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Published in:
International Journal of Entrepreneurial Behaviour and Research

Published: 01/01/2021

Document Version
Final published version

Document License
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Link to publication

Please cite the original version:
Kulkov, I. (2021). Next-generation business models for artificial intelligence start-ups in the healthcare industry. *International Journal of Entrepreneurial Behaviour and Research*. https://urn.fi/URN:NBN:fi-fe2022021819760

The current issue and full text archive of this journal is available on Emerald Insight at:
https://www.emerald.com/insight/1355-2554.htm

Next-generation business models for artificial intelligence start-ups in the healthcare industry

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Received 27 April 2021
Revised 9 July 2021
29 September 2021
Accepted 4 October 2021

Abstract

Purpose – Value creation based on artificial intelligence (AI) can significantly change global healthcare. Diagnostics, therapy and drug discovery start-ups are some key forces behind this change. This article aims to study the process of start-ups' value creation within healthcare.

Design/methodology/approach – A multiple case study method and a business model design approach were used to study nine European start-ups developing AI healthcare solutions. Obtained information was performed using within and cross-case analysis.

Findings – Three unique design elements were established, with 16 unique frames and three unifying design themes based on business models for AI healthcare start-ups.

Originality/value – Our in-depth framework focuses on the features of AI start-up business models in the healthcare industry. We contribute to the business model and business model innovation by systematically analyzing value creation, how it is delivered to customers, and communication with market participants, as well as design themes that combine start-ups and categorize them by specialization.

Keywords Artificial intelligence, Healthcare, Value creation, Business model design

Paper type Research paper

1. Introduction

Many researchers consider artificial intelligence (AI) to be a key technology in the new industrial revolution; it can change interaction between business participants and society as a whole (Brynjolfsson and Mcafee, 2017; Buch *et al.*, 2018; Fleming, 2018). The use of AI capabilities has already been felt by industries such as design, manufacturing, logistics and others that actively respond to changes and improvements (Gero and Sudweeks, 2012; Chien *et al.*, 2020; Klumpp, 2018). According to early research, AI capabilities are actively used in healthcare, particularly in diagnostics, therapy, healthcare management and drug development (Ivan and Velicanu, 2015; Fleming, 2018; Hamet and Tremblay, 2017). Compared to other industries, healthcare is more conservative, where the cost of error would be high. Therefore, most healthcare innovations are carefully monitored by registering and approving authorities, as well as by physicians who use new opportunities. Nevertheless, new technologies, including AI, are the future, and maybe the present in healthcare (Jiang *et al.*, 2017; Kulkov, 2021). The capabilities of AI are assumed to contribute to increasing access to quality healthcare, reducing errors and increasing medical personnel training (Mak and Pichika, 2019; Miller and Brown, 2018).

The classic definition of AI was offered by McCarthy (1959), namely, AI is a type of machine that is inherent in intelligent behavior. In other words, AI is the science of how to teach computers to do something that a person can do more successfully at the moment

International Journal of Entrepreneurial Behavior & Research
Emerald Publishing Limited
1355-2554
DOI 10.1108/IJEBR-04-2021-0304

(Rich, 1985). Machine learning refers to basic algorithms applied by using a large number of similarly structured tasks in order to identify patterns. In turn, deep learning is a set of approaches used in machine learning using the feature/representation learning technique without specific algorithms for special tasks (Goodfellow *et al.*, 2016). The possibility of using such algorithms has been available for more than 50 years; however, the real application has become possible mainly due to the increase in IT in recent years. In turn, AI algorithms in medicine are used to approximate human resources and knowledge in the analysis of unstructured medical data. A key AI challenge in the industry is to analyze patient data for diagnostics, treatment and recovery processes. The fastest-growing applications of AI in healthcare are telemedicine, robotics (especially robotic surgeons) and high-tech pharmaceuticals.

