Received 21 February 2023
Revised 5 September 2023
12 October 2023
Accepted 5 November 2023

Stand-alone or run together: artificial intelligence as an enabler for other technologies

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Abstract

Purpose – The purpose of this study is to examine the role of artificial intelligence (AI) in transforming the healthcare sector, with a focus on how AI contributes to entrepreneurship and value creation. This study also aims to explore the potential of combining AI with other technologies, such as cloud computing, blockchain, IoMT, additive manufacturing and 5G, in the healthcare industry.

Design/methodology/approach – Exploratory qualitative methodology was chosen to analyze 22 case studies from the USA, EU, Asia and South America. The data source was public and specialized podcast platforms.

Findings – The findings show that combining technologies can create a competitive advantage for technology entrepreneurs and bring about transitions from simple consumer devices to actionable healthcare applications. The results of this research identified three main entrepreneurship areas: 1. Analytics, including staff reduction, patient prediction and decision support; 2. Security, including protection against cyberattacks and

This research was partially sponsored by the Jenny and Antti Wihuri Foundation, Finland. This research was partially sponsored by the research center XPRES (Excellence in Production Research) – a strategic research area in Sweden.

The authors thank Narmin Zeynalli and the Baltic Science Network Mobility Program for Research Internships (BARI) for initial assistance.

During the preparation of this work, the authors used ChatGPT to assist with language verification and polishing. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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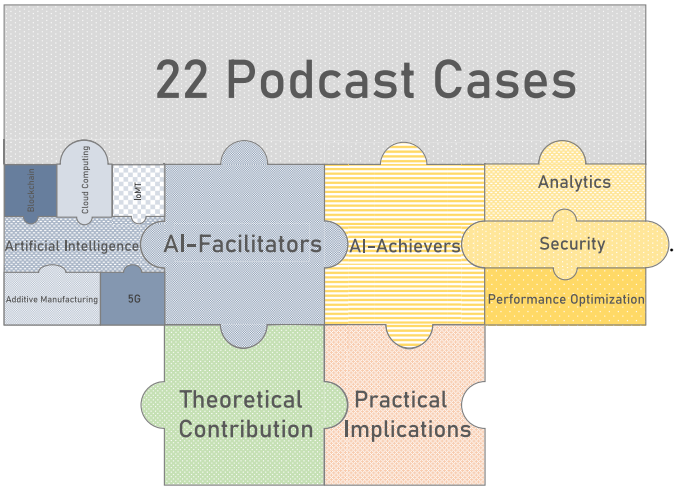
International Journal of Entrepreneurial Behavior & Research
Vol. 30 No. 8, 2024
pp. 2082-2105
Emerald Publishing Limited
1355-2554
DOI 10.1108/IJEBR-02-2023-0169

detection of atypical cases; 3. Performance optimization, which, in addition to reducing the time and costs of medical procedures, includes staff training, reducing capital costs and working with new markets.
Originality/value – This study demonstrates how AI can be used with other technologies to cocreate value in the healthcare industry. This study provides a conceptual framework, "AI facilitators – AI achievers," based on the findings and offer several theoretical contributions to academic literature in technology entrepreneurship and technology management and industry recommendations for practical implication.

Keywords Artificial intelligence, Health care, Analytics, Security, Performance optimization, Conceptual framework
Paper type Research paper

Graphic abstract



Introduction

Emerging technology researchers and practitioners agree that artificial intelligence (AI) is the next "general-purpose" technology after the steam engine, electricity and the internal combustion engine (Brynjolfsson and Mcafee, 2017; Russell, 2021). AI should become the basis for revolutionary breakthroughs in developing various industries and society. Applying new technologies, including AI, has led to breakthroughs in design, logistics, manufacturing and more (Chatterjee *et al.*, 2021; Upadhyay *et al.*, 2022; Woschank *et al.*, 2020; Yeo *et al.*, 2022). In turn, the healthcare industry is more focused on using AI in diagnostics, therapy, healthcare management and drug development (Kulkov, 2023). However, other technologies like blockchain, cloud computing, the Internet of Medical Things (IoMT) and others are emerging into health care. There is much competition from technology entrepreneurship, as well as the conservatism of the healthcare industry, complicating the mass introduction of new technologies in practice. Many agree the main reason for the difficulty of implementing in a focal industry is the cost of error (Foshay and Kuziemsky, 2014; Rebuge and Ferreira, 2012). Therefore, most healthcare entrepreneurs and their innovations are strictly controlled by industry stakeholders. Combining the advantages of several technologies can become another benefit for entrepreneurs operating in the focal industry, as well as hospitals, doctors, patients and policymakers.

This paper adheres to AI's classical definition as a machine with intelligent behavior (Mccarthy, 1959). In most social studies, AI includes machine learning, deep learning, neural

networks and so on (Kratsch *et al.*, 2021; Kraus *et al.*, 2020). AI algorithms' main function is to process large amounts of data to determine certain patterns as results. Cloud computing is a collection of services such as servers, databases and storage on the Internet—the so-called "cloud"—to increase flexibility in processing and save resources (Qian *et al.*, 2009). Blockchain is a collection of blocks (a list of records) interconnected by cryptographic algorithms and distributed ledger technology (Monrat *et al.*, 2019). IoMT is a collection of medical devices and related technological solutions connected to an IT system using computer networks, additive manufacturing and 3D printing. IoMT consists of building digital 3D models of objects (Mohd Aman *et al.*, 2021). In turn, 5G is a new communication protocol providing increased data transfer rates and allows device-to-device integration (Hassan *et al.*, 2019). In general, all these technologies are used in health care. However, most often, they are fragmented, reducing their productivity and the value that can be generated for industry stakeholders.

The motivation for our study is twofold. First, from a theoretical perspective, most studies on AI's role in health care are devoted to successful cases in diagnostics, therapy and other areas (Hee Lee and Yoon, 2021; Yu *et al.*, 2018), the role of technology business in industry transformation (Kulkov *et al.*, 2023a, b, c), ethics (Bartoletti, 2019) and trust (Omrani *et al.*, 2022). Many authors combine different technologies and emphasize the importance of their implementation for healthcare needs (Aceto *et al.*, 2018; Syeed *et al.*, 2022). Conversely, researchers state that AI enables literature technology to empower society and processes (Secinaro *et al.*, 2021). Some health studies mention that AI's primary use is in health care but leave this area open for other researchers (Giuggioli and Pellegrini, 2023; Panch *et al.*, 2019). Research shows that using a single technology may be insufficient for a technology entrepreneur to succeed or lead to negligible market share (Foshay and Kuziemsky, 2014; Rouidi *et al.*, 2022; Syeed *et al.*, 2022). We hypothesize that value creation based on combining technologies can become a competitive advantage for a technology entrepreneur. Second, from a practical perspective, the leading medical associations—Healthcare Executive Group, USA, and The European Public Health Association—in 2021 and 2022 identified technologies as the healthcare industry's main challenges, opportunities and hopes placed on technology, which are rated as revolutionary. Moreover, our AI studies in health care show that policymakers and hospitals are more willing to test and implement new technologies (virtual reality, blockchain, IoMT, etc.) if they already have a successful experience.

