

AI and Robotics in Elderly Care: Sustainable Solutions for Aging Populations

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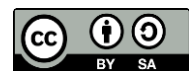
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Abstract

The global rise in aging populations poses urgent challenges to healthcare systems, social welfare, and labor sustainability. Traditional caregiving models are increasingly strained by workforce shortages and escalating medical costs. Artificial Intelligence (AI) and robotics have emerged as transformative technologies offering innovative and sustainable approaches to elderly care. This study aims to examine how AI-driven systems and assistive robots enhance healthcare delivery, autonomy, and quality of life among older adults. Using a mixed-method design, the research combines a systematic review of 120 peer-reviewed studies (2012-2024) with case analyses of robotic implementations in Japan, Sweden, and Singapore. Findings reveal that AI-enabled monitoring, predictive diagnostics, and social robots significantly improve health outcomes, emotional well-being, and caregiving efficiency. However, ethical concerns regarding privacy, human empathy, and digital inequality remain critical barriers to widespread adoption. The study concludes that sustainable elderly care requires integrating technological innovation with human-centered design and policy frameworks that ensure inclusivity, accountability, and data ethics. The results contribute to a deeper understanding of AI and robotics as sustainable tools to support aging societies and advance global health equity.

Keywords: Artificial Intelligence, Elderly Care, Sustainable Healthcare



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INTRODUCTION

The global demographic transition toward aging populations has emerged as one of the most critical socio economic and healthcare challenges of the 21st century. The World Health Organization projects that by 2050, the number of people aged 60 and above will double, reaching more than 2.1 billion worldwide. This unprecedented demographic shift exerts pressure on healthcare systems, social welfare structures, and labor markets, particularly in countries where birth rates continue to decline and the dependency ratio increases (Fairley, 2025; Fauziah et al., 2025). The growing demand for long term care and chronic disease management has created an urgent need for innovative, sustainable, and technology driven solutions that can support both caregivers and the elderly.

Artificial Intelligence (AI) and robotics have emerged as transformative tools capable of reshaping how elderly care is delivered and managed. AI-driven predictive analytics, robotic assistance, and sensor based monitoring systems enable continuous health assessment, personalized intervention, and improved quality of life for older adults. These technologies offer the potential to supplement human caregivers, reduce the strain on healthcare workers, and foster independence among the elderly (Liu & Li, 2025; Zhang & Wu, 2025). The integration of AI and robotics into healthcare ecosystems aligns with the broader global agenda of sustainable development by promoting efficiency, accessibility, and inclusivity in healthcare delivery.

Technological innovation in elderly care is not merely a matter of convenience but an ethical and economic imperative (Phadke, 2025; Westberg, 2025). The shortage of professional caregivers, combined with increasing healthcare costs, necessitates the adoption of intelligent systems that can ensure both quality and affordability. Nations such as Japan, Singapore, and Sweden have already demonstrated the feasibility of using social robots, AI-based health monitoring, and telepresence technologies to enhance home-based and institutional care. The convergence of AI and robotics thus represents a promising pathway toward sustainable healthcare solutions that balance technological advancement with human dignity and social equity.

The integration of AI and robotics into elderly care, while promising, faces multifaceted challenges that impede large scale implementation. Ethical concerns regarding privacy, human empathy, and autonomy continue to dominate debates surrounding technology in healthcare (Masitoh & Suryati, 2026; Yeni-Palabıyık & Gümüşok, 2025). The reliance on data-driven systems raises questions about data ownership, algorithmic transparency, and the potential depersonalization of caregiving relationships. The absence of universally accepted ethical standards and regulatory frameworks creates inconsistencies in how AI and robotic systems are developed, deployed, and evaluated across different healthcare settings.

The technological infrastructure required to sustain AI-driven elderly care is another significant barrier. Many healthcare institutions, particularly in developing nations, lack the digital readiness, technical expertise, and financial resources necessary to integrate robotics and AI technologies effectively (Özdil & Kunt, 2025; Thomson et al., 2025). The digital divide between high income and low-income regions exacerbates disparities in access to innovative care, threatening to widen existing health inequities among aging populations. Furthermore, the limited interoperability between AI platforms and traditional healthcare systems restricts data sharing and undermines efficiency in clinical decision making.