AI combines machine learning, deep learning and language recognition capabilities for structured and unstructured data (Hamet and Tremblay, 2017; Jackson, 2019). It includes the creation and adjustment of algorithms that may solve inherently human tasks. AI's key task in healthcare is to find the right information and assist in decision-making (Murdoch and Detsky, 2013). The advantage of AI over humans is its ability to process a volume of information that may not be available to a human throughout life (Buch *et al.*, 2018). Currently, companies offering AI solutions in other industries are actively seeking to improve customers' internal and external business processes, involve and track personnel to solve business problems, etc. (Brynjolfsson and Mcafee, 2017).

Nevertheless, despite growing success of healthcare AI, our knowledge of the business models for companies providing AI solutions in healthcare is little. Moreover, previous research on the commercialization of AI provides few recommendations for companies on how to act in the focal market. This may be due to the customers' and end-users' lack of understanding of the AI value structure. Along with large IT companies, there are many start-ups that offer unique values for healthcare. At the same time, AI business literature lacks theoretical concepts and frameworks for analyzing companies offering AI healthcare solutions. Our theoretical motivation for the study is based on limitations of several recent papers that highlight the need to study the use of AI in various industries (Ng and Wakenshaw, 2017; Stiglitz, 2019; Verhoef and Bijmolt, 2019). Moreover, our study's practical motivation was the project participation about the role of new technologies in workplace transfer from developing to developed countries. We found that the project participants working but not specializing in healthcare view the market, partners and opportunities offered by the healthcare industry differently. Business models, development strategies, opportunities and work methods of the participating companies differ, offering ample opportunities for analysis.

The purpose of our research was to study in depth the processes of forming business models for AI startups in the healthcare industry. We agree that AI and healthcare literature are two topics that have been studied many times, and the number of works in these areas is difficult to calculate. However, our task was to describe the processes of creating value for medical stakeholders from the business side. This topic has hardly been researched before (but see Garbuio and Lin, 2019 for an exception) and is a priority area for researchers according to, e.g. Verhoef and Bijmolt (2019) or Verhoef *et al.* (2021).

Based on this background, we decided to study how companies offer AI solutions exclusively in healthcare. This article aims to analyze the business models of the companies that offer AI solutions and create value for their partners. To implement this task, we used the proposed activity system design framework (Zott and Amit, 2010; Amit and Zott, 2012) to study the main design parameters and elements of the business model for the AI providers. This approach is suitable for studying the processes of formation and transformation of the company's business model (Amit and Zott, 2012). Studying the business model for the company compares favorably with existing analogues (see for example, Teece, 2010) by

offering two components for developing a business model by entrepreneurs based on design elements and design themes. This approach is suitable not only from a practical point of view, as it gives direct recommendations on how to form a company's business model, but also allows for the development of new concepts in an environment with limited data. Using the activity system design framework, we can demonstrate the differences between the new business model and existing analogues that are available on the market.

The theoretical contribution to the literature is based on the development of business model and business model innovation literature through structural analysis of companies providing AI solutions in healthcare. We offer several unique and common units that can be used by companies entering the healthcare market, as well as by researchers to further explore the phenomenon.

2. Literature review

2.1 The use of AI in healthcare

Researchers highlight several areas in which AI companies could create value in healthcare. The first is a tool for screening or detecting abnormalities. For example, AI can pre-evaluate radiology or ophthalmology images in terms of needing to assess the information by a human specialist (He *et al.*, 2019; Hosny *et al.*, 2018; Ting *et al.*, 2019). The second area for widespread AI use is therapy, for which researchers emphasize the support of complex decisions by the physician, including in the absence of proper qualifications. Companies having chosen this direction are developing solutions that automatically identify risk factors for the patient, determine the likelihood of the onset/development of diseases, comply with clinical recommendations and reduce the time for patient risk assessment (Topol, 2019). Compared to people, these companies' business models offer speed, consistency and productivity. Automating standard time-consuming medical procedures allows attention to be given to tasks that require more human capital. The third opportunity for AI start-ups to emerge could be the discovery of new molecules to fight diseases more quickly than other IT solutions. AI is used to perform the most complex calculations, including the analysis of chemical and genetic data (Fleming, 2018).