This research aims to illustrate technology entrepreneurship contribution to transforming the healthcare sector. We identify elements justifying the entrepreneurship advantages and explore the main innovations bringing about transitions from simple consumer devices to actionable healthcare applications. Another aspect considered is how health organizations cocreate value using AI with other technologies for smart health care. Through multiple case study analyses, our paper shows how industry stakeholders can design specific interventions and analyze information in real time. This point is crucial since healthcare innovation and technology aim to create value for organizations and improve people's lives.

Therefore, this study aimed to understand how AI contributes to developing other technologies in health care to create perfection in the general technological transformation of the healthcare industry. The research question for this study was as follows: "*How does AI contribute to the emergence and development of other technologies in healthcare?*" To answer this question, we analyzed 22 podcast case studies on integrating several new technologies, including AI, in healthcare institutions. The obtained results allowed us to identify AI's role in the emergence and development of new technologies in health care (cloud computing, blockchain, IoMT, additive manufacturing printing and 5G), as well as note three main directions for using AI in alliance with other technologies in health care (analytics, security and performance optimization).

The paper is organized as follows: After the Introduction, we review the main points about technology entrepreneurship and value creation in health care. The Method section describes how we collect and code data for our study. Our Findings consist of key outcomes from analyzed interviews supported by quotes from podcasts. We provide a conceptual framework,

"AI facilitators – AI achievers," that joins studied technologies and findings. In the Discussion section, we suggest areas where AI's role is important for using other technologies in health care. Sections Theoretical Contribution and Practical Implications aim to demonstrate our contribution to existing literature and practice. The Conclusion section ends the article.

Literature review

Technological change management in a healthcare context

The increased focus on technology in health care has placed a critical need to investigate how organizations effectively implement and manage change within their development processes. Therefore, understanding the relevant aspects of technology management, particularly when considering introducing AI in health care, is crucial. This chapter explores the current literature around change management in a healthcare context and using AI as an enabler for other technologies.

The management of technological change for healthcare providers must be organized and coordinated to result in successful implementations. Research in this area has identified multiple strategies and methods, each serving a purpose in the change management process (Bates *et al.*, 2003; Cresswell and Sheikh, 2013).

One approach to successful change is utilizing the "influence model," which identifies the roles of leaders and stakeholders in the change process (Sunder, 2016). This method involves worker involvement and organizational learning processes and has been used to manage the introduction of digital healthcare technology (Wu and Chen, 2014). The focus on stakeholder assessment is critical, as it allows organizations to identify and develop strategies tailored to individual stakeholders' needs (Brugha, 2000). Also important is that successfully implementing technology-driven change requires frequent communication and long-term training for implementing skills and understanding the desired results (Cabrera *et al.*, 2001). Reliable information must be provided to employees and stakeholders to ensure the change process is managed effectively (Epstein and Roy, 2001). Moreover, there should be an open dialogue between stakeholders and workers that encourages cooperation and trust (Ruppel and Harrington, 2000). This dialogue will help ensure everyone understands the consequences of the change and is willing to collaboratively work towards the expected outcomes. Finally, assessing employee learning and behavioral changes is essential to ensure the change process's desired effect is achieved (Diamantidis and Chatzoglou, 2014).

Furthermore, healthcare organizations must identify the organizational barriers and resistance to change to manage technological change effectively (Landaeta *et al.*, 2008). The amount of perceived risk, uncertainty and lack of social support often prevents organizations from transitioning between different technological systems. Organizations must create an appropriate culture of acceptance, understanding and trust to overcome these challenges through activities involving top-down and bottom-up approaches (Lisewski, 2004). Also, they must provide education and training on new technologies, along with a gradual implementation of the technology, to ensure it is used correctly. Finally, organizations must create forums for developing communication and feedback between the designers and end-users to ensure the technology is correctly adapted to user preferences and needs (Schnall *et al.*, 2016). Healthcare organizations should also consider different factors when choosing technology, such as cost, reliability, accuracy and user-friendliness (Brewster *et al.*, 2014). The organization must consider the potential risk, as technology can often fail; thus, establishing clear rules and protocols when dealing with technological problems is vital.

AI usage as an enabler for other technologies in health care is increasingly becoming necessary to facilitate the rapid and reliable sharing of health information. AI can be used to predict or even prevent potential health risks (Adly *et al.*, 2020). AI-enabled applications are increasingly used to support health providers in patient care, emphasizing AI technology's potential and value.

In our study, we lean significantly on the groundwork laid by Giuggioli and Pellegrini (2023), who were pioneers in mapping and systematically analyzing the academic literature concerning the interrelationship between entrepreneurship and AI. Their comprehensive review provides a critical foundation for understanding how AI technologies have become an integral part of entrepreneurial activities. They categorize various ways that AI impacts entrepreneurship, such as enhancing operational efficiency, driving new business models and enabling new types of customer engagement. Their work points to an emerging research agenda in which the intersection of AI and entrepreneurship promises to be a fertile ground for both theoretical and empirical studies. Complementing this is the theoretical model developed by Chalmers *et al.* (2021), which delves into the specific roles that AI can play in the entrepreneurial process within healthcare. They propose that AI serves not just as a tool but as an active agent in identifying opportunities, mobilizing resources and scaling ventures in healthcare. This conceptual framework pushes us to think beyond the traditional confines of technology as a passive enabler and instead consider its dynamic role in shaping entrepreneurial strategies and actions.

In conclusion, this literature review has highlighted the importance of technology management in health care and AI use as enabling other technologies. Organizations must focus on stakeholder engagement, organizational culture and change strategies to successfully manage the introduction of new technologies. Through AI-enabled healthcare applications, organizations can reduce the burden of healthcare workers and promote better patient care.

Technology entrepreneurship in healthcare

The concept of technology entrepreneurship serves as a linchpin in the convergence of technological innovation and business ventures. Technology entrepreneurship is not merely the act of starting a new business; it extends to the creation, innovation and scaling of technology-based businesses, where the primary focus lies in the commercialization of technology (Autio, 2005; Shane, 2003). It emerges as a multidisciplinary field of study that combines elements from engineering, business and management to leverage technological advancements for economic gains (Dwivedi *et al.*, 2021; Kulkov *et al.*, 2023a, b, c; Kulkova *et al.*, 2023).

