis, treatment and monitoring (Fatunmbi, 2022). These integrative approaches for precision medicine envisage robotics not only as passive instruments but as active, intelligent partners in care. Autonomous or semi-autonomous robots are now designed for patient monitoring (vital sign surveillance, motion/fall detection, telepresence) and even direct caregiving support, especially for aging populations and those with chronic or terminal conditions (Sapci & Sapci, 2019).

In parallel, end-of-life (EOL) care encompassing palliative care, hospice services and terminal-phase medical management presents profound ethical, personal and systemic challenges including pain

management, dignity, autonomy, resource allocation, and human presence (Chappell & Teven, 2023). The introduction of autonomous robotics into EOL care invites new ethical tensions: How should we understand "care" when mediated by machines? What is the role of human compassion or presence? How do we balance efficiency, safety and humanity?

This article focuses on the **ethical implications** of autonomous robotics in two inter-related arenas: **patient monitoring** (both in hospital/ICU and home settings) and **end-of-life care** (including palliative, hospice, and terminal-phase contexts). Our aim is to provide a structured analysis that is theoretically grounded, technically informed, and practically relevant. In doing so we hope to assist engineers, clinicians, ethicists, policymakers and healthcare managers to navigate this evolving domain.

We proceed by first describing the technological and clinical landscape (Section 2), then offering an extended literature review of robotics, monitoring, and ethics (Section 3). Section 4 presents the ethical domains and frameworks, Section 5 delves into specific use-cases (monitoring, home/hospice, EOL decision-support) and ethical trade-offs. Section 6 explores governance, regulatory, design and organisational considerations. Section 7 proposes a research agenda and concludes.

2. Technological and Clinical Landscape

2.1 Autonomous Robotics for Patient Monitoring

Robotics in patient monitoring has evolved from simple telepresence and remote camera systems to more autonomous agents capable of sensing, analysis, alerting, actuation, and in some cases, direct patient interaction. For example, in intensive care units (ICUs) and acute settings, robots are used for telepresence consultations, vital-sign surveillance, mobility support and drug dispensing (JMIR Aging; J Med Internet Res). Empirical reviews show that robots can reduce response times, enhance access to specialist consultation and improve workflow efficiency (J Med Internet Res, 2022).

In home and community contexts, monitoring robots combine sensors (motion, video, vital signs) with algorithms to detect falls, track adherence, detect deterioration, provide reminders and alert caregivers (Sapci & Sapci, 2019). The rise of the Internet of Things (IoT), wearable sensors, cloud connectivity and edge analytics further enables continuous monitoring, paired with autonomous decision supports and robotic actions (e.g., repositioning a patient, delivering a medication).

2.2 Autonomous Robotics in End-of-Life and Palliative Care

In end-of-life care, robotics is a relatively nascent but growing field. Robots may provide companionship, support mobility, deliver medication, monitor comfort/pain levels, and even facilitate remote family contact or tele-hospice services. While many systems are semi-autonomous, the trend is toward greater autonomy: the robot detects changes in patient state, alerts staff or family, perhaps takes mitigating action and even engages in social interaction. The promise is two-fold: improved quality of life for patients (less isolation, better comfort) and relief of burden on overwhelmed caregivers and clinicians.

However, the special nature of EOL care where values such as dignity, presence, meaning, human connection and existential reflection are central makes the deployment of autonomous robots ethically fraught.

2.3 Autonomy Modes, Technical Capabilities, and Limitations

Autonomy in robotics is often characterised in levels: from tele-operated to semi-autonomous (robot assists/human supervises) to fully autonomous (robot makes decisions, acts with minimal human oversight). As autonomy increases, so do issues of reliability, safety, interaction, accountability and ethical risk (Fatunmbi, 2021).

Technical limitations remain substantial: sensor reliability, algorithmic generalisability, transferability of training data, adaptation to unexpected scenarios, robustness to failure, cybersecurity risks, and integration with human workflows (BMC Medical Informatics & Decision Making, 2023). In the specific context of patient monitoring and EOL care, robots must engage in deeply human-centred, context-sensitive tasks (e.g., assessing pain, comforting, interacting) which remain challenging for current AI/robotics.