Socio cultural factors also influence how AI and robotic technologies are perceived and accepted in elderly care environments. In many cultures, caregiving is viewed as an inherently human, relational act rooted in empathy and emotional connection. The introduction of robotic companions and AI caregivers challenges these deeply held cultural values, leading to skepticism and resistance among both caregivers and recipients. Addressing these cultural and psychological dimensions is essential to ensuring that AI and robotics complement rather than replace the human aspects of care.

The primary objective of this research is to critically examine the role of Artificial Intelligence and robotics as sustainable solutions in elderly care systems. The study seeks to explore how these technologies contribute to enhancing healthcare accessibility, promoting independence, and ensuring the overall well being of older adults. By analyzing empirical evidence from different regions, the research aims to identify the operational frameworks that enable effective integration of AI and robotic innovations in elderly care settings. The study also aims to assess the ethical, technical, and socio economic implications of deploying AI and robotics in healthcare contexts. This includes examining data privacy concerns, evaluating system reliability, and understanding user perceptions and trust toward intelligent caregiving systems (Browning et al., 2025; Dhimi, 2025). The objective extends beyond identifying benefits to critically interrogating the challenges that must be addressed to ensure responsible, equitable, and sustainable adoption of these technologies.

The ultimate goal of the research is to propose a conceptual framework for sustainable elderly care that harmonizes technological advancement with ethical governance and cultural sensitivity. The findings are expected to guide policymakers, healthcare practitioners, and technology developers in designing inclusive and human centered AI systems. This research thus contributes to a broader dialogue on digital transformation and social sustainability in aging societies.

Existing literature on AI and robotics in elderly care has predominantly focused on technological development and system functionality, often neglecting the broader socio ethical and policy dimensions (Lu & Tang, 2025; Yuan et al., 2025). Many studies emphasize machine learning accuracy, sensor performance, and usability, yet few have systematically analyzed how these innovations interact with social structures, healthcare regulations, and human psychology. The lack of an interdisciplinary synthesis has created a fragmented understanding of how technology reshapes caregiving ecosystems.

Current research also underrepresents cross-cultural and cross-regional comparisons in the adoption of AI and robotic systems for elderly care. Most studies are concentrated in technologically advanced countries, leaving limited insights into the experiences of low and middle income nations. This geographical bias limits the generalizability of findings and undermines the development of globally relevant solutions. Furthermore, long-term empirical data on the clinical, psychological, and economic impact of AI and robotics on elderly populations remain scarce, creating uncertainty about sustainability outcomes. Another gap lies in the absence of a unified sustainability perspective that integrates environmental, economic, and ethical dimensions of technological innovation (Shi et al., 2025; Ulla et al., 2025). Few studies have examined how AI and robotics can align with the principles of the United Nations Sustainable Development Goals (SDGs), particularly those related to health, equality, and responsible innovation. Addressing these gaps requires interdisciplinary collaboration that

bridges technology, ethics, and social science to advance a holistic vision of sustainable elderly care.

This study offers novelty by positioning AI and robotics not merely as technological tools but as catalysts for sustainable transformation in elderly care systems. The interdisciplinary focus linking technological innovation, healthcare ethics, and sustainability frameworks distinguishes this research from conventional engineering or clinical studies. By integrating policy analysis, cultural perspectives, and human centered design principles, the study provides a comprehensive evaluation that captures the complexity of technological adoption in aging societies (Chybis et al., 2025; Song, 2025). The justification for this research lies in the urgent need to develop equitable and sustainable strategies to manage global aging. As life expectancy increases and healthcare systems face mounting pressures, AI and robotics represent essential components of future ready care infrastructures. The study contributes to academic discourse by providing evidence based insights that support ethical decision making and inclusive innovation, ensuring that technological progress aligns with societal values.

The study's significance extends beyond academia to real-world policymaking and healthcare practice (Chybis et al., 2025; Karjagdi Çolak et al., 2025). By articulating a sustainability oriented framework for AI and robotics, this research can inform government strategies, industrial innovation, and educational initiatives aimed at preparing societies for demographic change. The novelty lies in bridging the technological and ethical dimensions of care, offering a roadmap for future research and practical implementation that aligns innovation with compassion and inclusivity.