Emerging medical technologies, including AI, should integrate into existing procedures, prove their effectiveness and advantages, obtain approval from regulatory authorities, and be approved by medical personnel. In healthcare, AI technologies assist in reducing and optimizing costs and increase benefits for healthcare providers and other market participants (Yu *et al.*, 2018; Garbuio and Lin, 2019).

To create AI-based value in any industry, preparing or training it using the available data is necessary. In healthcare, such data can be related to the procedures of physicians (electronic medical records and notes, images, laboratory tests), scientific articles, medical devices, etc. The main goal of such actions is to identify patterns in similar data and determine the results inherent in a particular group (Mak and Pichika, 2019). AI allows for the study and identification of problems in complex data sets and provides the results for practical use. Some researchers insist that AI is capable of independently adjusting to current changes; however, others disagree and consider it a disadvantage (Jiang *et al.*, 2017). Perhaps this is due to the interpretation of the concept of additional configuration.

Researchers highlight the role of AI in oncology (Talari *et al.*, 2019), neurology (Ganapathy *et al.*, 2018) and cardiology (Johnson *et al.*, 2018), mainly because these diseases are so widespread; therefore, early recognition of symptoms is critical for timely treatment and the lives of patients. Moreover, early diagnosis could be achieved by analyzing procedures and physician notes, which is a strong point for AI. In addition, AI allows information to be received in real time, which predicts the occurrence of disease trends at the country or regional level (Ivan and Velicanu, 2015).

Table 1 shows the key trends in healthcare AI. The following topics are the most requested by AI researchers.

2.2 Business model for AI companies

Using business models to understand value creation and competitive advantage is a permanent rising trend of academics and practitioners (Chesbrough, 2010; Zott *et al.*, 2011). The modern economy offers new opportunities for participants to create value mechanisms not only within the company but also in collaboration with new participants (Zott and Amit, 2009), social improvements (Thompson and MacMillan, 2010), sustainability (Schaltegger *et al.*, 2016) and others. In this work, we define the terms *create value* and *capture value* based on the work of Amit and Zott (2012). By creating value, we mean the value formed by the manufacturer, where the cost of manufacturing the product is less than the cost of selling it to the customer. In turn, capture value means the transit of value from the supplier to the manufacturer. In the healthcare system, these processes can differ depending on the stakeholder. On the one hand, there are private companies that form a product or service and offer it to the consumer in exchange for a reward. On the other hand, there are hospitals that are non-profit organizations that generate maximum value, provided they do not exceed costs. The capturing of value in this case will manifest itself in cases where the profit increases.

There are several main types of business models for companies that develop AI solutions (Faggella, 2021). First is the AI SaaS Product Vendor, whose business model is based on a fairly superficial solution to the customer problem, lack of specialization and maximization of the customer base. Second is the AI Product Vendor. The business model of such a company partially borrows the principles of the AI SaaS Product Vendor; however, more effort is invested in an individual approach, and there are pilot projects, customer data are used and revenue from each of the customers grows over time. Next comes the AI Platform Vendor. Companies prefer to work in a long-term relationship with the client, and there is in-depth user training. The next business model is AI Technical and Management Consulting, which include companies that are interested in a long-term relationship with a client and are focused on implementing several projects. The final business model is AI Management Consulting. These companies offer a range of short-, medium- and long-term AI projects for the customers.