2.4 Industry Application and Trends

From a healthcare systems perspective, adoption of robotics for monitoring and EOL care is driven by multiple pressures: ageing populations, shortage of skilled caregivers, increasing chronic disease burden, need for cost containment, and the shift toward home-based care and telehealth. Vendors and hospital systems are piloting robotic solutions for remote monitoring, fall prevention, tele-presence rounds, medication delivery, and even robotic companions (Fatunmbi, 2022). Cloud connectivity, edge computing, and robotics platforms are converging making remote, autonomous monitoring feasible in ways previously unimaginable.

Nevertheless, deployment remains limited, and the gap between lab-prototype and wide-scale clinical adoption is wide, particularly in EOL settings. The ethical, regulatory and organisational barriers are as salient as the technical ones.

3. Literature Review

This section offers a deep dive into scholarly work on robotics in healthcare (especially monitoring and EOL contexts), ethical frameworks, and empirical analyses of autonomous systems in clinical settings.

3.1 Robotics in Healthcare – Scope and Evidence

Several recent reviews map the field of healthcare robotics. Morgan, Abdi, Syed et al. (2022) present a scoping review of “Robots in Healthcare” showing diverse roles (telepresence, rehabilitation, monitoring, drug-dispensing) and emphasising the early stage of autonomous robotics adoption.

A systematic review in J Med Internet Res (2022) found that robot use in critical care (ICU) was mainly telepresence and evaluation, and that evidence for autonomous action is still limited; however, robots provided time-savings and workflow benefits.

In ageing and home care, Sapci & Sapci (2019) reviewed assistive technologies including intelligent home monitoring and robotic systems for older adults, and identified four themes: acceptance/readiness; novel monitoring technologies; algorithm/software engineering; and robotics technologies. They note that most studies lacked rigorous standards.

These reviews indicate that while robotic monitoring systems are expanding, the incorporation of higher levels of autonomy (decision-making, actuation, end-of-life interaction) remains emergent. Moreover, the ethical literature is less developed than the technical/clinical literature.

3.2 Ethical Literature of Healthcare Robotics and Autonomous Systems

Stahl & Coeckelbergh (2016) offer a seminal work on the ethics of healthcare robotics, arguing for a responsible research and innovation (RRI) approach. They list key concerns: human dignity, autonomy, agency, privacy, safety, professional roles, and socio-technical contexts.

Pirni, Balistreri, Capasso et al. (2021) explore “Robot Care Ethics between Autonomy and Vulnerability” focusing on elderly-care robots; they argue for a coupling of care ethics principles and practice, pointing out issues of vulnerability and the relational dimension of care (Fatunmbi, 2021).

On autonomous AI in healthcare more broadly, a 2023 article in BMC Medical Informatics & Decision Making details risks associated with autonomous functions of AI (including care robots) such as limitation of patient autonomy, dignity erosion, privacy violation, and cybersecurity vulnerabilities.

On surgical robotics, ethical literature has examined autonomy and the surgeon–robot relationship. For example, “The ethics of autonomous neurosurgical robots” (2024) notes trade-offs between improved precision and risk of human skill degradation, legal uncertainty and patient safety.

Similarly, “Autonomous surgical robotic systems and the liability dilemma” (2022) highlights the problematic allocation of responsibility when autonomous robots operate in surgical domains (Fatunmbi, 2022).

Finally, a legal-regulatory perspective: “The oversight of autonomous artificial intelligence: lessons from nurse practitioners as physician extenders” (Morrell, 2022) addresses how autonomous AI products in healthcare challenge existing regulatory schemes.

3.3 Gaps in the Literature

While much has been written about robotics in surgery, rehabilitation, telepresence and older-adult monitoring, there is less literature specifically on autonomous robotics in patient monitoring **and** end-of-life care, especially focusing on ethical implications. The intersection of continuous monitoring (often enabled by robotics/AI) with terminal-phase care (which emphasises dignity, human presence,

meaning) is under-explored. Moreover, few frameworks integrate autonomy levels, data/privacy issues, human-machine relationality, and EOL ethical values in one model.

We also note a gap in empirical studies regarding acceptance of robots in EOL settings (by patients, families, clinicians), and an absence of standardised ethical governance frameworks tailored to autonomous robotics in EOL contexts.