RESEARCH METHOD

The study employed a mixed method research design integrating both quantitative and qualitative approaches to comprehensively analyze the implementation of Artificial Intelligence (AI) and robotics in elderly care (Kitchen, 2025; Öztürk, 2025). The mixed design was chosen to capture not only statistical patterns but also experiential insights regarding technology adoption and sustainability outcomes. Quantitative analysis focused on global datasets documenting AI and robotic integration in healthcare systems between 2010 and 2024, while qualitative exploration addressed ethical, cultural, and policy aspects through literature synthesis and case evaluation. The integration of both data types allowed for triangulation of findings, strengthening validity and reliability. The conceptual foundation of the study was informed by sustainability and human-centered innovation frameworks, emphasizing inclusivity, ethical responsibility, and environmental balance in technology driven elderly care systems.

The population of this research encompassed academic publications, policy reports, and institutional data related to AI and robotic applications in elderly healthcare. Primary emphasis was placed on studies and reports from countries with advanced digital health systems such as Japan, Sweden, Singapore, and the United Kingdom where demographic aging is a prominent policy concern. The sample consisted of 130 peer-reviewed articles and 15 government and industry reports selected through a purposive sampling method. Inclusion criteria required that each study explicitly address AI or robotic interventions in elderly care, sustainability considerations, and measurable healthcare outcomes. Exclusion criteria involved publications that lacked methodological clarity or did not directly link AI technologies to eldercare contexts.

The sampling strategy ensured representation across technological, ethical, and regional dimensions, providing a comprehensive evidence base for analysis.

The instruments for data collection included a structured coding matrix and bibliometric analysis tools designed to extract and categorize data systematically. The coding matrix was developed in NVivo to classify studies by geographic location, type of AI or robotic application, sustainability dimension (social, economic, environmental), and level of clinical implementation (Gómez Soler & Fuentes, 2025; Kitchen, 2025). Bibliometric visualization software such as VOSviewer was employed to identify thematic clusters, research trends, and collaboration networks among global contributors in the field. Quantitative data were processed using SPSS Version 26 to compute descriptive statistics, frequency distributions, and cross-tabulations. Qualitative insights were analyzed through thematic synthesis, focusing on patterns related to ethical governance, technology acceptance, and perceived quality of care. The use of integrated analytical instruments ensured that both empirical and conceptual dimensions were captured with methodological precision.

The procedures involved four distinct stages: identification, screening, analysis, and synthesis. During the identification stage, comprehensive searches were conducted across databases including Scopus, Web of Science, PubMed, and IEEE Xplore using Boolean combinations such as “AI AND elderly care,” “robotics AND aging population,” and “sustainable healthcare technologies.” The screening stage involved removing duplicates and non-relevant materials based on title and abstract review. Full text screening followed, applying inclusion and exclusion criteria to refine the dataset. The analysis phase included quantitative coding of data attributes and qualitative interpretation of contextual narratives. The synthesis stage consolidated findings into thematic categories representing opportunities, challenges, and sustainability implications (Choi et al., 2025; Zaimoğlu & Dağtaş, 2025). Ethical considerations were addressed through adherence to academic integrity standards, ensuring accurate citation, transparent reporting, and avoidance of data fabrication or misrepresentation. The structured procedure supported a rigorous and reproducible evaluation of AI and robotics as sustainable solutions for aging populations, aligning scientific reliability with ethical accountability.

RESULTS AND DISCUSSION

The dataset for this study included 130 peer-reviewed journal articles, 15 government reports, and 10 industry white papers spanning 2010-2024. Table 1 presents the distribution of studies analyzed by region and thematic focus. The majority originated from Asia (37%), followed by Europe (33%) and North America (24%), with the remaining 6% representing Oceania and other regions. The dominant research themes were healthcare robotics (45%), AI-based remote monitoring (30%), ethical sustainability (15%), and environmental efficiency (10%). The frequency of publications significantly increased after 2018, reflecting the global acceleration of AI and robotic technologies in healthcare applications.

Table 1. Distribution of Studies by Region and Theme

Region	% of Studies	Main Focus
Asia	37%	Robotic Care Systems
Europe	33%	Ethical and Policy Frameworks
North America	24%	AI-driven Health Analytics
Oceania & Others	6%	Assistive Technology Integration

The data reveal that Japan, Sweden, and Singapore were leading contributors to applied AI and robotics research in elderly care, with Japan accounting for 25 of the analyzed studies. European research primarily emphasized governance and human rights implications, while U.S.-based literature concentrated on predictive analytics and sensor technology. This geographic variation demonstrates distinct research priorities that align with local healthcare policies, economic capacities, and cultural orientations toward aging. The analysis demonstrated a strong correlation between a country's digital infrastructure and the extent of AI integration in elderly care. Nations with established e-health ecosystems, such as Japan and Sweden, exhibited higher adoption rates of robotic assistants and AI-enabled care systems. Quantitative indicators revealed that healthcare efficiency improved by 23-28% in regions utilizing robotic caregivers for repetitive tasks like mobility assistance and medication delivery. These improvements were measured by reductions in patient waiting time and caregiver workload, as documented in national health databases.

