4

Experience in AI and Deep-Tech Business Models in Healthcare

Daniel Nierhauve

The healthcare sector is currently facing enormous challenges such as rising costs, an aging population, and an increasing shortage of skilled professionals. At the same time, technological developments in the fields of artificial intelligence (AI) and DeepTech offer significant opportunities to effectively address these challenges. The potential of these technologies lies not only in boosting efficiency but also in making substantial qualitative improvements in patient care (Topol 2019). From applications in diagnostics and therapy to efficient management and secure utilization of medical data, numerous innovative business models are emerging that can transform healthcare in the long term (Accenture 2017).

A central area of application for AI is in medical diagnostics. AI-powered deep learning methods enable the analysis of medical imaging data – for example, from radiology and pathology – with greater accuracy and speed than human experts (Litjens et al. 2017). This is particularly invaluable in the early detection of cancer or other hard-to-diagnose conditions (Esteva et al. 2017). As a result, new business models such as AI-supported diagnostic platforms can be offered as services to hospitals or specialized diagnostic centers. These offerings could, for instance, be financed via flexible pay-per-use models, where costs are directly linked to the services rendered (PwC 2019). Furthermore, personalized medicine offers enormous potential by combining genetic information, patient histories, and real-

AI helps to create individually tailored treatment suggestions and medication plans.

time health data through AI to create individually tailored treatment suggestions and medication plans. Thus, companies could provide continuously updated and customized treatment options through subscription models, thereby ensuring high-quality patient care (Collins and Varmus 2015).

In addition to diagnostics, the field of AI-powered robotics also presents promising prospects. AI-based surgical robots enable procedures with unprecedented precision, significantly reduce risks, and contribute to shorter treatment durations and lower associated costs (Yang et al. 2017). Companies could focus on offering complete service solutions for surgical systems ("Robotics-as-a-Service"), which would allow hospitals to upgrade their infrastructure to state-of-the-art standards without high upfront investments (Frost & Sullivan 2020). Moreover, AI-based platforms in preventive medicine offer the possibility of continuously monitoring health data and providing users with targeted preventive measures before diseases develop. Such innovative prevention models could be particularly beneficial for health insurers aiming to reduce long-term healthcare costs (Deloitte 2019).

Furthermore, the integration of AI with virtual reality (VR) and augmented reality (AR) opens entirely new perspectives in surgery. AR glasses could supply surgeons with real-time, patient-specific information during procedures, leading to safer and more efficient operations. VR technologies already enable medical personnel to train in realistic, risk-free virtual environments, which is especially advantageous for complex or rare procedures (Zhang et al. 2020).

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A leading figure in the field of AI and medicine is Prof. Dr. Felix Nensa from the Institute for Artificial Intelligence in Medicine (IKIM) in Essen. He and his team are intensively researching AI-supported applications in radiology. The results of his work – particularly the automated and precise analysis of medical imaging data – significantly contribute to making hospital processes more efficient, accelerating diagnoses, and enhancing the overall quality of medical care (Institute for Artificial Intelligence in Medicine n.d.).

> *The ongoing digitalization in healthcare also provides a unique opportunity to render existing processes considerably more efficient and transparent. Digital patient records, cloud-based data management systems, and automated communication platforms can greatly accelerate administrative workflows, reduce errors, and improve patient safety. As a result, doctors and nursing staff could be significantly relieved and have more time to devote to their primary responsibility – patient care (World Health Organization 2016).*

At the same time, AI technology offers new perspectives for drug development and the conduct of clinical trials. Through predictive models and data-driven analyses, development cycles could be substantially shortened and risks better assessed. AI-supported applications could also greatly enhance the care of the elderly and chronically ill by detecting anomalies early and promptly alerting care providers (Mak and Pichika 2019).

Moreover, a deeper look at the fundamental question is worthwhile: What structural business models can be derived from the increasing integration of AI and DeepTech in healthcare? In addition to traditional licensing and service offerings, platform models are emerging in which patient data, algorithms, service providers, and care facilities are orchestrated on digital marketplaces. Such platforms could ultimately function as intermediary infrastructures that coordinate care, accelerate innovation, and establish new value chains (Deloitte 2020).