In the healthcare sector, technology entrepreneurship assumes a distinct significance. The industry's unique nature—encompassing stringent regulations, ethical considerations and the imperatives of patient care—necessitates a nuanced approach to entrepreneurial activities (Hill and Wright, 2000). It is within this framework that the utilization of AI opens new entrepreneurial avenues. AI technologies, ranging from predictive analytics to machine learning algorithms, offer transformative capabilities that are redefining healthcare service delivery (Topol, 2019).

Technology entrepreneurship in healthcare embodies a dual focus: solving complex health-related issues while establishing sustainable business models. It involves the development of novel technologies or the innovative application of existing technologies to address healthcare challenges (Beninger *et al.*, 2019). Such ventures often require interdisciplinary collaborations among healthcare providers, engineers and business professionals to ensure that the technological solutions are not only innovative but also practical, scalable and ethically sound (Chesbrough, 2010).

Entrepreneurs in this sector are uniquely positioned to catalyze disruptive innovations. They often act as intermediaries who can translate medical needs into technological solutions and vice versa, playing a crucial role in the ecosystem of healthcare innovation (von Hippel, 2006). Moreover, technology entrepreneurs contribute to value co-creation in healthcare, often developing solutions that benefit multiple stakeholders, including patients, healthcare providers and other businesses (Prahalad and Ramaswamy, 2004).

As healthcare continues to evolve in the age of digital transformation, the role of technology entrepreneurship becomes increasingly pivotal. It holds the promise of expediting the transition towards more efficient, patient-centric models of care while fostering

innovation and economic growth. Thus, understanding the dynamics of technology entrepreneurship in healthcare is not just an academic exercise but a practical necessity for the sustained advancement of the sector.

Value creation and co-creation in healthcare through AI and other technologies

The integration of AI with other emerging technologies offers a compelling avenue for value creation and co-creation in the healthcare sector (Chesbrough, 2010; Prahalad and Ramaswamy, 2004). Value creation refers to the process by which technology solutions, such as AI, contribute to solving healthcare challenges in a manner that is perceived as valuable by stakeholders, including patients, healthcare providers and policymakers. This could manifest in various forms such as cost savings, improved patient outcomes or heightened healthcare efficiency (Porter and Teisberg, 2006).

On the other hand, value co-creation signifies a more collaborative approach where multiple stakeholders are involved in the value-generation process (Vargo and Lusch, 2004). In healthcare, this involves the intersection of technological solutions with healthcare delivery (Barrett *et al.*, 2015). Both technology developers and healthcare providers collaborate to create new or enhanced forms of value. This is especially relevant when considering the integration of AI with other technologies, like the Internet of Things or blockchain (Kaplan and Haenlein, 2019). The amalgamation of these technologies can lead to improved data analytics, enhanced security measures and streamlined performance—areas that we discuss in greater detail in the "Theoretical Contribution" section of this paper.

In sum, value creation is no longer a one-sided effort led by technology entrepreneurs but involves active participation from various stakeholders, including healthcare providers and end-users (Normann and Ramírez, 1993). This new paradigm has substantial implications for technology entrepreneurship and management, particularly in a healthcare setting, as it alters the traditional roles and responsibilities, potentially leading to innovative business models and strategies (Teece, 2010).

Methodology

We chose the exploratory qualitative research design (Kalu and Bwalya, 2017) as the main method for our study. This approach has advantages when studying a limited amount of data, including cases of new trends and phenomena. As a data source, we used public podcast platforms (Apple Podcasts, Google Podcasts and Spotify) and specialized ones dedicated to new technologies (e.g. Emerj). Podcasts are a convenient source of information since they combine accessibility, the ability to verify the results other researchers obtained and the speed of the study, increasing the relevance of the results. In our case, this source of information made forming a sample of business and hospital representatives possible. Simultaneously, we could not influence the interviewees, increasing the impartiality of the results. Also worth noting is that most of the podcasts targeted an audience that was prepared in advance. We note this as an advantage, as the interview time was reduced; in most cases, the description of generally accepted concepts and technologies was minimized and a more interesting discussion and analysis occurred.

Data collection

Altogether, we selected 22 cases where interviewees presented the experience of integrating or applying a solution based on new technology (virtual reality, blockchain, IoMT, etc.) by combining AI in the healthcare industry based on one object (hospital, department, etc.), see detailed information in Appendix. Most often interviewed were founders with positions, for example, CEOs and Business Development Managers, CTOs of companies, representatives of

technical departments, leading engineers, integrators and consultants. Physicians participated in minority interviews, most often as the second participant. The interviews were selected based on a publication date before June 01, 2022, without an initial countdown date. However, all collected cases were implemented no earlier than 2010. Podcasts were searched for by combining the keywords "artificial intelligence," "AI," "machine learning," "deep learning," "robotics," "health care," and "medicine." In some cases, selecting the "healthcare" section was possible in the podcast platform to search for interviews that interested us. The selected interviews were first reviewed by description, keywords and transcribed text, if available, to identify implementing or using a technology-based solution***. The same interviewee could be interviewed in several episodes. However, two technologies had to be used in one case (hospital, department, etc.). Another search by case title and interviewee was performed to collect extra data or identify podcasts on other platforms. Most of the cases were from the USA and Europe; some were from Asia and South America. Additional data were collected from the websites of developers and integrators, hospitals, health portals and more. The selected podcasts were 15 and 55 min long and in English. The topics of the podcasts were quite diverse but focused on the experience of implementing and using technological solutions for healthcare needs.