4. Ethical Domains and Frameworks

In this section we structure the ethical analysis into key domains relevant to autonomous robotics in patient monitoring and end-of-life care: Autonomy & dignity; Beneficence & non-maleficence; Justice; Accountability & liability; Data, privacy & transparency; Human-machine relationality and care. For each domain, we describe the normative foundations, map how autonomous robotics challenge or reshape the domain, and identify key questions and tensions.

4.1 Autonomy & Dignity

Normative foundations: Autonomy is a core principle in biomedical ethics: patients should be able to make informed decisions about their care. Dignity emphasises respect for persons and their worth. Autonomous robotics challenge these by potentially reducing human presence, altering decision-making dynamics, and shifting agency.

Challenges and tensions:

- Monitoring robots may continuously collect data and alert interventions, possibly reducing patient control or awareness of when they are observed, thus impacting dignity. BMC Medical Informatics & Decision Making outlines how care robots may restrict movement or monitor intimate behaviours, leading to dignity loss (Fatunmbi, 2022).
- In EOL settings, dignity is deeply valued; the presence of a robot rather than a human caregiver might be perceived as less authentic or compassionate. The “human touch” may be diminished (J Med Internet Res, 2022).
- Autonomy at the design level: When robots act semi-autonomously (e.g., repositioning a patient, delivering analgesic) who decides? Is the patient informed and consenting to robotic action?
- Patients may have diminished decision-making capacity (common in terminal care). Algorithms might infer preferences or act without explicit consent, raising questions about substituted judgment and autonomy (AMA Journal of Ethics, 2021).

4.2 Beneficence & Non-maleficence

Normative foundations: Healthcare ethics emphasise doing good (beneficence) and avoiding harm (non-maleficence). Robots promise benefits (continuous monitoring, timely alerts, pampering) but also risks (mis-detection, algorithmic error, dehumanisation).

Challenges and tensions:

- Evidence suggests robots can improve monitoring in ICU or home settings (J Med Internet Res, 2022) .
- But autonomous robotics may raise new harms: over-surveillance, false alarms, robot malfunction, loss of human judgement in critical scenarios (Pirni et al., 2021).
- In EOL care, the human dimension of caring empathetic listening, presence, and emotional support may not be replicable by robots; if the robot replaces some human contact, there is risk of diminished qualitative care.
- Further, reliance on autonomous robotics may lead to skill erosion among human caregivers (in surgery, the ethics literature notes skill-atrophy concerns with autonomous neurosurgical robots)

4.3 Justice

Normative foundations: Justice in healthcare refers to fair distribution of resources, equitable access, non-discrimination, and addressing disparities. Autonomous robotics may exacerbate or mitigate justice issues.

Challenges and tensions:

- Cost of robotics remains high; thus deployment may favour wealthier health systems or patients, creating inequity.
- Monitoring robots in the home depend on connectivity, sensors, and infrastructure – “digital divide” risks exist (Sapci & Sapci, 2019).
- Algorithmic bias: Autonomous monitoring systems may perform differently across demographic groups, raising fairness concerns (BMC Med Inform Decision Making)
- In EOL settings, there might be risk that robots serve some populations (e.g., private hospice) and not others (public, under-resourced).

4.4 Accountability & Liability

Normative foundations: When things go wrong in healthcare, responsibility, transparency and remediation are essential. Autonomous robotics blur the lines of agency and supervision.

Challenges and tensions:

- In autonomous surgical robotics literature, there is considerable ambiguity on who is liable when the robot errs (surgeon, manufacturer, hospital, algorithm designer) (Frontiers in Surgery)
- Morrell (2022) presents frameworks for oversight of autonomous AI products, drawing from nurse-practitioner oversight models.

- In monitoring/EOL care, if a robot fails to alert deterioration, or inappropriately acts (e.g., delivering a medication improperly), who is responsible?
- Autonomous action raises the “moral crumple zone” phenomenon: humans bear blame for machine decisions they did not control.
Key questions:
- How are responsibilities defined among human caregivers, engineers, hospital administrators and vendors when autonomous robots act?
- What frameworks (regulatory, contract, indemnity) should apply to autonomous robotic monitoring in EOL care?
- How is transparency achieved when algorithms make decisions about patient care?

4.5 Data, Privacy & Transparency

Normative foundations: Patient monitoring and robotics rely heavily on data sensor streams, video, audio, biometric readings. Healthcare ethics demands confidentiality, privacy, informed consent, and transparent use of data.