A particularly sensitive area remains data protection. It is often portrayed as a hindrance to innovation; however, the actual problem does not lie in the need for protection itself but in the lack of intelligent solutions. AI can even be part of the solution: privacy-by-design approaches, federated learning, or synthetic data offer new ways to reconcile data protection with innovation. The key is a paradigm shift: data protection must be understood as a design criterion from the very beginning and integrated technically into all relevant systems (Cavoukian 2011).

Data protection must be understood as a design criterion from the very beginning.

At the same time, the political and organizational complexity within healthcare institutions should not be underestimated. Projects often fail due to internal power structures, conflicting interests, or a lack of vision. Particularly when introducing disruptive technologies, it is crucial to establish clear governance and form strategic alliances within institutions. Successful stakeholder management in this context means involving not only doctors and nurses but also administration, IT departments, and patient committees. Only in this way can the necessary acceptance be achieved on a broad basis (European Commission 2018).

> *A promising outlook on further fields of application demonstrates just how broad the realm of AI in healthcare still is. In genomics, AI-supported pattern recognition identifies new therapeutic approaches. Speech AI finds application in automated documentation or patient communication, particularly in telemedicine. Even in psychotherapy, AI is increasingly used – for example, to analyze emotional states or to provide supplemental care via chatbots that deliver evidence-based content (Accenture 2021).*

The societal benefits of this transformation are immense. AI can help make medical care more resilient, equitable, and individualized. Patients benefit from faster diagnoses, personalized treatments, and a system that is more focused on prevention and proactive care. Healthcare institutions can allocate resources more precisely, avoid overloading their staff, and increase job satisfaction among medical professionals. Ultimately, a forward-looking healthcare system is created – one defined by innovation, efficiency, and humanity (World Economic Forum 2020).

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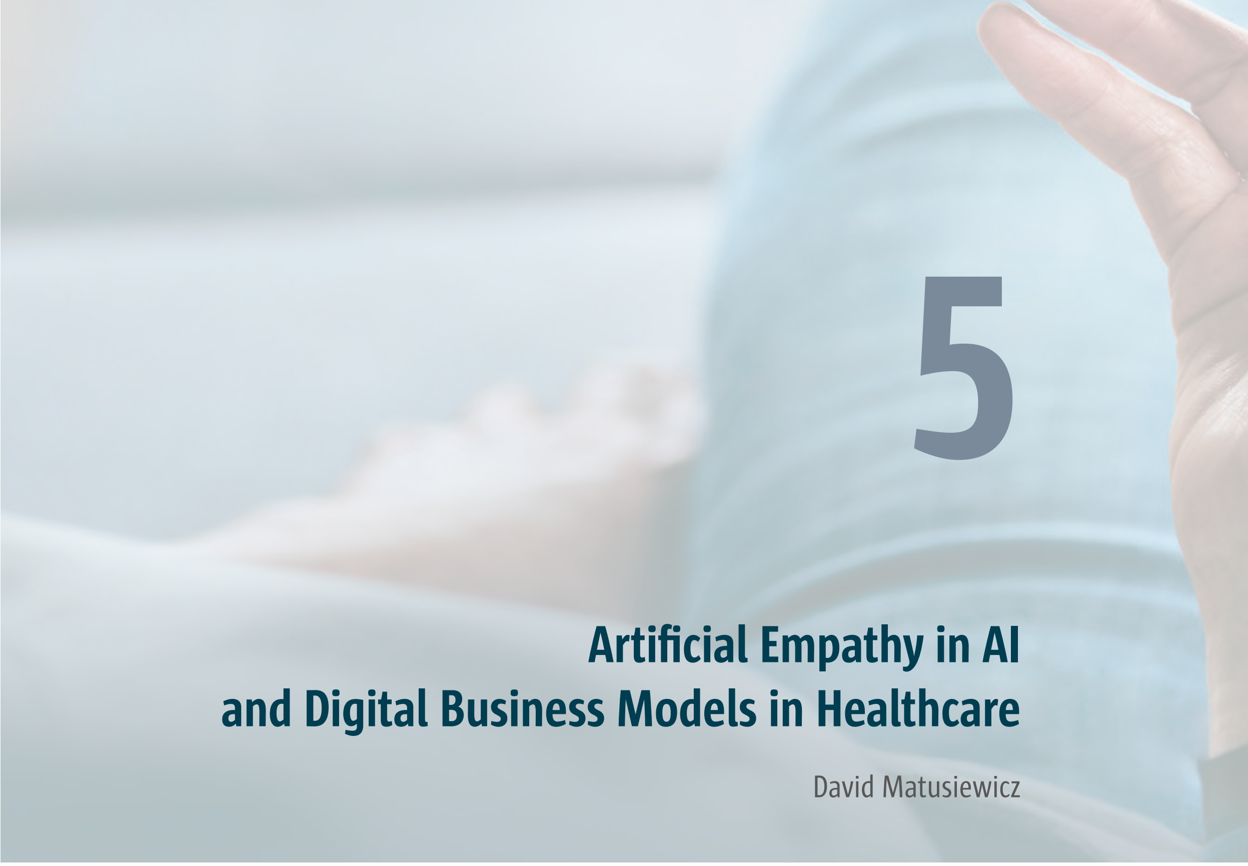

