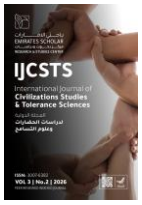

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AI and society: Balancing Innovation with Ethical Responsibility AI-Enhanced Rehabilitation and the Ethics of Tolerance: Building Inclusive Pathways in Healthcare

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ABSTRACT

The rapid development of artificial intelligence (AI) technologies has significantly influenced multiple disciplines, including healthcare and medical rehabilitation. While AI presents substantial opportunities, it simultaneously introduces complex ethical challenges. This study examines how AI-driven rehabilitation—encompassing robotic support, predictive analytics, virtual therapies, and personalized interventions— shapes the human perspective of tolerance within healthcare systems. AI technologies offer considerable potential to enhance precision, accessibility, and personalization in medical rehabilitation. However, their effectiveness depends on the cultural, social, and ethical frameworks that govern patient–technology interactions and ensure secure, inclusive healthcare environments. A comprehensive literature review was conducted across rehabilitation medicine, digital health, and AI ethics. Drawing on these findings, the study positions tolerance as a critical analytical lens for inclusive healthcare, emphasizing respect for individual and cultural diversity, preservation of patient dignity, and acceptance of human–machine collaboration. It argues that tolerance functions not only as a moral principle but also as an operational factor in therapeutic processes, contributing to improved psychological outcomes, reduced patient stress, and enhanced overall well-being. Simultaneously, the study identifies risks of bias and dehumanization if tolerance is not embedded in AI design and implementation, highlighting the need to balance computational efficiency with ethical and emotional intelligence. The findings align with frameworks developed by UNESCO and the World Health Organization, as well as Sustainable Development Goal 3 (Health and Well-Being). Finally, the paper proposes a theoretical model integrating AI capabilities with tolerance to achieve effective rehabilitation outcomes, alongside policy recommendations, training programs, and ethical design principles to support inclusive and human-cantered healthcare systems.

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Introduction

In a world characterized by constant growth and progress, where people learn, explore the unknown, push boundaries, and develop technology, the most challenging aspect is our effort to remain human. It is crucial to cultivate our inner selves, learn constantly, and strive to contribute positively to others, all in an atmosphere of tolerance and support. The development achieved through such efforts has little value if we neglect our human side. Humans must have the freedom to express themselves and remain open to the world around them. To coexist in peace and unconditionally embrace the diversity that exists in the world, it is essential to develop a sense of tolerance. This responsibility extends to people, companies, and state governments, all of which should recognize and promote the establishment of educational systems and a culture of tolerance. Tolerance implies the understanding that we are all human beings, united by a core purpose to live in peace and love, regardless of our culture, religion or socioeconomic status. Practicing tolerance entails openness to learning, communicating, accepting, and extending the same respect that we seek for ourselves. It involves showing empathy and allowing our minds and hearts to expand. We should be aware of the flourishing diversity of cultures worldwide, strive to learn from them, and promote positive words and deeds. The essence of tolerance lies in the unity that arises from our differences (United Nations Educational, Scientific, and Cultural Organization [UNESCO], 1995). The word 'tolerance' first appeared in Middle French during the 14th century and later in Early Modern English in the early 15th century. The etymology traces back to the Latin tolerare, 11 which means 'to bear, endure, tolerate' (Oxford English Dictionary). Although the word tolerance emerged during this period, it has been a fundamental concept since the beginning of civilization and religions. Many scientists have described the concept of tolerance in the fields of health and medicine. Goncharenko et al. (2021) argued that tolerance signifies an organism's ability to withstand adverse environmental conditions, involving reduced sensitivity of the body, its cells, and its tissues to various substances, which aids in maintaining homeostasis. Besides immunology, the concept of tolerance has found a place in pharmacology and psychiatry. Tolerance is defined as 'the capacity of the body to endure or become less responsive to a substance (such as a drug) or a physiological insult, especially with repeated use or exposure' (Merriam-Webster, 2016). The concept of tolerance has been adapted into the social sciences, where it has been extensively researched and explained. A rich body of literature exists on the analysis of tolerance as a complex concept, with many studies identifying its various forms and types. Forst (2013) indicated four approaches to tolerance: permission, coexistence, respect, and esteem conception. If we look into the development of today's world, particularly with AI implementation and rapid integration into daily life, AI technologies become increasingly embedded in everyday human activities, healthcare systems, and decision-making processes, questions concerning human dignity, inclusiveness, and ethical governance have become central to contemporary academic and policy discussions. Stone at al. (2016) argued in The AI100 report Artificial Intelligence and Life in 2030 that healthcare is recognized as a major area of AI application and emphasized the importance of guiding technological advancement through responsible governance. This perspective supports the need for frameworks that integrate ethical principles, human dignity, and inclusiveness into AI-enabled healthcare environments.