Companies offering AI solutions as AI SaaS and AI Products operate in a narrow market, and the number of customers is usually small. The AI solutions of such companies are highly specialized and have a better chance of conquering this niche than general AI platforms. The duration of the sale and integration depends on the magnitude of the changes that the

Table 1. The key trends of AI applications in healthcare

Topics discussed	Big Data in healthcare	Collaboration between stakeholders	Industry transformation
Diagnostics	Johnston *et al.* (2019)	He *et al.* (2019), Hosny *et al.* (2018), Ting *et al.* (2019)	Ivan and Velicanu (2015)
Treatment	Talari *et al.* (2019), Ganapathy *et al.* (2018)	Topol (2019), Mak and Pichika (2019)	Hamet and Tremblay (2017), Mak and Pichika (2019)
Pharma	Cubric (2020), Henstock (2019)	Southall *et al.* (2019), Colombo (2020), Harrer *et al.* (2019), Kulkov (2021)	Chan *et al.* (2019), Fleming (2018)
All	Kumar *et al.* (2020)	Brynjolfsson and Mcafee (2017), Fleming (2018), Yu *et al.* (2018), Garbuio and Lin (2019)	Carter (2018), Corea (2019), Buhmann and Fieseler (2021), Jiang *et al.* (2017)

consumer's business processes go through. Consumers that undergo more changes will usually see a higher product price. AI companies will strive to automate processes and train programs based on previously validated data. This moves away from customization will make it easier and faster to prepare, integrate and accelerate the market share.

Researchers study companies and their business models as a competitive advantage (Markides and Charitou, 2004). On one hand, compared to recent experiences, new business models and working methods in the market could displace obsolete competitors and offer customers more value (Guerrero *et al.*, 2021; Silva *et al.*, 2020; Kulkov *et al.*, 2020). Business model design studies are a continuation of research (Casadesus-Masanell and Ricart, 2010; Wirtz, 2018). Business model design is how a company interacts with other market participants. The main factors in this case are the overall value created by using the business model and the company's ability to commercialize the benefits. However, the main limitation is the company's operating environment. Conversely, companies commercialize ideas, products and technologies through their business models. Thus, the business model can be considered a subject of the process, and it includes options for cooperation with market participants.

Companies in various industries use AI capabilities to transform their strategies, business models and value creation processes (Teece, 2018; Kulkov *et al.*, 2021). Over the past decade, AI solutions have penetrated many industries, such as logistics, manufacturing, financial markets and more (Chien *et al.*, 2020; Wang, 2019; Truby *et al.*, 2020). Companies offering retail AI solutions offer a value proposition based on consumer behavior and developing solutions to increase turnover and change both the inside of grocery stores and the geographical location of the stores themselves (Grewal *et al.*, 2017). The finance industry has pioneered the use of AI to assess the likelihood of fraud and mitigate the consequences (O'Leary, 1995). Urban planning and infrastructure development can be based on autonomous vehicles which collect data on city traffic, later analyzed using AI solutions, and offer recommendations for adapting urban infrastructure in response to emerging needs (Gusikhin *et al.*, 2007; Nallaperuma *et al.*, 2019).

Creating value for a company can come from a variety of sources. Consumers or investors can order an AI solution to collect vital information about a patient's health (Garbuio and Lin, 2019). This approach requires a certain positioning and an established reputation, but it allows for clear product positioning and prompt feedback, which is necessary for the developer. The formation of original AI-based business models for the company in healthcare is complicated by the lack of digitized data, difficulties gaining access to them and transferring them for processing. Patients and database owners are reluctant to share information for fear of disclosure (Abouelmehdi *et al.*, 2018). An additional barrier to developing an original AI business is the fragmentation of the company's counterparties. Generally, medical organizations are the key consumer of services; patients become users and often provide personal data for processing, and insurance companies are payers (Barlow *et al.*, 2006).