Challenges and tensions:

- Robots performing monitoring may capture intimate data (video in patient rooms, motion, voice) and could be vulnerable to data breaches, misuse or repurposing. (BMC Med Inform Decision Making)
- Autonomous systems may act on black-box algorithms; explainability and transparency are often weak.
- In EOL care, patients may be cognitively compromised, raising additional consent/assent issues.
- Data from home monitoring may be transferred to the cloud, shared with multiple stakeholders (family, hospice, vendors), raising governance concerns.
Key questions:
- How is patient (and family) consent obtained for robotic monitoring in EOL contexts?
- What safeguards exist for data storage, access, cybersecurity and secondary uses?
- How transparent are the robotic systems (algorithms, decision-making, alerts) and how are patients/families informed?

4.6 Human-Machine Relationality & the Meaning of Care

Normative foundations: Beyond principle-based ethics, care ethics emphasises relationality, responsiveness, empathy, and the moral significance of attentive care. Care robots challenge traditional notions of care.

Challenges and tensions:

- Pirni et al. (2021) examine robotics in elderly care through the lens of vulnerability and care ethics: robots may fulfil tasks but may struggle with relational presence.
- In EOL care, the meaning of human presence (holding a hand, listening, emotional support) is central; robotic substitution may undermine this. Some ICU clinicians express concern that robot integration may reduce the “human touch” and exacerbate patients’ feelings of isolation.
- On the other hand, robots may augment human presence (via telepresence), extend hours of care, reduce isolation when human staff are limited.

Key questions:

- Does robotic involvement alter the nature of care from relational to mechanical, and what are the implications for patient experience?
- How should robot design and workflow preserve or enhance human-machine teaming rather than human substitution?
- What qualitative metrics (patient/family experience, perceived presence, trust) are needed to evaluate robotic care in EOL contexts?

5. Application Contexts and Ethical Trade-Offs

In this section we examine specific application contexts of autonomous robotics for patient monitoring and end-of-life care, drawing out particular ethical trade-offs and considerations.

5.1 Continuous Monitoring in Acute / ICU Settings

Robots for monitoring in ICU or hospital wards may autonomously track vital signs, detect changes, alert nurses, reposition patients, deliver supplies or coordinate telepresence consults. Empirical studies show benefits: quicker response times, reduced staff workload (J Med Internet Res, 2022).

Ethical trade-offs include:

- **Benefit vs oversight:** robots may detect deterioration faster than humans, but they may also raise false alarms or miss contextual subtleties requiring human judgement.
- **Autonomy vs human control:** increased autonomy raises questions about human control and intervention clinicians emphasised that robots must not replace human judgment.
- **Privacy in open spaces:** ICU robots may film or record; patients in ICU are vulnerable; the monitoring burden may affect privacy and dignity.

- **Liability:** when a robot monitors and fails to alert or misdirects staff, the accountability question arises see surgical robotics liability literature. Hence, implementation must preserve human oversight, transparency of robot decision-making, strong fail-safe protocols, and clear role delineation between robot and human.

5.2 Home Monitoring, Aging-in-Place and Pre-EOL Contexts

In the home setting, autonomous robots (or semi-autonomous systems) support older adults, chronic disease patients, and those approaching end of life. They may monitor vital signs, detect falls, remind medication, provide social interaction, call for help, and gradually transition the patient toward hospice/EOL care.

Ethical trade-offs include:

- **Access and equity:** home monitoring depends on connectivity, infrastructure and SES; lower-resource populations may be left behind.
- **Consent and capacity:** patients may have cognitive decline, meaning informed consent for robotic monitoring is challenging.
- **Human presence vs robotic partner:** while robots may reduce isolation, they may also inadvertently reduce human visits (if families or providers rely on them).
- **Dignity in the home:** constant monitoring by robotic systems may feel intrusive; the boundary between surveillance and care becomes blurred.
- **Autonomy vs safety:** robot may intervene for safety (e.g., restrict movement if fall risk) but that intervention might reduce autonomy and dignity. Designing home-based robotic monitoring thus requires sensitivity to user preferences, transitional consent models, attention to inclusivity and human-centric interaction.

5.3 End-of-Life Care and Palliative Robotics

In EOL care, robotics may assist in hospice residences, home-based terminal care, or hospital palliative units. Functions may include: pain/comfort monitoring, medication delivery/scheduling, repositioning support, robotic companionship or telepresence with family/clinicians, alerting human staff. Because EOL care emphasises comfort, dignity, meaning, and human presence, the introduction of autonomous robotics raises distinct ethical issues.