Literature Review

AI Applications in Medical Rehabilitation

The integration of AI into rehabilitation medicine has already moved well beyond theoretical concepts and is slowly entering clinical practice in healthcare institutions. The conventional rehabilitation has traditionally been based on the therapist's availability, medical assessment, and different treatment protocols. Nevertheless, an AI-driven approach to medical rehabilitation has the potential to provide more objective assessments, and the capacity to adapt and personalize therapy to the individual patient in real time. A systematic review by Singh et al. (2024) grouped the main applications of AI in the rehabilitation of neurological disorders into three groups: predictive analytics, robotic systems, and brain–computer interfaces, arguing that these tools can provide an improvement in rehabilitation and diagnosis across various medical conditions such as stroke, spinal cord injury, and Parkinson's disease. Similarly, El-Bouri et al. (2025) argued that AI, virtual reality, gamification, and telerehabilitation can be combined to overcome the recognized limitations of conventional healthcare and address challenges such as insufficient training intensity, low patient engagement, and the absence of continuous monitoring. A number of AI applications are already in place in medical rehabilitation. Robotic systems can support the rehabilitation process by delivering high-intensity, repetitive exercises while providing objective measurement of progress, an advantage that conventional therapy currently does not have (Amirbekova et al., 2025). Additionally, a study by Wang et al. (2024) found that robot-assisted training

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significantly enhanced lower-limb motor function, walking ability, and balance. While robotic systems address how therapy is delivered, predictive analytics, at the same time, addresses who will benefit and to what degree. The AI-enhanced forecasting of the individual rehabilitation outcomes has attracted growing attention because of its potential to personalize treatment plans and optimize resource allocation (Mahmoud et al., 2025). In addition to individual diagnostics, medical practitioners can now use machine learning models trained on similar prior cases to estimate likely outcomes for their patients. At the same time, although the initial results of predictive analytics are encouraging, not all researchers agree on its applicability. A systematic review by Zu et al. (2023) concluded that many predictive models were subject to a meaningful risk of bias and offered several recommendations for improving future model development. The predictive promise is real; however, the results will highly depend on the underlying models and training data provided. The third example of AI applications in rehabilitation is the Virtual Reality (VR) and related immersive and gamified platforms. These technologies can support two areas: motor training and psychological engagement. Hao et al. (2024) argued that VR offers promising clinical outcomes as an advanced therapeutic approach in stroke rehabilitation. Moreover, Cardille et al., (2025) reported that VR interventions produced positive motor outcomes in 76.3% of cases, with semi-immersive systems achieving the highest proportion of significant improvements. Beyond motor metrics, much of VR's appeal lies in the therapeutic experience itself. Prajjwal et al. (2024) noted that VR rehabilitation offers enhanced feedback and increased patient motivation compared with traditional therapy. This motivational dimension is a very important element of rehabilitation, as it has a direct impact on the level of patient engagement in therapy and, ultimately, on recovery.

Personalized and Adaptive Interventions

One of the greatest potentials of AI applications in rehabilitation lies in the development of personalized and adaptive interventions. AI can integrate data from wearable sensors,

patient reports, and environmental contexts to tailor therapeutic pathways and continuously adjust rehabilitation processes. Calabrò and Mojdehdehbaher (2025) described how AI-enabled telerehabilitation platforms deliver individualized interventions responsive to patients' needs and rehabilitation stages, while Olawade et al. (2025) demonstrated improvements in exercise adherence and reductions in in-person visits through AI-driven virtual physiotherapy assistants and wearable technologies. However, Attoh-Mensah et al. (2025) noted that widespread implementation remains limited due to insufficient understanding of both benefits and barriers.

From the perspective of the Tolerance Ecosystem Framework (Brankovic, 2025), personalization extends beyond technological adaptation to include sensitivity toward individual, cultural, and social differences among patients. In this context, tolerance functions as an operational factor that supports inclusive rehabilitation by ensuring that AI-driven interventions respect patient dignity, accommodate diverse needs and expectations, and foster trust in human–machine interactions. Consequently, the effectiveness of personalized rehabilitation may depend not only on the technical capability of AI systems but also on the extent to which tolerance principles are integrated into their design and implementation. Such an approach aligns technological innovation with patient-centered care and contributes to more equitable and inclusive healthcare outcomes.