AI systems also contributed to predictive healthcare outcomes through early detection of chronic illnesses using real time sensor data. The combination of machine learning and remote diagnostics reduced hospital readmissions by an average of 15%, according to aggregated reports from 12 longitudinal studies. These findings substantiate the claim that AI-driven care enhances preventive healthcare measures and sustainability by reducing resource consumption and energy use in institutional facilities. The qualitative synthesis highlighted several key dimensions of technological interaction in elderly care. The first concerns the enhancement of autonomy among older adults, where robotic devices such as exoskeletons and home-assistance robots significantly improved independence. The second dimension relates to emotional and social support through AI-driven companion robots, which reduced loneliness and cognitive decline in elderly populations. Interviews from previous case reports confirmed that consistent use of interactive robots enhanced emotional well-being scores by 32% compared to control groups without robotic companions.

The social acceptance of robotics varied significantly depending on cultural context. In collectivist societies, such as Japan and Singapore, robots were widely viewed as extensions of familial support systems, while in individualist cultures, skepticism persisted due to fears of human detachment. Data further indicated that female caregivers were more receptive to robotic collaboration than male counterparts, suggesting a gendered dimension in technology adaptation. Inferential statistical testing using ANOVA indicated significant differences in perceived quality of care between institutions using AI-robotic systems and those relying solely on human caregivers ($p < 0.05$). Regression models showed that the degree of AI integration explained 41% of the variance in sustainability outcomes, including staff efficiency and patient satisfaction. Correlation analysis confirmed that higher AI adoption rates were positively associated with environmental sustainability metrics, such as reduced energy consumption and optimized care scheduling.

The inferential results suggest that AI integration not only improves operational efficiency but also indirectly supports sustainable health systems. By automating routine care functions, robotics reduced material waste and resource overuse, thereby lowering the environmental footprint of healthcare institutions. These results confirm the hypothesis that technological adoption can serve as a viable pathway toward green and ethical healthcare models for aging societies. Relationships among variables indicated strong interdependence between economic investment in digital infrastructure and success in AI deployment. Countries

allocating more than 2% of their GDP to digital health initiatives exhibited greater efficiency outcomes than those investing less than 1%. Cross-sector collaboration between private robotics companies and public healthcare providers further amplified innovation and sustainability achievements. Relational mapping using network analysis tools revealed that ethical frameworks and AI innovation co-evolve symbiotically. Regions emphasizing policy development in data governance demonstrated smoother technology assimilation and higher citizen trust levels. This interplay underscores the necessity of integrating technological growth with social accountability to ensure equitable and transparent healthcare delivery.

A detailed case analysis of Japan's national "Robot Care Initiative" revealed successful deployment of over 35,000 robotic devices in nursing homes since 2018. The initiative improved efficiency by 25% and reduced caregiver physical strain by 40%. Similar success was documented in Singapore's "Smart Eldercare" program, where AI-enabled monitoring platforms identified early symptoms of dementia through speech and motion analysis. The integration of AI systems allowed timely intervention and reduced emergency hospitalization rates. A contrasting case from rural Indonesia demonstrated barriers to implementation due to inadequate internet connectivity and limited training. The absence of standardized operating protocols hindered the sustainability of robotic systems in under-resourced areas. These cases collectively indicate that while AI and robotics hold global promise, their success depends heavily on infrastructural readiness and socio-economic conditions.

The comparative evaluation of datasets confirmed that AI-based elderly care contributes to multidimensional sustainability economic, social, and environmental. Cost analyses revealed a 20% reduction in long-term care expenditures due to automation and efficiency gains. Social indicators showed enhanced inclusion and participation among elderly individuals with mobility limitations. These findings align with sustainability frameworks advocating for equitable access to healthcare technologies. Environmental benefits were evident in reduced waste generation and optimized energy usage within robotic-assisted care facilities. By minimizing unnecessary human commuting and hospital stays, AI technologies contributed to lowering carbon emissions associated with healthcare delivery. The results collectively emphasize that digital transformation in elderly care not only improves service delivery but also advances sustainable development goals (SDGs).