Coding and analysis

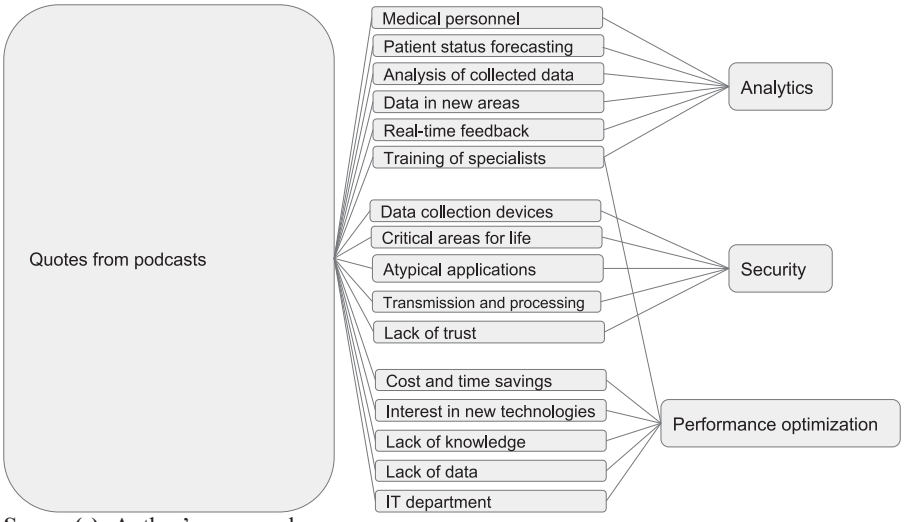
In line with qualitative research best practices (Bazeley and Jackson, 2013), we employed Nvivo for our text analysis of the podcast transcripts. This software facilitated rigorous coding procedures, thematic clustering and pattern recognition. For analytical methods, we utilized a mixed approach incorporating both link analysis and correspondence analysis, supported by academic recommendations for qualitative research (Miles and Huberman, 1994). Link analysis was beneficial for mapping out the relational structures between key terminologies (Wasserman and Faust, 1994). Meanwhile, correspondence analysis enabled us to examine the relationships between various categories or themes, contributing to the richness of our data interpretation (Greenacre, 2010).

The first step toward analyzing our data was to encode the raw data (audio or podcast text). The analysis consisted of listening to or reading podcasts by at least three researchers in parallel several times to identify key phrases relevant to the research topic. Encoding key phrases for podcasts allowed us to generate the first level of codes based on interview data. The second step of coding was the analysis of the received first-level codes to identify common patterns and relationships between codes. The second level codes relate to key areas of effectiveness in applying a combination of AI and other technology. We used the academic literature and industry-specific reports to confirm the identified second-level codes. The third level of coding and analysis was determining the highest level of categories based on theory and practice. Figure 1 provides our approach to coding and analyzing data for the study.

Methodological rigor and validation

To bolster the methodological rigor of this study, we employed a structured coding scheme inspired by Eisenhardt's approach to case study research (Eisenhardt, 1989). This coding scheme was designed to capture key themes relevant to technology entrepreneurship in healthcare, thereby accounting for the varying interview styles found across the different podcasts.

Addressing the concern of survey bias, we conducted a supplementary analysis of the podcasts, systematically comparing key findings and takeaways to existing academic literature, as suggested by Yin (1992). This step served to cross-reference and validate our interpretations, further ensuring the reliability of our findings.



Source(s): Author's own work

Figure 1.
Data coding and analysis for research

We also included an additional layer of methodological scrutiny by applying validation and accuracy measures commonly used in meta-studies (Cooper, 2010). This involved assessing the level of agreement or variation between the podcast findings and existing academic sources as is standard in qualitative research (Denzin and Lincoln, 2011; Flick, 2007). This additional layer assures readers of the comprehensiveness and reliability of our research data.

This section aims to address the reviewer's concerns about methodological rigor and data validation, providing a transparent account of the steps taken to ensure both the reliability and accuracy of the study's findings.

Findings

Our Findings are based on the collected data during the analysis of podcasts. We present the main benefits of AI's power in combination with other new technologies in health care and support our findings with several interview quotes.

Cloud computing

Combining AI-driven analytics with the power of the cloud enables more data to be generated and aggregated from previously disparate systems. Interviewees were more inclined to identify deviations in behavior concerning public health and an individual patient's needs. Policymakers and hospitals can respond to new cases based on evidence and predict developments in the face of scarcity and the fragmentation of sources. Some speakers focused on reducing administrative costs in the industry, which comprise a significant portion of healthcare costs. See a few key quotes from this area:

> We have noticed that several large medical centers have launched a cloud platform plus deep learning solutions for analytics to accelerate doctors' decision making.

> Cloud solutions collect and process data on patients with confirmed COVID-19 or its symptoms [. . .] If AI identifies a deviation in the condition [. . .], the medical staff is informed about the case, and a visit or telemedicine appointment can be scheduled.

Blockchain

According to the almost unanimous opinion of the interviewees, blockchain technology's main advantages in health care are the security of data transfer and storage among stakeholders. The demand for this technology is for tracking and identifying medical products, especially medicines; maintaining audit reports, especially licensing activities; electronic health records, fraud reduction; and more. In turn, combining blockchain with AI analytics makes predicting trends possible and, even more so, provides in-demand medical services. The results of analytical forecasts can be provided automatically to patients, doctors, insurance companies and other interested parties. The following are some typical quotes from the analyzed podcasts:

> The possibilities of AI and blockchain in this project will be to provide individualized patient recommendations . . . [and also] be used to conduct clinical trials.

> [A company] uses Big Data and blockchain to fight the opioid market through data sharing among medical personnel.

Internet of medical things

IoMT solutions based on wireless technologies currently cope with diagnostics, therapy, rehabilitation and other tasks. However, the increased throughput and lower time delay will be needed in more demanding applications such as telesurgery. To solve such problems, the combination of 5G data transmission, AI analytics and IoMT, such as robots, will make switching to seamless compatibility possible in the speed of medical care and its cost. Such will increase the efficiency of both specific medical areas and the overall healthcare system as was noted during the interviews:

> The application of [AI] in IoT is characterized by bringing intelligence into devices. As a result, combined AI-IoT devices generate a very large amount of sensor data, which is analyzed and used as a source of self-learning.

> The key areas of application of IoMT with reference to [AI] algorithms are 1. Tracking the condition of patients, especially chronic ones; 2. Work with medical stocks of medical institutions; 3. Analysis and prioritization of incoming patients; 4. Remote patient monitoring.

Additive manufacturing

Processing Big Data to find the optimal solution for printing a customized medical product, such as an implant, is a promising area for using AI in additive manufacturing. Experts note a reduction in resources for additive manufacturing and manufacturing time and increased resistance to stress. Machine vision allows us to identify the relationship between individual parameters, which can hardly be done with a specialist. We offer several quotes collected during the podcasts:

> The monotony of processes and a huge number of combinations of solutions is the best task [for AI].

> Analytics can reduce material consumption by up to 70% in our practice . . . A sustainable approach to personalized solutions is the basis for promoting our company forward.