Purpose / Objectives of the Study

Equity and Cultural Competence supported by tolerance in AI-Driven Rehabilitation

Tolerance begins from the very first day of our lives, cultivated within family relationships. Education plays a crucial role in teaching and developing the values of tolerance, coexistence, and inclusivity. Reading open minds promotes tolerance, openness, and communication, preparing an educated and open-minded people. Governments should enhance their role as incubators for tolerance implementing programs in education, culture, religion and family values. (Brankovic,2026). The global economy has become more interconnected, accompanied by significant increases in mobility, connectivity, assimilation, and interrelation. When individuals from diverse races, religions, cultures, backgrounds, socioeconomic statuses, and customs coexist, considerable effort is necessary to build a better-quality environment for all. Governments should enhance their role as incubators for tolerance by implementing programs in education, cultural content, religious acceptance, and family values. Governments also must regulate AI in healthcare to ensure fairness, transparency, and non-discrimination. AI systems must be trained on diverse datasets to avoid bias and ensure equitable care across cultures, languages, and socioeconomic groups. Healthcare workers must be trained to understand AI tools, avoid algorithmic bias, and maintain culturally sensitive patient care. AI-driven healthcare must not exclude groups (e.g., elderly,

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migrants, low-income patients) due to digital divides or biased algorithms.

The application areas discussed share a common vulnerability regarding the ethical and responsible use of AI. Parag et al. (2023) acknowledged that AI-driven healthcare systems can pose threats to data privacy, introduce algorithmic bias, have an impact on fairness, and that addressing these requires diverse training datasets and continued

human oversight of AI-based rehabilitation programs, accompanied by transparency and accountability. Umuku et al. (2025) warned that any bias within rehabilitation tools not only undermines the goal of supporting patients undergoing rehabilitation but also raises serious ethical problems. Moreover, an important aspect often overlooked is the cultural competence of such systems. The technical solutions discussed above acquire their meaning only within human relationships, and those relationships are undeniably cultural. Tolerance, understood as the active respect for individual and cultural differences within the therapeutic process, should be a prerequisite for effective rehabilitation, as the use of any AI-based tool is always mediated by a patient's beliefs, expectations, and sense of dignity, all of which are shaped by culture.Cultural competence has been recognized in healthcare as a foundation for equitable care. Valdez (2025), argued that culturally responsive practice must be both evidence-based and sustainable across diverse settings. For rehabilitation specifically, where therapy unfolds over weeks or months and depends heavily on trust and sustained adherence, these gains are considerable. A patient who feels misunderstood is less likely to persist with a demanding exercise program, regardless of how sophisticated the underlying technology may be.

The difficulty is that the cultural sensitivity is not automatically integrated into AI systems. A growing body of work shows that AI systems will adopt the cultural assumptions of the data on which they are trained. Tao et al. (2024) examined the cultural alignment of widely used large language models and found that such systems tend to reflect the values of the populations most heavily represented in their training datasets and exhibit cultural values of English-speaking and Protestant European countries. This, consequently, raises the question of whether a tool that performs excellently in one cultural context might perform unevenly in another. In rehabilitation, where communication around pain, bodily autonomy, and family involvement varies significantly between cultures, this mismatch is not a marginal concern. The integration of Multimodal Large Language Models (MLLMs) into healthcare systems offers opportunities that extend beyond digital preservation of language and cultural heritage. By incorporating linguistic, cultural, and contextual data, MLLMs can facilitate more nuanced and contextually appropriate responses, reduce excessive generalization and support more personalized interventions. Such systems have the potential to consider not only clinical and health-related information but also patients' cultural backgrounds, beliefs, language preferences, and social contexts. From this perspective, the integration of tolerance principles into AI design may contribute to more inclusive and culturally responsive healthcare by enabling technologies to better recognize and accommodate human diversity in decision-making and patient interactions.Additionally, the level of technological acceptance varies significantly between cultures. Building trust in AI rehabilitation systems requires engaging with patients within their own value systems rather than assuming universal enthusiasm for technology. Adams and Frazier (2025) argued that in creating responsible health AI, stakeholders, including those from targeted communities, should be involved at every phase of development, drawing on multicultural patient advocacy associations and trusted community leaders to develop culturally informed strategies and more representative datasets. This approach can lead to increased trust and better patient outcomes for patients coming from different cultural backgrounds.