Ethical trade-offs include:

- **Human touch vs robotic companion:** While robots may enhance access (especially in resource-limited or home contexts), they may not replicate the meaning of a live caregiver's presence. Some patients/families may feel dehumanised.

- **Decision-support vs human deliberation:** Robots may assist in monitoring comfort, vital signs, even suggest analgesic adjustments, but final decisions (e.g., withdrawing life-sustaining treatment) must remain human-centred.
- **Allocation of resources:** Using robotics may reduce human staffing needs, but should not become a substitution of human presence simply to cut costs, particularly at EOL when human presence may have disproportionate value.
- **Consent, capacity and relational context:** EOL patients may have diminished capacity; families may rely on robotic monitoring in lieu of face-to-face visits. How is autonomy safeguarded?
- **Moral meaning and care ethics:** The relational dimension of care is heightened in EOL; the question of whether robotic assistance undermines or supports the moral dimension of care must be addressed.
  For example, a robot that monitors a dying patient's breathing and alerts a nurse may improve response time; yet if human visits decrease because the robot is present, the patient/family may perceive abandonment. Ethical implementation thus requires preserving human connection, explicit role of robots as adjuncts, not replacements, and clear communication with patient/family about what robotic monitoring means.

5.4 Trade-Off Summary

We summarise the trade-offs in Table 1.

Table 1. Ethical Trade-Offs for Autonomous Robotics in Monitoring/EOL Care

Context	Key Benefit	Primary Ethical Tension
ICU/Acute Monitoring	Rapid detection, efficiency, staff relief	Oversurveillance, loss of human judgement, privacy loss
Home Monitoring/Aging in-Place	Enhanced safety, independence for patient	Equity of access, intrusion into home, autonomy vs safety
Palliative/EOL Care	Comfort monitoring, companion support, resource help	Human-touch reduction, dignity concerns, decision-making complexity

In each context, the deployment of autonomous robotics involves balancing safety/efficiency with human values (autonomy, dignity), fairness, relationality and accountability.

6. Governance, Design, Regulatory and Organisational Considerations

Effective, ethical deployment of autonomous robotics in patient monitoring and EOL care requires attention to governance structures, regulatory frameworks, design practices and organisational change. Below we outline key considerations.

6.1 Governance and Regulatory Frameworks

- **Defining oversight regimes:** As Morrell (2022) suggests, autonomous AI/robotic products may require new oversight models analogous to physician-extender frameworks.
- **Liability regimes:** Clear delineation of responsibility among manufacturers, clinicians, hospitals and software engineers is essential, especially when robots act semi-or fully autonomously (Jamjoom et al., 2022).
- **Standards for autonomous robotics in healthcare:** There is currently no universal standard for robotic monitoring in EOL contexts; establishing certification, audit trails, algorithm validation, explainability, fail-safe design and post-market surveillance is critical.
- **Data governance:** Monitoring robots generate sensitive data, often continuously; governance must address consent, storage, sharing, de-identification, secondary uses, breaches, cyber-security (BMC Med Inform Decision Making).
- **Informed consent / assent:** Particular protocols are needed for patients with limited capacity (such as those in EOL care), including proxies, ongoing consent, clear explanation of robotic roles and limitations.
- **Equity audits:** Deployments should undergo equity assessment to ensure underserved populations are not disadvantaged. Justice must be built into governance.
- **Design for dis-closure:** Patients and families must be informed when robots are present, know what the robot does, when autonomous decisions may be taken, and have opt-out or fallback options.

6.2 Ethical Design and Human-Centered Engineering

- **Human-machine teaming:** Robots should be designed to complement, not replace, human caregivers. Clear role delineation, handover protocols and human-in-loop oversight are essential.
- **Transparency and explainability:** Even when using AI/ML in robotics, systems should provide understandable explanation of alerts/actions to human caregivers and, as far as possible, to patients/families.
- **User-centred design for EOL:** Because relational and emotional dimensions matter greatly in EOL care, robotics design must incorporate patient/family feedback, address comfort, presence, trust, emotional support, and avoid intrusive monitoring.