5G

Software developers, integrators and tech customers in the healthcare industry are challenged to combine the powers of AI and 5G to achieve capital investment reduction, service expansion and performance optimization. Representatives of private clinics hope to

generate new revenues through new solutions. The proposed solutions based on combining AI and 5G allow the industry to (1) transfer large files faster for further analysis; (2) increase the possibilities of telemedicine in the consultations and operations field; (3) improve communication and experience associated with using solutions based on virtual, augmented and mixed realities; (4) monitor, forecast and issue rapid responses to emergencies, such as those associated with treating patients. Below are a few key quotes from the interviews:

> For connected health, the promise of 5G technology is the ability to put in place an instantaneous integration between a patient's remote monitoring device and a robust medical history data set in the cloud.

> While 5G enables a high bandwidth transmission, AI will turn data into actionable information. The combination of 5G and AI will further transform health care, driving greater efficiencies in patient care and cost models.

Discussion

Our study's results allow us to note several main directions for using AI with other technologies in health care. These areas are analytics, security and performance optimization. In the following, we will discuss how new opportunities affect the current state and overcome key industry challenges.

Analytics

The most intriguing potential for entrepreneurs is to use AI with other technologies when, if not replacing a physician, "reduce the need for personal meetings" as was mentioned during the interview. Predicting medium and long-term changes in a patient's condition depending on current behavior is a top priority for the healthcare industry from the business side. Information collected with IoMT, storage with blockchain, transmission with 5G and processing with AI enables the focal industry's transformation.

Based on the listened-to interviews, we highlight the processing of large arrays of unstructured data as the main current advantage of AI analytics in health care. This approach makes providing "new solutions for areas that were previously inaccessible" to an analysis by researchers and practitioners possible; the company's CTO provides the opinion. The following examples were classified based on interviews and included analyzing a group of patients with rare diseases and identifying new approaches to treatment or developing individual plans based on a large sample. Moreover, AI analytics allows physicians to offer "real-time recommendations based on received data from IoMT." For groups with a rare disease, a new solution may be proposed, the development of which was less commercially attractive for big pharmaceutical companies but is now possible for small and medium companies.

At the intersection of Analytics and Performance optimization areas is "training medical specialists based on naturalistic simulations." AI-based training of specialists has numerous advantages over traditional methods that are tied, for example, to a specific lecturer. AI algorithms, with other technologies, such as cloud computing, allow a student to "connect databases and form scenarios that are inaccessible to humans"; blockchain will allow companies to "securely store the results and verify users," as highlighted in podcasts. Moreover, the learning algorithm can adapt to the student's previous results and form an individual learning program. However, while teaching medical personnel, the algorithm is also self-learning. We can assume the moment the algorithm is trained to make decisions about the patient, the quality of the recommendations will be superior to human counterparts—a significant advantage for countries with a developing medical

infrastructure. A long and expensive stage of training specialists, capital investments in buildings and equipment and the maintenance of narrow specialists can be passed. Conversely, a doctor's status may change due to new technologies. A less-trained specialist or general practitioner can provide medical appointments to patients supported by technology.

However, interviewees noted "a lack of data for problem-solving at the hospital level." In most cases, hospitals cannot generate millions of data lines in specific areas for sufficiently complete algorithm training. Medical practitioners express doubts about the need and possibility of using AI locally and pay more attention to the regional or country level. Therefore, we predict more entrepreneurial prospects for integration at the level of a country or several united countries, for example, on a regional basis. The collected data at this level may suffice to form a prognosis at the level of society, followed by individual proposals to specific patients. In turn, connecting additional sources such as industry reports, news and peer-review databases of publications can contribute to more accurate forecasts and faster algorithm learning. However, existing restrictions on the storage and transfer of personal data reduce the proposed efficiency. See more in the Security chapter.

Security

AI is becoming a critical system for controlling the growing amount of IT-based infrastructure. According to interviewees, the number of IoMT devices will reach 50bn by the decade's end. Currently, most devices, including those critical for the life of patients, such as insulin pumps or pacemakers, have Internet access, increasing the chances of scam attacks. According to respondents, in case of success on the part of scammers, patients may be "amended in the data for diagnosis" or "treatment plan," which can lead, among other things, to fatalities. AI-powered cybersecurity, like traditional methods, allows for "better prevention, detection, and mitigation of a threat that is critical in the healthcare industry," as the software company's CEO declared, which was confirmed during other interviews.

A common method of attacking IoMT without an AI component is to increase requests from nonexistent users, often bots, to overload the device and introduce a malfunction. Classical security systems cannot always identify the threat and distinguish the sudden influx of real users from scammers. Most often, hiring additional employees does not solve such problems since attacks usually start suddenly and reach a peak in a matter of time. In turn, AI security systems perform their functions offline without human support. Advanced AI-based security systems understand the difference between the normal state of operation and hacking attempts; these systems also prevent attacks. Moreover, the security system recognizes normal and abnormal activities for a particular user or device. That "users trust the hardware and software associated with AI despite the lack of understanding of the decision-making principles" is also worth noticing. Attackers can exploit this trust and go unnoticed. The interviewees compare a prepared AI system for security to the human immune system: "the fight against a new virus without prior knowledge of it through testing and understanding the threat." Simultaneously, the AI system must act according to the threat level. Protection against attack should not lead to the system's destruction and stop the device or manufacturer's operation. "Business as usual" is becoming a major benefit of opting for AI in healthcare security.

The whole industry must develop rules and principles for using AI's power to securely store, transfer and process data. The main barrier to implementing the rules is "the need to access closed large datasets for training" as was frequently mentioned during the podcasts. Providing access to and transferring Big Data is new for most medical institutions, causing uncertainty and distrust for the collaboration's participants, especially small businesses. Patients can object to their data being used in processing. For example, patients with rare diseases can be identified, even in an anonymous database.

Performance optimization

We will not dwell on AI's typical benefits in the healthcare industry, such as cost and time savings. Demonstrating new parameters less obvious to other researchers requires more discussion.

In general, the division of opinion among podcast participants is worth noting. We can discuss cautious optimism in representatives of hospitals and the healthcare system using technology. These interviewees discuss their expectations for AI analytics and combining AI capabilities with other technologies. The number of successful and proven integrations leaves much to be desired; more efforts are needed to promote the potential of using new technology features. Moreover, medical customers (for example, hospitals or medical doctors) are questioning the need to apply new technologies and abandon the usual automation of industrial processes and procedures. The cost of a mistake is quite high in health care and an increase in the efficiency or speed of decision-making by a few percent is insufficient for the industry. As we expected at the beginning of the study, business representatives are very enthusiastic about change. However, small business representatives often fail to demonstrate sufficient experience in integrations, while customers consider experience from the non-medical industry irrelevant in the focal industry. Representatives of large businesses and consultants offer solutions at different levels. For example, they aim to solve specific problems at the hospital level or forecast the industry's development at the state level. The general distrust among market participants is worth noting. However, the overall industry understands the benefits of new technologies, their combinations and the need to move to new standards.