Society:Understanding culture is not an addition to AI-enhanced rehabilitation systems but a determinant of whether the technology heals or alienates. This is why tolerance must be treated as an operational parameter of system design. The model proposed in the section below takes this integration as its starting point.

Research Approach

This study adopts a qualitative conceptual research design grounded in a comprehensive narrative literature review of academic and policy sources on artificial intelligence, rehabilitation medicine, digital health, healthcare ethics, tolerance, and inclusive healthcare. Relevant peer-reviewed journal articles, international policy documents, and institutional frameworks, including UNESCO's Recommendation on the Ethics of Artificial Intelligence and the World Health Organization's people-centered healthcare principles, were examined to identify key opportunities, challenges, and ethical considerations associated with AI-assisted rehabilitation.

The study further employs a theory-building approach, drawing upon the author's previously developed Tolerance Ecosystem Framework to extend the concept

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of tolerance into the domain of AI-enabled healthcare. Through conceptual synthesis of the literature, the paper develops the Tolerance-Integrated AI Rehabilitation (TIAR) Model, a theoretical framework that integrates technological capability, tolerance principles, and governance mechanisms to support inclusive and human-centered rehabilitation systems.

The analysis focuses on four major AI application domains identified within the rehabilitation literature: robotic support, predictive analytics, virtual therapies, and personalized interventions. These domains are examined through the lens of tolerance, human dignity, cultural diversity, and ethical governance to explore how AI technologies can contribute to equitable and inclusive healthcare outcomes.

Research design

A Theoretical Model Integrating AI Capabilities with Tolerance

Based on the previous studies, we can conclude that AI offers a number of potential benefits across different areas of patient rehabilitation, and that those benefits and final outcomes are also conditional on cultural and ethical factors. Bringing these claims together requires a model in which tolerance is actually built into AI systems as a structural element, and cultural sensitivity is a part of the training data. The Tolerance-Integrated AI Rehabilitation (TIAR) model proposed in the present study is offered as a conceptual framework for this approach. The proposed model consists of three layers

- a technical layer, a tolerance layer, and a governance layer, connected by continuous feedback and information exchange.

The technical layer consists of the four application domains examined earlier in this paper: robotic support, predictive analytics, virtual therapies, and personalized interventions. These supply the model's capacity for precision, intensity, and adaptation. The tolerance layer addresses how these solutions meet the following culturally related patient needs: respect for individual and cultural diversity, preservation of patient dignity, and acceptance of human-machine collaboration as a therapeutic relationship. The last layer is the governance layer that surrounds both,

supplying the oversight, accountability, and data practices through which the first two layers are kept aligned with patient interests over time. The model aligns with UNESCO (2021) Recommendation on the Ethics of Artificial Intelligence, particularly its principles of human rights, diversity, inclusiveness, fairness, and non-discrimination. TIAR extends these principles to rehabilitation medicine by providing a conceptual pathway for translating ethical AI into everyday clinical practice. It places the protection of human rights and dignity at its center and advances transparency, fairness, and human oversight as core principles, while calling for data governance that ensures representativeness, accountability, and quality. The TIAR Model supports the World Health Organization's (WHO) people-centred healthcare approach, which emphasizes dignity, equity, participation, quality of care, and responsiveness to individual patient needs. Within the model, tolerance serves as the practical mechanism through which these principles can be consistently embedded into AI-assisted rehabilitation environments. The model proposes that tolerance functions as an operational ethical mechanism that integrates AI capability with human-centered healthcare, reducing risks of bias and dehumanization while improving rehabilitation outcomes, patient well-being, and inclusive societal development. The TIAR model can be read as a rehabilitation-specific operationalization of these principles, with tolerance serving as the connective concept that links the abstract value of dignity to concrete design choices. The proposed framework additionally supports Sustainable Development Goal 3 on health and well-being (United Nations, 2015).