5

Artificial Empathy in AI and Digital Business Models in Healthcare

David Matusiewicz

The digital transformation of healthcare is accelerating, driven by artificial intelligence (AI) and the emergence of new business models. Among the most compelling – and controversial – developments is the integration of *artificial empathy* into AI systems. As healthcare organizations strive to balance efficiency, patient satisfaction, and economic sustainability, the role of empathetic AI is evolving from a futuristic concept to a practical tool. This article explores the promise, challenges, and business implications of artificial empathy in healthcare.

5.1 Defining Artificial Empathy in Healthcare

Artificial empathy refers to the ability of AI systems to recognize, interpret, and respond to human emotions in a manner that simulates human empathy. In healthcare, this capability is leveraged to improve patient-provider communication, support mental health, and enhance the overall patient experience (Morrow et al. 2023)

Empathetic AI is not about replacing human compassion, but about augmenting it. By analyzing language, tone, facial expressions, and behavioral cues, AI can provide insights into a patient's emotional state, helping clinicians tailor their interactions and interventions.

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5.2 The Clinical Impact: Beyond Efficiency

Empathetic AI is not about replacing human compassion, but about augmenting it.

While AI's operational efficiency – such as automating administrative tasks and supporting clinical decision-making – is well documented, artificial empathy also offers transformative potential for patient outcomes:

- Continuous Support: AI-powered companions can provide reassurance and guidance between clinical visits, addressing patient loneliness and anxiety, especially during vulnerable moments.
- Personalized Interactions: Through natural language processing and sentiment analysis, AI can interpret emotional cues and alert clinicians to underlying distress or non-adherence risks.
- Improved Outcomes: Research shows that when empathy is effectively communicated, patient satisfaction, adherence to treatment, and health outcomes improve significantly.

For example, the Mayo Clinic is developing hundreds of AI algorithms, some of which help predict health outcomes and personalize treatment. Their approach emphasizes trustworthy AI and human oversight, ensuring that technology complements rather than replaces clinical judgment.

5.3 Digital Business Models: Monetizing Empathetic AI

The integration of artificial empathy into healthcare is spawning new digital business models, including:

- AI-Powered Virtual Health Assistants: Subscription-based or pay-per-use platforms offer symptom triage, mental health support, and chronic disease management, often with empathetic interfaces to foster trust and engagement.
- Remote Monitoring and Behavioral Analytics: SaaS (Software-as-a-Service) solutions use empathetic AI to monitor patient well-being, detect early signs of distress, and notify care teams, enabling proactive interventions and reducing costly hospitalizations.
- Patient Engagement Platforms: Digital tools that combine AI-driven empathy with educational content and personalized reminders are sold to providers and payers aiming to boost adherence and satisfaction scores.
- Mental Health and Wellness Apps: Direct-to-consumer apps leverage empathetic chatbots to provide companionship, coaching, and crisis support, often monetized through freemium models or partnerships with employers and insurers.