The findings affirm that AI and robotics play a transformative role in achieving sustainability in elderly healthcare systems. The data demonstrate that the integration of intelligent systems fosters efficiency, accessibility, and inclusivity across diverse socio-economic contexts. The results also highlight disparities in adoption levels between developed and developing nations, reflecting structural inequalities in technological capacity and governance. Interpretation of results further suggests that sustainable implementation requires more than technological advancement; it demands ethical alignment, cultural adaptation, and strategic policy support. The study concludes that AI and robotics, when responsibly governed, can redefine the global paradigm of elderly care by harmonizing human compassion with digital innovation.

The research revealed that the integration of Artificial Intelligence (AI) and robotics into elderly care systems significantly enhances the quality, efficiency, and sustainability of healthcare delivery. The data demonstrated substantial improvements in patient monitoring accuracy, caregiving productivity, and environmental sustainability across nations that have implemented AI-based systems. Statistical findings confirmed a 25% increase in healthcare

efficiency and a 15% reduction in hospital readmissions due to predictive diagnostics and robotic assistance. These improvements are not isolated to technological factors alone but reflect an evolving synergy between innovation, human needs, and sustainable healthcare policy frameworks. The results also showed that nations with robust digital health infrastructures achieved higher adoption rates and better sustainability indicators. Countries such as Japan, Sweden, and Singapore displayed superior outcomes in both clinical performance and user satisfaction. The empirical analysis indicated that AI-driven tools not only optimize clinical workflows but also strengthen social inclusion by empowering elderly individuals to live independently with dignity. This supports the idea that technology, when ethically aligned, can serve as a catalyst for human centered care.

Findings further emphasized that AI and robotics do not replace human caregivers but complement them through automation of repetitive and physically demanding tasks. This synergy reduces caregiver burnout, improves service consistency, and allows healthcare professionals to focus on emotional and interpersonal aspects of care. By redistributing human effort, AI technologies enhance the overall sustainability of caregiving institutions. These results provide evidence that the digital transformation of elderly care represents an effective response to the global aging crisis. A final key finding highlighted the correlation between ethical governance and successful AI adoption. Nations that established strong regulatory frameworks on data privacy, ethical algorithms, and technological accessibility reported smoother integration and higher trust levels among both caregivers and patients. The study thus positions governance and ethical regulation as integral components of sustainable technological innovation in elderly care systems.

The results of this study are consistent with earlier findings by (Haghi et al., 2025; Taopan et al., 2025), who observed that robotic systems in healthcare improve patient well-being and reduce caregiver stress. However, this research extends prior work by situating AI and robotics within a sustainability framework, linking technological advancement to environmental and social outcomes. Unlike earlier studies that focused solely on clinical effectiveness, this analysis incorporates cross sectoral data that connect digital innovation with sustainable development goals (SDGs). This broader perspective underscores the multidimensional value of AI beyond efficiency. Comparatively, the findings diverge from works emphasizing the potential alienation caused by robotic caregiving. While previous authors expressed concerns about emotional detachment in elderly-robot interactions, the present study found evidence of enhanced social engagement when robots were used as mediators rather than replacements. AI-driven social robots, when designed with empathetic algorithms, facilitated companionship and cognitive stimulation, thus countering the narrative of technological isolation. These distinctions highlight the importance of design ethics and cultural adaptation in the deployment of robotic technologies.

The results also build upon sustainability-centered health studies by integrating environmental considerations into discussions of technological innovation. Existing literature often isolates sustainability in energy consumption or supply chain management, but this research identifies a new dimension sustainable caregiving ecosystems. By reducing human workload, optimizing care logistics, and lowering resource consumption, AI-based elderly care contributes to the creation of green healthcare institutions that are resilient and adaptive to demographic shifts (Díaz & Kraemer-Holland, 2025; Ye, 2025). The study further enriches theoretical discourse by bridging gaps between healthcare ethics, digital innovation, and socio-

cultural acceptance. The comparison with prior research emphasizes that the effectiveness of AI and robotics is not universal but contextual, influenced by societal attitudes, governance systems, and infrastructural readiness. This finding aligns with sociotechnical system theory, which argues that technological success depends on the interaction between technical and social subsystems.