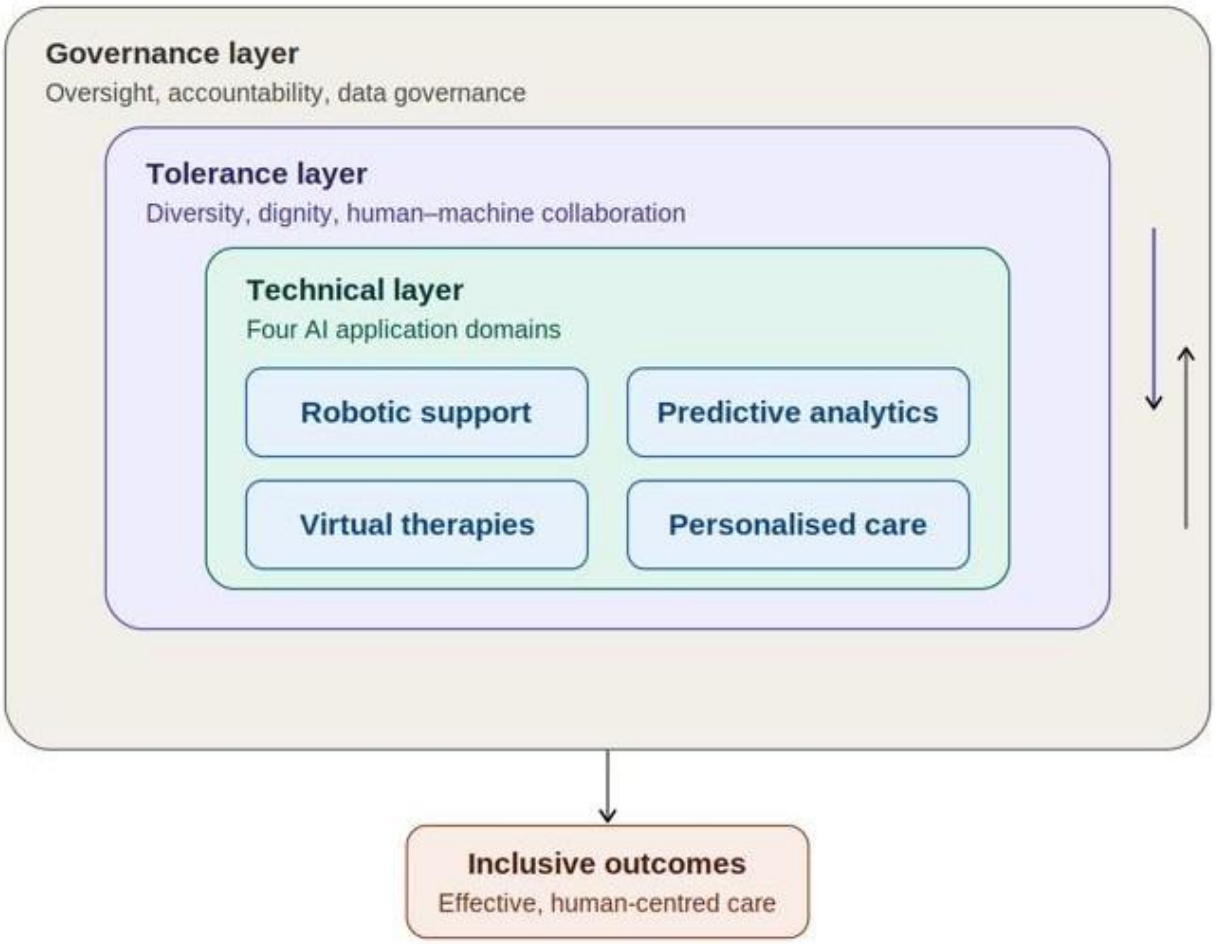
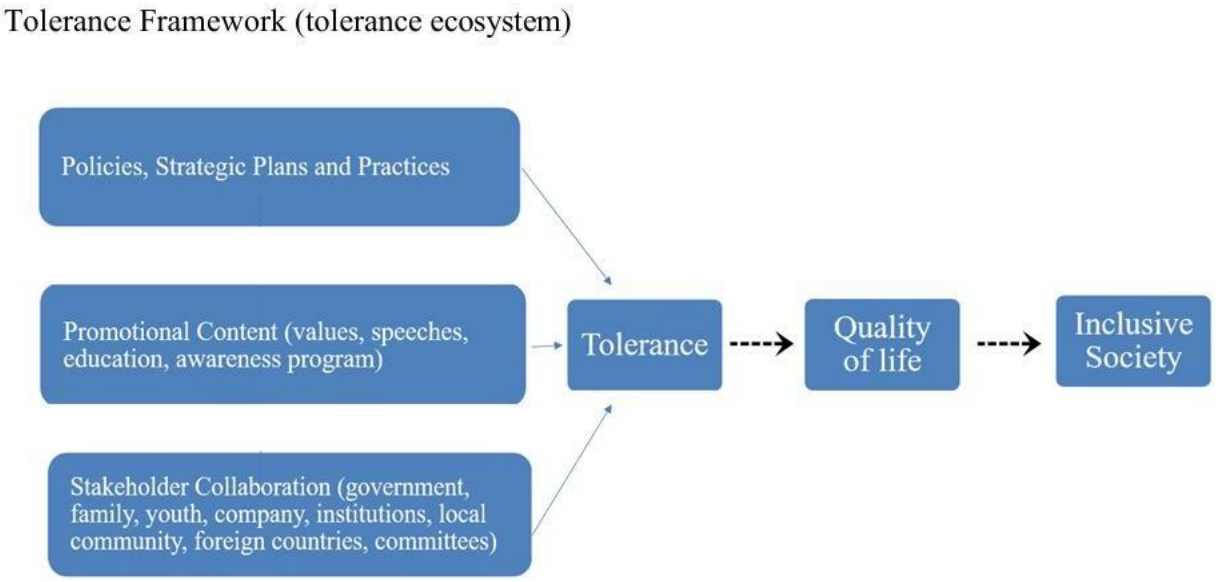