Leveraging new AI capabilities not only transforms the traditional methods of interaction between the supplier and the customer but also creates new markets. New relationships are becoming more evidence-based and personalized. AI is gradually moving into the value chain, transforming from an interesting and promising novelty to a serious player who can lead the largest companies' business processes. In turn, the existing research has a common drawback, namely, the lack of an integrated approach to business applications of AI in practice. Most often, single successful cases do not provide a general theoretical understanding of the framework for studying successful practices. In turn, practitioners do not receive specific recommendations on how to commercialize industrial AI solutions, interact with customers and form unique business models.

Verhoef and Bijmolt (2019) highlight that the study of changes in business models influenced by new technologies like AI and others is an increasingly relevant area (Ng and Wakenshaw, 2017; Kumar *et al.*, 2021). The authors also note that business models built on new technologies create new value for stakeholders, and more attention is required to form value and methods of delivering it to consumers. In our study, we specifically look at how AI start-ups in healthcare create value and how that value is delivered to healthcare stakeholders. Verhoef and Bijmolt (2019) also notice the importance of strategic choices for a company that chooses digital technologies as the basis of their business. Our research based on cross-case analysis suggests several key factors that form the basis for a new company's business strategy. The articles included in the issue edited by Verhoef and Bijmolt (2019) also increase knowledge of the application of new technologies in business but are not a substitute for our research. Several articles investigate how the application of new technologies is changing the business models of companies in the marketplace (e.g. retail) (Reinartz *et al.*, 2019). First, we are different from the article because we study start-ups and their business models. Second, our research focuses on the healthcare industry, which definitely differs from retail. From a theoretical point of view, we structure and analyze how value can be created and captured in the healthcare market. From a practical point of view, we offer bricks that will be in demand by potential founders of companies in the process of creating a unique value proposition and forming their niche in the market. Verhoef and Bijmolt (2019) also offer some directions for future research that fit our article exactly. First, they propose to increase knowledge of business model formation, which will be of great importance in developing companies and implementing changes in industries. The authors expressly state that "digital business models are a kind of blind spot within our discipline." Our study addresses this observation and highlights the importance of examining the business models of companies offering AI solutions in healthcare. Second, Verhoef and Bijmolt (2019) emphasize the importance of understanding how value is generated when developing digital business models. In our research, we answer this question by considering AI as a technology that creates new value for different types of healthcare stakeholders. Third, Verhoef and Bijmolt (2019) say that urgent research is needed on what resources and capabilities companies need to change their business models. Our article explores the resources and capabilities of emerging companies in shaping value in healthcare.

There are similar studies that look at this topic, but from a different angle. Angeli and Jaiswal's (2016) study is one of the most promising. We believe that access to quality healthcare is important for all patients without any limits. However, we should note a significant difference in our research. First, Angeli and Jaiswal (2016) are primarily concerned with patient inclusion, that is, looking at the possibility of accessing healthcare from the patient's point of view. In turn, our research aims to explore the opportunities offered by new technologies, namely AI, in developing new business models for companies. Moreover, we are looking at the changes that hospitals and physicians can undergo when using AI in their working routine. Therefore, like Angeli and Jaiswal (2016), we are looking at a similar problem about access to healthcare, but from the perspectives of other stakeholders.

3. Method

With the lack of studies on how AI impacts healthcare, the relevance of research in connection with the growing interest in commercializing emerging technologies, and the research question, we chose the multiple case study as the main approach for this research (Eisenhardt and Graebner, 2007; Yin, 2018). According to studies on AI in healthcare (He *et al.*, 2019; Wiens *et al.*, 2019; Dzobo *et al.*, 2020), we determine that the main areas of application are diagnostics, therapeutics, population health management and drug discovery. We selected companies that were founded no more than five years ago, have headquarters in the EU and specialize in

only one of the focal areas. Sampling was performed using the Crunchbase platform. We identified 98 European start-ups meeting these criteria. In a detailed study of the companies' websites, we determined that about 40% of these businesses did not update the information for at least six months, which was further confirmed by the fact that only nine companies agreed to a personal meeting or an online interview. The resulting sample lacks start-ups that develop AI solutions in population health management. The interviews revealed that large companies and their computing power, such as IBM Watson, are used for these purposes. Additional parameters limiting the appearance of population healthcare management start-ups include significant differences between healthcare systems in different countries, the cost of developing and maintaining such solutions and the cost of error (Miller and Brown, 2018; Hamet and Tremblay, 2017). Table 2 presents the companies, their specializations, countries of origin and positions of the interviewed representatives.