Entrepreneurs also face challenges in promoting solutions that combine multiple technologies. Success may depend on the sophistication of the IT department, its role in decision-making at the local level and the industry development strategy at the regional or national levels. Interviewees mention "the readiness of management at the hospital level," "the existence of national regulations" and "the regulation of the healthcare industry" as important factors for business development and success in the industry. We also pay attention to the growing trend of IT staff importance at the local level, which could promote new ideas and support integration. In general, IT's importance at the hospital level is not controversial; however, not everyone is ready to accept that the IT department is getting increasingly more opportunities to make decisions about a particular hospital's development.

Although the formation of new niches may become more promising for entrepreneurs and promise new opportunities for clinics, the lack of regulations can become an insurmountable barrier to business development. Overcoming institutional obstacles to applying new healthcare technologies can be critical, especially for companies.

Conceptual framework

Significant changes result from using new technology in health care, such as cloud computing, blockchain, IoMT, additive manufacturing and 5G. These technologies help develop novel strategies and fresh ideas for handling data, delivering health care, maintaining security and improving performance in health care. We offer a conceptual framework in which we define and investigate the interrelations between technologies and their effects on the healthcare sector.

The first set of innovations, consisting of cloud computing, blockchain, IoMT, additive manufacturing and 5G, can be referred to as "AI facilitators" for health care. These technologies create the infrastructure and require tools to boost productivity. Large amounts of medical data can be managed and stored more easily thanks to cloud computing, giving interested parties the access, they require. Blockchain technology is employed as a secure method of data distribution and storage, which is crucial for privacy. IoMT tracks a patient's health and communicates online between medical devices and healthcare professionals. For

delivering individualized services and diagnosing medical disorders, additive manufacturing gives models of organs and unique devices. Medical services may now be delivered more quickly thanks to 5G technology, which is especially desired in distant areas.

For the healthcare sector, the second group, which consists of analytics, security and performance optimization, might be called "AI achievers." These processes are meant to boost the efficiency of health care. Healthcare analytics offers real-time data on patient health. Protecting sensitive data and devices from unwanted access is the goal of security. Performance optimization boosts the efficiency of individual operations and the entire system, including remote access, treatment and other functions.

The conceptual model proposes a relationship between "AI facilitators" and "AI achievers" in the healthcare system. "AI facilitators" aim to create methods, tools and infrastructure to make healthcare processes work more efficiently. In turn, "AI achievers" are designed to increase efficiency and improve performance in the healthcare industry. Remote patient monitoring, made possible by cloud computing and IoMT, enables medical professionals to monitor patients' vital signs in real-time and react rapidly to changes in their health. Thus, healthcare professionals can take steps to avoid or minimize health conditions before they become serious, which can improve patient outcomes. Combining blockchain and analytics can enhance patient outcomes by offering a safe and open platform for exchanging and analyzing medical data. Analytics may give healthcare providers information about patient health and guide the development of novel medicines, while blockchain can ensure patient data is secure from illegal access. The healthcare sector may benefit greatly from 5G technology. It may enable real-time remote monitoring using IoMT, telemedicine and a more reliable and faster exchange of medical data. Giving patients access to care where conventional health care is unavailable can enhance patient outcomes. Healthcare professionals can make data-driven decisions and streamline their procedures by using analytics to support them in spotting trends and patterns in patient data. By offering a safe and open platform for maintaining and exchanging medical data, using cloud computing and blockchain can result in greater productivity.

Upon further reflection, we acknowledge that our conceptual framework could benefit from additional academic support. In this vein, our framework is influenced by the Resource-Based View (RBV) theory which emphasizes the strategic role of valuable, rare and non-substitutable resources in gaining and sustaining competitive advantage (Barney, 1991). The alignment of AI technologies with other digital resources in healthcare falls well within the RBV paradigm, which contends that the integration of heterogeneous resources can produce a synergistic value greater than the sum of individual resources (Peteraf, 1993; Wernerfelt, 1984). Additionally, our notion of value co-creation in healthcare settings aligns with the Service-Dominant (S-D) logic, which emphasizes the collaborative creation of value in complex systems (Vargo and Lusch, 2008). Specifically, technology, in this case, becomes an operant resource that participates actively in the value co-creation process. These theoretical foundations provide a stronger anchor for our conceptual framework and elucidate the mechanisms through which AI and other technologies can contribute to healthcare entrepreneurship and management.

Integration of the conceptual framework in healthcare context

Our conceptual framework that delineates technologies into "AI facilitators" and "AI achievers" has profound implications for understanding and managing technological change in healthcare. This unified discussion bridges the gap between our conceptual framework and its practical application in the field of healthcare technological change management, thereby extending the academic discourse.

Conceptual underpinning and technological change management

The concept of "AI facilitators," which include cloud computing, blockchain, IoMT, additive manufacturing and 5G, provides the technological backbone that underpins healthcare systems. These facilitators resonate with the foundational aspects of technological change management, focusing on creating an organizational culture receptive to technological shifts (Landaeta *et al.*, 2008; Lisewski, 2004). They enable stakeholder engagement and alignment, considered essential components for successfully navigating change (Brugha, 2000; Ruppel and Harrington, 2000).

Conversely, "AI achievers," which comprise analytics, security and performance optimization, serve as actionable tools that healthcare organizations deploy to realize specific objectives. These fit into the "influence model," emphasizing the role of leadership and stakeholders in effectuating change (Sunder, 2016; Wu and Chen, 2014). For instance, analytics serve as crucial decision-support mechanisms, aligning with managerial needs for reliable information during transitional phases (Epstein and Roy, 2001).

Strategic alignment

Our framework suggests a two-tier strategy for healthcare technology management. "AI facilitators" require integration into existing healthcare systems, necessitating changes in infrastructure, protocols and stakeholder engagement. "AI achievers," on the other hand, focus on leveraging this new infrastructure for targeted outcomes, such as enhanced analytics, robust security measures and optimized performance. These two layers demand coordinated, strategic efforts in change management, considering both technological and operational variables (Firk *et al.*, 2021; Wu *et al.*, 2006). Staff training, data integrity, privacy and accessibility should be critical elements of this change management strategy (Bani Issa *et al.*, 2020).

Operationalizing the conceptual framework in the context of technology entrepreneurship

Technological change management in healthcare is not merely about adopting new technologies but also involves the necessary adaptations and evolutions in organizational structures, processes and strategies (Benner, 2009; Grynko *et al.*, 2020). Our conceptual framework operationalizes these academic discussions by identifying how healthcare organizations can strategically deploy "AI facilitators" to establish a robust technological base. Subsequently, "AI achievers" leverage this base to realize specific healthcare objectives.