These models are reshaping the healthcare value chain, allowing organizations to scale personalized care, and tap into new revenue streams, while addressing workforce shortages and rising patient expectations.

5.4 Challenges and Ethical Considerations

Despite its promise, artificial empathy in healthcare faces significant hurdles:

- **Authenticity and Trust:** Patients may perceive AI-generated empathy as inauthentic, which may potentially undermine trust in the care process. A lot of patients express hesitation about AI involvement in their healthcare, highlighting the need for human oversight and transparent communication about AI's role (Kerasidou 2020).
- **Bias and Fairness:** AI systems trained on biased data may misinterpret emotional cues, leading to inequitable care or reinforcing stereotypes.
- **Privacy and Consent:** Empathetic AI often requires access to sensitive personal information, which raises concerns about data security and informed consent.
- **Professional Boundaries:** There is an ongoing debate about the appropriate division of labor between AI and human clinicians, especially in emotionally charged situations where human judgment and compassion are critical.

To address these issues, experts advocate for rigorous qualification processes, regulatory oversight, and the retention of human clinicians "in the loop" to provide reassurance and accountability.

5.5 Reconceptualizing Compassion: The Human-AI Caring System

Recent research suggests that compassion in healthcare can be reconceptualized as a *human-AI system of intelligent caring*, comprising six elements:

1. Awareness of suffering
2. Understanding the context and significance of suffering
3. Connecting with the patient's experience
4. Judging the need to act
5. Responding with the intention to alleviate suffering
6. Attending to the outcomes of the response

These elements can operate at both individual and systemic levels, enabling a cyclical process of alleviating suffering that leverages the strengths of both humans and machines.

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5.6 Case Studies and Real-World Applications

- Virtual Companions for Chronic Illness: AI-powered assistants provide 24/7 support, medication reminders, and emotional check-ins, reducing hospital readmissions and improving quality of life for patients with chronic diseases.
- Behavioral Cue Analysis: AI analyzes video or audio recordings of patient interactions to provide real-time feedback to clinicians, helping them adjust their communication style and better align with patient needs.
- Mental Health Chatbots: Digital platforms offer empathetic listening and coping strategies for users experiencing anxiety or depression, extending the reach of scarce mental health professionals.

These applications demonstrate how empathetic AI can fill care gaps, support overburdened clinicians, and foster therapeutic alliances that drive better outcomes.

Strategic Implications for Healthcare Organizations

To harness the benefits of artificial empathy, healthcare organizations should (see also Matusiewicz and Werner 2025; Moors 2025):

- ***Invest in Human-AI Collaboration:*** *Train clinicians to work alongside empathetic AI tools, leveraging their insights while maintaining human oversight and relational skills.*
- ***Prioritize Ethical AI Development:*** *Implement safeguards to ensure fairness, transparency, and patient privacy, and involve diverse stakeholders in AI design and deployment.*
- ***Align Incentives and Regulation:*** *Work with policymakers and payers to create reimbursement models and regulatory frameworks that reward empathetic, patient-centered care.*
- ***Foster a Culture of Trust:*** *Communicate openly with patients about the role of AI, emphasizing its supportive function and the continued importance of human compassion.*

5.7 Conclusion: The Future of Empathetic AI in Healthcare

Artificial empathy is reshaping healthcare, not by replacing human connection, but by amplifying it. As digital business models evolve, empathetic AI offers scalable solutions to some of the sector's most pressing challenges – workforce shortages, patient engagement, and the need for personalized, compassionate care. The path forward lies in strategic collaboration between humans and machines, guided by ethical principles and a shared commitment to healing. By embracing this symbiosis, healthcare can become not only more efficient, but also more humane (Matusiewicz and Werner 2025).

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