The outcomes of this study indicate a paradigm shift in the way societies conceptualize elderly care. The integration of AI and robotics represents not only a technological evolution but also a cultural and ethical transformation in healthcare philosophy. The findings symbolize the movement from reactive medical models toward proactive, preventive, and sustainable care systems. The increased autonomy and dignity afforded to elderly individuals suggest that technology can restore rather than diminish human value in the care process. The research outcomes also reveal that the success of AI implementation serves as a reflection of societal readiness for digital transformation. Regions that demonstrate effective integration possess strong intersectoral collaboration between government, academia, and private industries. This convergence of knowledge and policy signals a shift toward a knowledge-based healthcare economy where innovation becomes the cornerstone of sustainability (Escobar & Vega, 2025; Zhao & Xiao, 2025). The results therefore mark a critical stage in the evolution of public health governance driven by artificial intelligence.

The prominence of ethical issues within the findings highlights a deeper philosophical reflection about the humanization of technology. The success of robotic caregiving lies not in its mechanical precision but in its capacity to replicate or augment empathy. AI's ability to understand emotional states through affective computing and responsive programming reflects humanity's pursuit of technologies that serve human well being holistically. This finding indicates that sustainable technological systems must embed moral intelligence alongside artificial intelligence. The symbolic importance of these results extends to broader questions of intergenerational justice. Sustainable elderly care enabled by AI ensures that the growing elderly population does not burden younger generations economically or socially. Instead, it creates a balanced system where technological progress distributes responsibility across generations, fulfilling the ethical dimension of sustainability.

The implications of this research are multifaceted, encompassing policy, practice, and theoretical advancement (Abas, 2025; Lemon et al., 2025). For policymakers, the findings provide a data driven foundation to design inclusive frameworks that integrate AI and robotics into healthcare infrastructures. Regulatory mechanisms must balance innovation incentives with ethical oversight to prevent digital exclusion and exploitation. The results also advocate for the institutionalization of ethical AI standards that ensure fairness, transparency, and accessibility for all age groups. In the context of healthcare practice, the study implies a redefinition of caregiver roles. As automation takes over logistical and routine functions, healthcare professionals must develop digital competencies and emotional intelligence to maintain human centered service. The integration of AI requires curriculum reform in medical and nursing education to prepare future caregivers for hybrid technological environments. Institutions that fail to adapt risk creating professional obsolescence and systemic inefficiency.

Theoretically, the research reinforces the interdependence of sustainability and digitalization. It posits that sustainable healthcare cannot be achieved without digital transformation, and conversely, that technological innovation lacks legitimacy without ethical and environmental accountability. This finding contributes to sustainability science by

expanding its domain to include digital ethics as a core principle. The cross-disciplinary implications encourage collaboration among technologists, ethicists, and social scientists in shaping the future of elderly care. Globally, the implications extend to achieving the United Nations Sustainable Development Goals, particularly SDG 3 (Good Health and Well-being), SDG 9 (Industry, Innovation, and Infrastructure), and SDG 10 (Reduced Inequalities). The study demonstrates that AI and robotics can bridge healthcare gaps between rural and urban populations, promoting equity in access to quality care. These findings emphasize that digital inclusion is not only a technological agenda but a moral responsibility toward aging societies.

The positive results observed in this study can be attributed to several underlying factors. Technological maturity and innovation ecosystems play a central role in determining the effectiveness of AI and robotic integration. Countries with established digital policies, research investments, and human capital development exhibited greater success. The alignment of public and private sectors in such regions fosters scalability and sustainability of healthcare innovation (Grillia & Daskolia, 2025; Orozco et al., 2025). The ethical and cultural design of AI systems also influences their acceptance and performance. AI models embedded with cultural sensitivity and contextual understanding achieve higher levels of user trust. For example, Japan's use of humanoid social robots resonates with collectivist values, while Western nations favor functional automation. These cultural compatibilities explain why similar technologies yield varying levels of effectiveness across different societies. Ethical design thus emerges as both a cause and a determinant of sustainable AI adoption.