Managing such change is rife with challenges, including resistance from staff and issues related to data security and integration. These challenges necessitate a change management strategy rooted in established principles (Iacob and Simonelli, 2020). Ultimately, our framework serves as a roadmap for the managerial implications of deploying "AI facilitators" and achieving the objectives set forth by "AI achievers." It emphasizes the importance of strategic alignment and effective change management processes for sustainable value creation and co-creation in the healthcare industry.

By intertwining our conceptual framework with existing literature on technological change management and technology entrepreneurship, we offer an integrated perspective that not only extends academic discussions but also provides actionable insights for practitioners in healthcare technology management.

Theoretical contribution

The landscape of healthcare is undergoing a significant transformation facilitated by technology entrepreneurship. This research takes a focused look at how AI, in concert with other emerging

technologies, serves as a catalyst for digital transformation in healthcare. Through this study, we explore the multi-faceted avenues through which technology entrepreneurs are creating new value propositions and establishing innovative business models. Our analysis contributes to the intersection of AI, digital transformation and entrepreneurship, offering a nuanced understanding of value creation in the healthcare industry. We target technology entrepreneurship and management as the key areas of theoretical contribution.

Our key contribution is that we shed light on growing practices in applying several technologies to create value in health care. Understanding the entrepreneurial practices in healthcare technology is crucial for both academics and practitioners. In this vein, our research introduces a comprehensive framework that elucidates how technology entrepreneurs are synergizing AI with other emergent technologies. This creates unique value across three pivotal domains: analytics, security and performance optimization. Through this framework, we unpack the mechanisms by which entrepreneurial ventures translate technological innovations into actionable healthcare solutions: 1. Analytics, for example, staff reduction, patient prediction and decision support; 2. Security, including protecting against cyberattacks and detecting atypical cases; 3. Performance optimization, which, in addition to reducing the time and costs of medical procedures, includes staff training, reducing capital costs and working with new markets. Working with medical staff, administration and IT staff of clinics is a critical step in establishing trust between them and entrepreneurs and increasing the success of integration.

Additionally, we contribute to numerous research requests for the role of AI and other technologies in health care, particularly the formation of business models (Schiavone *et al.*, 2023) and business strategies (Rouidi *et al.*, 2022; Saura *et al.*, 2023; Syeed *et al.*, 2022) for companies operating in the focal market. The nexus between technology entrepreneurship and healthcare has garnered increasing scholarly interest. In response to this, our study aims to illuminate how technology entrepreneurs are capitalizing on AI and other digital technologies to offer unique value in the healthcare sector (Leone *et al.*, 2021). Through a multi-method approach, this research explicates how AI can serve as a catalyst for digital transformation, enabling new business models and opportunities for entrepreneurs in healthcare (Foshay and Kuziemsky, 2014; Rouidi *et al.*, 2022). Our approach allows us to identify industrial niches that may be in demand by businesses, including those previously unattractive in health care and design a unique value proposition and a way to deliver it to potential consumers. We specifically demonstrate elements (analytics, security and performance optimization) that must be used to increase success and the barriers companies will face when implementing projects. Our findings open the field for further theoretical study of the direction and prerequisites for forming practical applications for business (Ciasullo *et al.*, 2022).

We also question the results of multiple studies on replacing medical personnel with algorithms (Goldhahn *et al.*, 2018; Shuaib *et al.*, 2020). Most researchers insist AI will complement the work of doctors and nurses. The medical doctor will be left with more communication and empathy, while the algorithms will take care of the routine (Botrugno, 2021; Buck *et al.*, 2022; Kulkov *et al.*, 2023a, b, c). Our research shows that in the long term, technological solutions will lead to a decline in the doctor's status as a decision-maker. Presumably, if IT solutions are not replaced by medical personnel, they will be removed from leadership positions in this cooperation. Currently, the main limitation is technology's inability to work without human supervision. However, even now, advanced AI-based solutions gain an advantage over even experienced personnel, for example, in diagnostics. We firmly believe the patient will continue needing a relationship with the hospital or staff; however, the contact person for the patient and their status will change over time. Staff training is also training and improving the IT solution; thus, crossing the threshold of human capability is a technical challenge and only takes time.

Technological entrepreneurship creates value in health care by overcoming human limitations or significantly reducing the cost and time of training, diagnosis, treatment and rehabilitation. However, the healthcare market gives entrepreneurs little opportunity to quickly promote their IT solutions due to many industrial and institutional barriers (Davenport and Kalakota, 2019; Kulkova *et al.*, 2023) and the cost of error. Business model innovation based on combining several technologies, including AI, provides another advantage for the entrepreneur to operate in the market.

Practical implication

The healthcare sector poses unique challenges and opportunities for technology entrepreneurs. Our research seeks to offer a practical roadmap for those looking to venture into this domain. We provide actionable insights and guidelines that can assist entrepreneurs in navigating the complexities inherent in the healthcare ecosystem. This practical roadmap aims to guide technology entrepreneurs in building scalable, value-driven businesses that contribute to the betterment of healthcare delivery and outcomes. Our contribution will also interest the owners and managers of private and public healthcare organizations planning to implement technological solutions in their practice.

While the implications discussed are indeed of high relevance to managers in healthcare technology, we also aim to highlight their importance for entrepreneurs, particularly those at the intersection of technology and healthcare. As our study includes interviewees from small and medium-sized companies who are often co-founders and serve in managerial roles, we believe that the insights can be extended to entrepreneurial settings. The interviews and conducted analysis allow us to suggest promising practices for entrepreneurs planning or already targeting the healthcare market with solutions based on several new technologies. As a chosen strategy for penetration and entry into the market, we can aim to work with medical personnel and form a new niche that other companies found unattractive.

Working with medical personnel can become an important market while allowing a technology company to enter this market. In general, interviewees discuss the cost of training and retaining medical specialists in key areas in healthcare institutions. In developed countries, highly specialized specialists may not find application in small places; however, their consultation costs increase sharply when a patient case happens. Training of medical personnel, including those based on individual programs, will reduce investment programs in health care. Thus, investments in constructing and maintaining training centers will decrease. While the existing restrictions on the capacity of training centers and the availability of their training staff are a barrier in the industry, they are an opportunity for technology entrepreneurs. Individually designed programs will allow the training of highly specialized and general practice doctors and nurses. In turn, developing countries may receive a massive boost in healthcare development and skip the stage of investing in infrastructure and training many specialists, including highly specialized ones. Patients from developing countries can access the latest medical developments and the best specialists. Therefore, the benefits of new learning solutions transcend traditional perceptions of accessibility but affect capital investment in building and maintaining healthcare infrastructure.