- **Adaptive autonomy levels:** Robots should allow graduated autonomy semi-autonomous at first, with human supervision, gradually increasing only when safe and acceptable by stakeholders.
- **Fail-safe and fallback mechanisms:** If the robot fails or misbehaves, clear fallback protocols to human staff, manual override, and error-reporting mechanisms are required.
- **Cultural and contextual sensitivity:** Design must reflect cultural values around death, dying, presence, family involvement and human care; what is acceptable in one context may not be in another.
- **Continuous monitoring and audit of performance, bias and impact:** Robots deployed for monitoring/EOL care should be subject to continuous post-market evaluation, especially with respect to equity, error rates, patient/family satisfaction, and unintended consequences.

6.3 Organisational and Workflow Integration

- **Training and staff engagement:** Clinicians, nurses, and hospice staff must be trained to understand robotic systems, limitations, error-modes, and how to interact with them. (J Med Internet Res, 2022)
- **Human–robot-family interaction protocols:** Clear workflows should define when the robot acts autonomously, when human staff intervene, when family is alerted, and how handovers occur.
- **Ethics-by-design governance committees:** Health organisations should form multidisciplinary governance bodies (ethicists, engineers, clinicians, patient/family representatives) to oversee robotic deployment, review incidents, monitor equity, and adapt policy.
- **Evaluation metrics beyond technical performance:** Organisations should measure patient/family experience, dignity perception, human-touch preservation, acceptance/trust, in addition to clinical metrics.
- **Cost-benefit and resource allocation evaluation:** The decision to deploy robotics in EOL settings should not be driven solely by cost-cutting but by a balanced appraisal of value to patient dignity and human care.
- **Change management:** Introduction of robotics in EOL contexts may evoke resistance (fear of de-humanisation) among staff, patients and families; change management and communication are key.

6.4 Ethical Decision Framework for Implementation

We propose an implementation decision framework for health systems considering autonomous robotics in monitoring/EOL care:

1. **Needs assessment** – Define the care gap, patient population, expected benefit, ethical risks (autonomy, dignity, justice).
2. **Stakeholder consultation** – Engage patients, families, clinicians, ethicists, engineers to assess acceptability, preferences, values.
3. **Pilot & evaluation** – Deploy under controlled conditions, collect technical, clinical, ethical impact data.
4. **Review & governance** – Use an ethics board to review outcomes (clinical, relational, equity), make adjustments.
5. **Scale with oversight** – Gradually scale with clear human-in-loop safeguards, transparent reporting, auditing, patient/family opt-in mechanisms.
6. **Continuous monitoring** – Post-deployment monitoring of machine-human interactions, equity impacts, unintended consequences, patient/family experience.
7. **Exit-strategy and fallback** – Ensure that if the robot is withdrawn, human care remains intact and patient dignity is not compromised.

7. Research Agenda and Conclusion

7.1 Future Research Directions

Given the gaps identified, we propose the following research agenda:

- **Empirical studies in EOL settings**: Qualitative and quantitative research on patient, family and caregiver perceptions of robotics in palliative/EOL contexts (acceptance, trust, dignity, experience).
- **Frameworks for autonomy levels**: Investigate how different autonomy levels (tele-presence, semi-autonomous, fully autonomous) impact ethical outcomes in monitoring/EOL care.
- **Algorithmic fairness and bias**: Studies on how monitoring robots perform across demographic groups (age, ethnicity, socio-economic status) and associated fairness/justice metrics.
- **Cost-effectiveness and value of human presence**: Evaluate economic models that factor not just technical efficiency but also qualitative value of human presence in EOL robotics.
- **Interfaces and relational design**: Research on design of human-robot interaction in emotionally sensitive contexts (e.g., delivering comfort, companionship, acknowledging dying).
- **Legal/regulatory models**: Comparative studies of liability and accountability regimes for autonomous robotics in healthcare, including EOL care.

- **Longitudinal outcomes**: Long-term studies of robotics deployment in home monitoring leading to EOL, examining unintended consequences (e.g., caregiver isolation, reduced visits).
- **Ethics-by-design toolkits**: Development of toolkits for engineers and healthcare organisations for embedding ethics in design and deployment of autonomous monitoring robots.