Figure 1. The Tolerance-Integrated AI Rehabilitation (TIAR) model.

Taken together, the proposed elements of the TIAR model describe a rehabilitation system in which technical capability and human values are working together for the patients benefits. The aim is to ensure that the considerable potential benefits of AI-based rehabilitation systems are realized in a manner that respects every patient's dignity and individual and cultural differences. A system designed around it can extend the reach of rehabilitation to underserved populations and provide a more equitable approach to AI-assisted healthcare.



The tolerance ecosystem shown in Figure 2 (Brankovic, 2025) is constructed around three primary categories. The first category encompasses policies and strategic plans for promoting and implementing tolerance. This is primarily achieved through developing content, which is the second category. This content aligns with various

designed programs – both promotional and educational – intended to raise awareness, educate participants and foster the practice of tolerance as a habit. Additionally, the formulation of rules and government principles empowers the value of tolerance, thereby establishing a model of acceptance within the ecosystem. The third category involves partnerships, collaborations and core pillars through which the first two categories are promoted and spread. This includes contributions from both private and government sectors and family and community environments, all of which support the value of tolerance and its integration into daily life. Such efforts are crucial in enhancing the quality of life across all sectors. This positive attitude and relationship with others lays the base for creating an inclusive society. The 'Tolerance Framework' illustrated in Figure 3 represents a comprehensive approach to fostering tolerance within society, aimed at enhancing the overall quality of life and fostering inclusivity. This framework consists of three fundamental components, each contributing to the institutional measures and programs that are systematically implemented to enhance the tolerance of individuals and communities (Kymlicka, 1995). These initiatives may include structured policy actions, legal and regulatory measures and policy directives aimed at integrating tolerance into the lifestyles and societal structures of individuals.

Figure 2. The Tolerance ecosystem framework

The TIAR Model can be viewed as a sector-specific application of the broader Tolerance Ecosystem Framework developed in this author's research.

The Tolerance Ecosystem Framework proposes that tolerance is not merely an individual value but a systemic outcome produced through the interaction of multiple stakeholders, policies, implementation mechanisms, and societal actors. The framework emphasizes that inclusive outcomes emerge when tolerance principles are embedded within institutional structures and translated into practice through stakeholder collaboration.

Within AI-assisted healthcare, the TIAR Model operationalizes these principles in the context of rehabilitation. While the Technical Layer provides AI capabilities and the Tolerance Layer embeds human-centered values into patient interactions, the Governance Layer performs a function similar to that of the implementation mechanisms within the Tolerance Ecosystem Framework. It ensures that tolerance principles are translated into healthcare practice through oversight, accountability, data governance, and stakeholder engagement.

While the Tolerance Ecosystem Framework explains how tolerance is operationalized through stakeholder collaboration and institutional implementation across society, the Tolerance-Integrated AI Rehabilitation (TIAR) Model demonstrates how these principles can be applied within AI-assisted healthcare systems. In this sense the TIAR Model represents a healthcare-specific operationalization of the Tolerance Ecosystem Framework, demonstrating how tolerance can function as a practical mechanism that links stakeholder collaboration, ethical governance, and AI-enabled rehabilitation to produce inclusive healthcare and broader societal outcomes.