Amit and Zott's design approach for studying the creation and capture of value by companies (Zott and Amit, 2010; Amit and Zott, 2012) is used to assess the company's impact on the market and provides an understanding of the change for other participants. The authors suggest using design elements and themes to study value creation and answer a few major questions detailing what makes up the activity system, how the elements are related and for whom they were developed. In turn, design themes suggest unifying parameters that describe models using design elements. The activity system design could become valuable for studying business models for AI start-ups in healthcare. On the one hand, this method allows for identifying and classifying unique characteristics inherent in a company operating in this industry. On the other hand, researchers can study the diversity within the emerging models and compare them.

Developing a new activity system is especially important in researching new types of activities or using a new set to change the traditional order of affairs. It has to do with exploring, structuring and understanding the unique constituent parts and the connections between them. First, it allows new opportunities to be identified. Second, it demonstrates heterogeneity and reveals promising new business models for companies. Therefore, the resulting framework from the analysis will help us understand the structure, the companies' business models and the new technology itself.

The main sources of information for the study are semi-structured interviews with six chief executive officers, one chief scientific officer and one business development director of the start-ups. Most of these representatives were also co-founders of the companies. Some interviewees preferred to focus more on certain parameters characterizing their companies. They were not limited to discussion topics, but they adhered to the proposed agenda consisting of background, unique value proposition, ways of creating and capturing value, value delivery methods, collaboration with customers and other market participants, and future plans. The interviews lasted 35–65 min and were recorded and conducted in English.

Table 2. Selected cases for the study

	Name	Acronym	Application area	Country of origin	Interview contact
1	Lytics	LYT	Diagnostics, therapy	Sweden	CEO
2	Byon8	B8	Diagnostics, therapy	Sweden	BDO
3	MMG Artificial Intelligence	MAI	Diagnostics	Spain	CEO
4	Precure	PRE	Diagnostics	Denmark	CEO
5	Cerebriu	CER	Diagnostics	Denmark	CEO
6	Elypta	ELY	Diagnostics	Sweden	CEO
7	Etsimo	EST	Diagnostics, therapy	Finland	CEO
8	SYNSIGHT	SYN	Drug discovery	France	CSO
9	Precisionlife	PCL	Drug discovery	UK	CEO

NVivo Pro 12 software was used to analyze the text after it was transcribed verbatim. Additionally, we used data from various sources, such as national and regional industrial ratings, presentations of the companies and their partners, websites and press articles. Nevertheless, the https://emerj.com platform has become a key additional source of data and verification of the results obtained. This site provides an opportunity to listen to podcasts of industrial practitioners about the use of AI in various industries, including healthcare. These sources were important in understanding the interactions between participants in the focal business ecosystem and contributed to triangulation of the received information (Jack and Raturi, 2006).

We chose the experience of developing business models from the point of view of AI start-ups. Our motivation was the following. On the one hand, AI start-ups are shaping their company and consumer value by putting new technological capabilities at the head of their company. They do not rebuild the usual business processes under the influence of AI or other technologies, as many medium or large healthcare solution developers do (Ilin *et al.*, 2018; Kulkov, 2021). Moreover, most innovations and breakthroughs are formed precisely among novel and small companies, which, if successful, are often acquired by large companies (Henkel *et al.*, 2015). Therefore, in five years, successful tech start-ups become larger and more mature, can be absorbed by other companies or disappear from the market due to failure. On the other hand, the majority of established companies consist of several people and are in dire need of additional staff with a lack of resources. The framework for our article consisted of studying start-up companies in order to study the formation of value for a mature industry in more detail. We see no contradiction for this approach. It would also be interesting to understand how large companies create value for the healthcare industry, but this was outside the scope of our study and already better studied in the literature (see, for example, Schuhmacher *et al.*, 2016; National Academies of Sciences, Engineering, and Medicine, 2017).