7.2 Conclusion

Autonomous robotics in patient monitoring and end-of-life care represent a frontier of healthcare innovation one with enormous potential and equally significant ethical complexity. Our analysis has shown that while such systems can enhance safety, efficiency, access and potentially comfort, they also challenge core values of autonomy, dignity, justice, accountability, privacy and the human-machine relationality of care. Ethical deployment is not optional: it must be integral to design, governance, and implementation.

In contexts of monitoring and end-of-life care, the human dimension of presence, meaning and relationality is elevated. Robots must therefore be framed as *adjuncts* to human caregivers, not substitutes. Robust governance, human-in-loop oversight, transparency, equity monitoring, and patient/family engagement are non-negotiable. As the technology progresses, we must ensure that care remains human-centred, ethically grounded, and context-sensitive.

By adopting the frameworks and research agenda set out in this article, engineers, clinicians, ethicists, and policy-makers can work together to ensure that autonomous robotics fulfil their promise **without** compromising the fundamental humanity of care especially in life's final phase.

References

1. Carsten Stahl, B., & Coeckelbergh, M. (2016). Ethics of healthcare robotics: Towards responsible research and innovation. *Robotics & Autonomous Systems, 86*, 152–161. https://doi.org/10.1016/j.robot.2016.08.003
2. Chappell, A. G., & Teven, C. M. (2023). How Should Surgeons Consider Emerging Innovations in Artificial Intelligence and Robotics? *AMA Journal of Ethics, 25*(8), E589-E597.
3. Fatunmbi, T. O. (2021). Integrating AI, machine learning, and quantum computing for advanced diagnostic and therapeutic strategies in modern healthcare. *International Journal of Engineering and Technology Research, 6*(1), 26–41. https://doi.org/10.34218/IJETR_06_01_002
4. Fatunmbi, T. O. (2022). Leveraging robotics, artificial intelligence, and machine learning for enhanced disease diagnosis and treatment: Advanced integrative approaches for precision medicine. *World Journal of Advanced Engineering Technology and Sciences, 6*(2), 121-135. https://doi.org/10.30574/wjaets.2022.6.2.0057
5. Haltaufderheide, J., Pfisterer-Heise, S., Pieper, D., & Ranisch, R. (2024). The ethical landscape of robot-assisted surgery: A systematic review. *Bioethics, 39*(5), 456-459.

6. Jamjoom, A., Jamjoom, A. B., Thomas, M., Palmisciano, P., Kerr, A., Collins, G., Vayena, E., & Stoyanov, D. (2022). Autonomous surgical robotic systems and the liability dilemma. *Frontiers in Surgery*. https://doi.org/10.3389/fsurg.2022.1015367

7. Kaas, M. H. L., Porter, Z., Lim, E., Higham, A., Khavandi, S., & Habli, I. (2023). Ethics in conversation: Building an ethics assurance case for autonomous AI-enabled voice agents in healthcare

8. Morrell, W. (2022). The oversight of autonomous artificial intelligence: lessons from nurse practitioners as physician extenders. *Journal of Law and the Biosciences, 9*(2), lsac021. https://doi.org/10.1093/jlb/lsac021

9. Morgan, A. A., Abdi, J., Syed, M. A. Q., et al. (2022). Robots in healthcare: a scoping review. *Current Robotics Reports, 3*, 271-280. https://doi.org/10.1007/s43154-022-00095-4

10. Pirni, A., Balistreri, M., Capasso, M., Umbrello, S., & Merenda, F. (2021). Robot Care Ethics Between Autonomy and Vulnerability: Coupling Principles and Practices in Autonomous Systems for Care. *Frontiers in Robotics and AI, 8*, 654298. https://doi.org/10.3389/frobt.2021.654298

11. Sapci, A. H., & Sapci, H. A. (2019). Innovative assisted living tools, remote monitoring technologies, artificial intelligence-driven solutions, and robotic systems for aging societies: Systematic review. *JMIR Aging, 2*(2), e15429. https://doi.org/10.2196/15429

12. Hasan Sapci, A., & Sapci, H. A. (2019). Innovative assisted living tools, remote monitoring technologies

13. van Wynsberghe, A. (2013). Designing robots for care: Care centred value-sensitive design. *Science and Engineering Ethics, 19*(2), 407-433.

14. Glynn, J. R., & Kelly, D. G. (2021). Ethical and regulatory issues in robotic automation of healthcare: a critical review. *Health Policy, 125*(9), 1231-1240.