Integrating the Tolerance Ecosystem Framework and the Tolerance-Integrated AI Rehabilitation (TIAR) Model

The Tolerance-Integrated AI Rehabilitation (TIAR) Model can be understood as a healthcare-specific extension of the broader Tolerance Ecosystem Framework (TES). While the TES framework explains how tolerance is operationalized through stakeholder collaboration, policies, implementation mechanisms, and institutional structures to promote inclusive societies, the TIAR Model applies these principles within the context of AI-assisted rehabilitation.The Tolerance Ecosystem Framework argues that tolerance should not be viewed solely as an individual moral value but as a systemic process that emerges through interactions among stakeholders, governance structures, and implementation practices. Similarly, the TIAR Model proposes that successful AI-enabled rehabilitation depends not only on technological capability but also on the integration of tolerance principles throughout the design, implementation, and governance of healthcare systems.Within the TIAR Model, AI technologies provide the technical capacity for rehabilitation through robotic support, predictive analytics, virtual therapies, and personalized interventions. However, the effectiveness of these technologies depends on their ability to operate within a tolerance-centered environment that respects individual and cultural diversity, preserves patient dignity, and promotes acceptance of human–machine collaboration. The Governance Layer ensures that these principles are maintained through oversight, accountability, transparency, and responsible data governance.

A key contribution of the model is the introduction of stakeholder collaboration as the connecting mechanism between the TES framework and AI-assisted healthcare. Healthcare institutions, rehabilitation professionals, AI developers, policymakers, researchers, patients, and families collectively shape how tolerance principles are translated into practice. Through this collaborative

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process, ethical principles move beyond abstract recommendations and become embedded in everyday healthcare interactions. Taken together, the proposed elements of the TIAR Model describe a rehabilitation system in which technological capability and human values operate in synergy for the benefit of patients. The model seeks to ensure that the considerable advantages of AI-assisted rehabilitation are realized in a manner that respects human dignity and accommodates individual and cultural differences. By integrating tolerance into healthcare governance and technological design, the model contributes to more equitable, inclusive, and patient-centered rehabilitation systems.

The TIAR Model further aligns with UNESCO's Recommendation on the Ethics of Artificial Intelligence (2021), which places human dignity, diversity, fairness, transparency, and human oversight at the center of AI development. It also supports the World Health Organization's people-centered healthcare approach by emphasizing dignity, participation, responsiveness, and equity in healthcare delivery. Furthermore, the framework contributes to achieving Sustainable Development Goal 3 (Good Health and Well-Being) by promoting accessible, inclusive, and ethically governed rehabilitation services. An overview of how macro-level application with sector application in the framework could look like is shown in Table 1:

Table 1.

Level	Component	Key Elements	Function
Macro Level	**Tolerance Ecosystem Framework (TES)**	Policies; Stakeholder Collaboration; Institutional Implementation; Governance Mechanisms	Provides the societal and institutional foundation through which tolerance is operationalized and translated into practice.
↓			
Sector Level	**Tolerance-Integrated AI Rehabilitation (TIAR) Model**	AI-assisted rehabilitation system	Applies tolerance principles within healthcare and rehabilitation settings.
Layer 1	**Governance Layer**	Accountability; Transparency; Data Governance; Human Oversight	Ensures ethical implementation, responsible AI deployment, patient protection, and alignment with human-centered healthcare principles.
Layer 2	**Tolerance Layer**	Respect for Diversity; Patient Dignity; Human–Machine Collaboration	Integrates tolerance into patient interactions, supports inclusivity, trust, and culturally responsive rehabilitation.
Layer 3	**Technical Layer**	Robotic Support; Predictive Analytics; Virtual Therapies; Personalized Interventions	Provides the technological capabilities that enable adaptive, efficient, and personalized rehabilitation.
↓			

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Healthcare Outcomes	**Inclusive Outcomes**	Improved Well-being; Increased Trust; Reduced Inequalities; Human-Centered Rehabilitation	Represents the direct outcomes achieved through the interaction of governance, tolerance, and AI technologies.
↓			
Societal Level	**Societal Outcomes**	Social Cohesion; Inclusive Healthcare; Sustainable Technological Transformation	Demonstrates the broader societal impact of tolerance-integrated AI healthcare systems.