Moreover, the hospital staff is a critical success factor for technology entrepreneurs. The initiative of doctors and desire to try something new may face a lack of understanding of its benefits. For most personnel, AI and even more so, combining several technologies, is a complex task. Businesses speaking the same language as medical doctors or collaborating with industry opinion leaders will benefit from integration. Simultaneously, working with hospital management is a crucial success factor. The administration's readiness for change is no less necessary than working with doctors. However, most administration representatives

refer to the industry's unpreparedness, administrative barriers and lack of understanding of the importance of the problem on the part of policymakers. An advanced IT department at the site is an ever-growing element for successful integration. Understanding the importance of cooperation between the administration and the IT department—that they are not in competition for resources and influence—is an essential parameter for the project's success.

Targeting existing markets is associated with previous unattractiveness for other players, such as pharmaceutical companies. In general, pharmaceutical companies are uninterested in the method of finding and providing data if the industry confirms the data. Reducing the risk of failure in this area may interest more prominent players. Previously, the costs of research and the commercialization of results, with a high probability of failure, contributed little to a wide choice of solutions for narrow groups of patients. Companies, especially SMEs, are willing to take on such risks. Thus, cooperation with big businesses, especially in the pharmaceutical direction, can be a new niche in demand. As an alternative to cooperation with hospitals, companies can cooperate with large integrators by offering their own solution, which will be part of a larger IT integration. In this case, the company can concentrate its efforts on development and reduce the activity in marketing and sales.

Decision support is the most obvious market for technology entrepreneurs, reflected in the explosive growth of offers. Most companies differ slightly. The customer cannot make a preference favoring any solution. With the emergence of companies is a large outflow of small companies from the market due to the inability to start selling their solutions. This circuit reduces industry confidence in small companies by favoring large suppliers and integrators. Increased optimism on the entrepreneurs' part finds little understanding on the industry's part, which is only partly due to the industry's lack of regulation.

Another new level could be preparing and cleaning up Big Data for the industry's needs. A significant limitation for companies in this market is the lack of access to verified and structured data. Market stakeholders' distrust of the collected data or data from other companies reduces the business's effectiveness. The companies estimate that about 80% of the time is spent preparing data and only about 20% processing it. The lack of rules and regulations, including self-regulation, limits new ideas and services entering the market. Some large companies with a long history, such as clinical trials, digitize the results obtained earlier. This data is sometimes available to other companies to form the overall public value. Using such data or partnering with large providers of verified data can be a promising niche for a technology entrepreneur.

We draw the attention of practitioners to working with IT departments as possible active allies when working with medical institutions. We believe this is an undervalued asset that can be the foundation for a business model innovation.

Limitations and future research areas

While our study provides significant insights into the application of AI and other technologies in healthcare, there are limitations that must be noted. First, our primary data source is podcasts, which might not offer as comprehensive a view as academic journals or databases. Second, our study focuses on healthcare in the USA, EU, Asian and South American markets, potentially limiting the generalizability of our findings. Lastly, we employed a conceptual framework, which, though effective, could be expanded upon in future studies.

Future research could focus on the ethical implications of AI in healthcare, which our study did not delve into. Researchers could also extend the study to other geographical markets to improve generalizability. Another avenue for research would be the development of more complex conceptual frameworks that integrate other theories or variables into the analysis.

Conclusion

Our study serves as a critical examination of how technology entrepreneurship leverages the potential of AI and other emergent technologies to reshape healthcare. We delve into the ways entrepreneurs are harnessing these technologies to improve healthcare delivery and outcomes. Our findings indicate that, far from being just an incremental change, technology entrepreneurship has the potential to enact a paradigm shift in healthcare, signaling a transformative approach to patient care, data analytics and overall health management. Twenty-two cases from the public and specialized medical podcast platforms were selected as the data source. All cases focused on the benefits of using a combination of technologies, including AI, in the healthcare industry in the USA, EU, Asian and South American markets. The results demonstrate there are three key areas: analytics, security and performance optimization. The collected results allowed us to offer input to the existing academic literature in the technology entrepreneurship and technology management field and form several practical recommendations for business and other stakeholders on business development in the healthcare field.

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Appendix

	Title	Date of issue	Platform
1	The TWIML AI Podcast (formerly This Week in Machine Learning and Artificial Intelligence)	15.07.2021	Google podcasts
2	AI for Humanitarian Health	21.05.2021	Google podcasts
3	AI for surgery	01.05.2021	Google podcasts
4	5 G and the future of AI in healthcare — with Dr Anthony Chang	24.09.2021	HIMSSCast
5	Ready for 5G?	21.01.2020	Google podcasts
6	Digital Health and Wearables Series	10.03.2021	Apple podcasts
7	John Nosta, talking about Digital Health, Innovation and Wearables	07.03.2021	Apple podcasts
8	Exponential Medicine: Podcast with Daniel Kraft, MD, Singularity University	27.05.2021	Google podcasts
9	Can blockchain help pharma find better drug trial participants faster and patients monetize their medical data?	27.02.2019	Apple podcasts
10	Can one bluetooth device + mobile app reduce stress and improve our quality of life?	20.03.2019	Apple podcasts
11	Clinical Entrepreneurship	02.08.2010	Apple podcasts
12	Emerging healthcare technologies–how are they changing us?	20.01.2012	Apple podcasts
13	The magic of everyday technologies	12.11.2019	Spotify
14	Technologies: love or hate them?	12.11.2019	Spotify
15	Christina Farr (CNBC) - Tech Giants in Healthcare	15.06.2019	Apple podcasts
16	Why poor diagnostic reasoning is failing patients, the public and health systems	06.02.2019	Spotify
17	AI for Speech Recognition – Current Companies, Technology and Trends	16.02.2019	Emerj
18	Professional Services Leaders: Map an AI Plan for Cost-Cutting, or Get Cut	25.05.2020	Emerj
19	Know4Go–EBM lecture	24.02.2011	Spotify
20	Small and Medium Medical Practices Need Business Support–EverHealth at HIMSS23	02.06.2020	Google podcasts
21	Educating and Training Future Cybersecurity Pros	15.07.2021	Google podcasts
22	How Vulnerable Is Critical Infrastructure?	17.05.2021	Google podcasts

Source(s): Author's own work

Table A1. Detailed list of podcast episodes analyzed in the study

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