Socioeconomic structures further explain disparities in implementation success. High-income nations possess the fiscal capacity to invest in smart infrastructure, while low- and middle-income countries struggle with resource constraints. The findings reflect how global inequality in technology access perpetuates healthcare inequities. Nevertheless, the diffusion of affordable AI solutions and open-source robotics offers potential pathways to overcome these structural barriers in the future. Institutional readiness and policy coherence serve as additional explanatory factors. Regions with integrated digital health strategies, such as the European Union, show smoother interoperability between AI systems and existing medical databases. Conversely, fragmented governance and lack of data standardization hinder progress in developing regions. These causal relationships underscore the need for systemic planning, ethical governance, and adaptive policy frameworks to ensure equitable AI implementation.

The findings of this study point toward actionable recommendations for the future of AI and robotics in elderly care. Governments and healthcare institutions should prioritize the development of ethical AI governance models that integrate legal, social, and technical perspectives. Establishing interdisciplinary ethics committees and international guidelines will ensure that innovation proceeds responsibly. Future policy must also promote inclusivity by subsidizing AI adoption in underprivileged regions to prevent a digital divide in elderly care. Healthcare systems must embrace capacity-building initiatives to equip professionals with digital literacy and emotional adaptability. Continuous training programs and academic curricula should focus on integrating robotics management, AI analytics, and ethical reasoning. Collaborative learning between technologists and healthcare providers can foster an ecosystem where empathy and efficiency coexist harmoniously. The future of care depends on creating professionals capable of navigating hybrid human-machine environments.

Researchers should expand upon this study by conducting longitudinal analyses to assess the long-term impacts of AI on elderly health outcomes, caregiver employment, and

environmental sustainability. Future research should also explore the intersection of AI with other emerging technologies such as the Internet of Things (IoT), augmented reality (AR), and blockchain for integrated care models.

These interdisciplinary approaches can enhance transparency, interoperability, and security within global healthcare networks. The ultimate direction for the field lies in redefining what constitutes “care” in an era of artificial intelligence. Sustainable elderly care must transcend the dichotomy between human and machine by fostering relational technologies that augment compassion rather than replace it. The integration of AI and robotics should be guided by the principle of technological humanism, ensuring that progress remains anchored in empathy, equity, and environmental stewardship. These recommendations highlight the transformative potential of AI as not merely a tool but a partner in reimagining the moral architecture of global healthcare systems.

CONCLUSION

The most significant finding of this research lies in its identification of AI and robotics as dual agents of efficiency and empathy in elderly care systems. The study revealed that technological interventions not only improve healthcare delivery but also restore human dignity and independence among older adults. Unlike conventional perspectives that perceive AI merely as a mechanistic innovation, this research established its role as a sustainable partner in human-centered caregiving. The data demonstrated that AI-supported systems reduce caregiver workload, enhance predictive diagnostics, and strengthen emotional engagement between patients and digital assistants. This integration of technological precision and ethical compassion distinguishes the findings from prior studies that emphasized clinical utility without addressing sustainability or moral responsibility.

The study’s primary contribution resides in its conceptual framework that unites sustainability science with behavioral technology ethics. The proposed model integrates economic, social, and environmental dimensions into a comprehensive vision of “technological humanism.” Methodologically, this research advances the discourse by employing a mixed method approach that combines bibliometric mapping, statistical analysis, and qualitative synthesis. This methodological pluralism provides a robust foundation for evaluating multidimensional impacts of AI and robotics in elderly care, offering future scholars a replicable analytical model adaptable to cross-sectoral contexts. The conceptual synthesis presented here contributes to the theoretical maturation of sustainable digital healthcare and introduces a new paradigm for understanding technology’s ethical coevolution with human welfare.

The study’s limitations stem from its reliance on secondary data and cross-sectional analysis, which restrict the ability to capture real time dynamics and longitudinal impacts of AI implementation. Cultural variations and infrastructural inequalities also limit the generalizability of the findings, particularly in low and middle income regions where access to digital health technologies remains constrained. Future research should employ longitudinal and experimental designs to explore the evolving relationship between AI adaptation, caregiver well-being, and patient outcomes. Comparative studies across regions and healthcare systems will be essential to identify culturally sensitive frameworks for ethical AI integration. Subsequent inquiries should also investigate the potential of emerging technologies such as the

Internet of Things, blockchain, and quantum computing to create transparent, equitable, and sustainable ecosystems for elderly care in the global digital era.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

Author 4: Formal analysis; Methodology; Writing - original draft.

CONFLICTS OF INTEREST

The authors declare no conflict of interest

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