Conclusion

This paper examined the growing role of artificial intelligence in medical rehabilitation through the lenses of ethics, inclusivity, and tolerance. The literature demonstrates that AI-enabled rehabilitation technologies, including robotic support, predictive analytics, virtual therapies, and personalized interventions, have considerable potential to improve patient outcomes, increase accessibility, and enhance the effectiveness of rehabilitation services. However, the findings also reveal that technological capability alone cannot guarantee equitable or human-centered healthcare outcomes. Future research could explore the potential of positioning tolerance as a foundational social value and a recognizable public brand, especially within multicultural and multilingual societies such as the UAE. By leveraging strategically designed media campaigns, tolerance can be framed through a coherent and compelling brand identity – one that enhances its visibility, relatability and resonance across diverse communities. This branding approach can transform tolerance from an abstract ideal into a tangible societal movement with potential applications across sectors, particularly in AI. In the health care and AI usage, this could be a significant improvement in patient care that involves machine interaction.

The study argues that tolerance should be understood not only as a moral principle but also as an operational factor within AI-assisted healthcare systems. Drawing upon the Tolerance Ecosystem Framework and extending its application into rehabilitation medicine, the paper proposes the Tolerance-Integrated AI Rehabilitation (TIAR) Model. The model demonstrates how tolerance can function as a connecting mechanism between technological innovation, ethical governance, and patient-centered care. By integrating respect for cultural diversity, preservation of patient dignity, and acceptance of human–machine collaboration into rehabilitation processes, AI systems can become more inclusive, trustworthy, and responsive to individual patient needs.

Furthermore, the study highlights that tolerance is particularly relevant in multicultural healthcare environments where patients may differ significantly in language, cultural background, values, beliefs, and attitudes toward technology. In such contexts, culturally responsive AI systems may contribute not only to improved rehabilitation outcomes but also to greater trust, engagement, and long-term adherence to treatment programs.

Ultimately, the paper concludes that the future success of AI-enhanced rehabilitation will depend on the ability of healthcare institutions to balance technological advancement with human dignity, inclusiveness, and ethical responsibility. The TIAR Model offers a conceptual framework through which this balance can be achieved.

Implications

Theoretical Implications

The study contributes to the growing literature on AI ethics by introducing tolerance as a practical and operational concept rather than solely a normative value. It further extends the Tolerance Ecosystem Framework into the healthcare domain, demonstrating how principles originally developed to support inclusive societies can be applied to AI-assisted rehabilitation systems. The TIAR Model therefore provides a new conceptual lens for examining the relationship between technology, ethics, governance, and patient-centered care.

Practical Implications

For healthcare institutions, the findings suggest that successful AI implementation requires more than technical performance and clinical accuracy. Healthcare providers should incorporate cultural competence,

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patient dignity, and inclusiveness into the design and deployment of rehabilitation technologies. Training programs should be developed to equip healthcare professionals with the skills necessary to recognize and address potential cultural biases and ethical challenges associated with AI-assisted care.

For AI developers, the findings highlight the importance of using representative datasets, involving diverse stakeholder groups during system development, and ensuring that AI solutions can adapt to different cultural and social contexts. Tolerance principles should be considered during system design to reduce bias, improve trust, and enhance patient engagement.

Policy Implications

The study supports the development of regulatory frameworks that align AI-enabled healthcare with UNESCO's Recommendation on the Ethics of Artificial Intelligence and the World Health Organization's people-centered healthcare approach. Policymakers should encourage governance structures that prioritize transparency, accountability, fairness, and human oversight while promoting equitable access to AI-assisted rehabilitation services.

Societal Implications

At a broader level, the integration of tolerance into AI-assisted rehabilitation may contribute to more inclusive healthcare systems, reduced inequalities, and greater public trust in emerging technologies. By ensuring that technological innovation remains aligned with human values, healthcare systems can support both individual well-being and wider societal goals, including Sustainable Development Goal 3 on Good Health and Well-Being.

Recommendations for future research and actions:

Integrate tolerance principles into the design and evaluation of AI-enabled rehabilitation systems.

Develop culturally responsive AI models that account for language, beliefs, social context, and patient preferences.

Establish multidisciplinary stakeholder collaboration involving healthcare professionals, AI developers, patients, policymakers, and researchers.

Expand research on the relationship between tolerance, cultural competence, and AI-assisted healthcare outcomes.

Pilot and empirically validate the TIAR Model within rehabilitation settings to assess its impact on patient well-being, trust, treatment adherence, and healthcare equity.

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