Analysis of the obtained information was performed using narrative and cross-case analysis (Eisenhardt, 1989; Makkonen *et al.*, 2012), and it consisted of several stages. We identified the design parameters that characterize the start-ups' uniqueness. These parameters were identified during the interviews and were repeated by various start-ups (Yin, 2012). At this stage, we adhered to the recommendations of Gioia *et al.* (2013) to conduct inductive research. Moreover, a thematic analysis (Boje, 2001) was used to examine the information obtained during the interviews since we concentrated on the personal experiences, actions and ideas of the interviewees. A narrative approach allows for the comparison of unique interviews that differ in terms of individual experiences and perspectives of the respondents (Labov and Waletzky, 1967). Next, we grouped similar parameters in design frames. Initially, nine frames were formed for activity system content, six for the activity system structure and eight for the activity system governance. To increase likelihood and objectivity, two additional researchers not present in the interviews participated in a deep analysis of the parameters and frames. Finally, we received six frames for content, four for structure and six for governance (see more in Appendix). In turn, the design themes were formed after the comparison using cross-case analysis and identifying features and matches in creating value for the healthcare industry. All design elements and design themes were revealed during the data analysis and were not predetermined. Therefore, all the design components were inductive in structure.

4. Empirical findings

This section describes the research results, namely structured data in the form of design frames of the activity system and cross-case analysis.

4.1 Design elements

The activity system and its design elements define its structure (Zott and Amit, 2010). We determined the frames of the start-ups' three design elements that develop AI solutions for healthcare after interviews with nine of their representatives, illustrated in Table 3.

4.1.1 Activity system content. Most of the studied start-ups consider specialization as the key area. The proposed solutions aim to create value in a narrow specialization of healthcare, for example in urology detection or orthopedic forecasting. According to the interviewees, competition in such narrow markets is great enough; however, the market is highly rewarded. Companies offer the reorganization of processes in healthcare to accelerate the customers' processes. The start-ups' key value proposition is the value creation for the customers by reducing costs of time spent on routine operations.

Companies with successfully integrated AI solutions may become consultants. However, the conservatism and vitality of the focal industry prevent rapid changes, which may be necessary for start-up companies. Consultants and most of their customers consider the risk of implementation to be high. Moreover, integration success depends on the involvement of C-level executives, the willingness of the system and personnel to switch to modern digital solutions and the availability of processed data.

As an alternative to the narrow specialization, companies could offer platforms with a set of solutions for the customers, which could be a combination of various IT services or technologies like AI, robotics and others. Platform solutions are adapted to the needs of a particular customer and can connect new partners via open API to increase generated value.

With initial success in a narrow specialization, start-ups could adapt the product to the needs of a similar field in healthcare, for example to detect other types of cancer or to analyze body tissues. Such development is a priority for companies like Cerebriu and Lytics. Most start-ups have certain flexibility that allows for relatively quick development and adaptation of solutions compared to the basic solution. Moreover, a set of several narrow specializations can gradually form a platform to solve several issues. One solution for expanding specialization could be the veterinary market. Despite its smaller size, there is a global trend to increase the cost of veterinary visits for pet owners. However, few start-ups consider veterinary medicine to be a logical continuation of the business. Adaptations could also be done for other countries' needs. Moreover, foreign customers may consider a successful home experience as a non-key parameter for collaboration. The difference in the health systems of countries within the EU or even within the same region, such as Nordic countries, remains significant despite attempts to standardize them.

Interviewees, especially those in drug discovery, stress that customers pay little attention to a particular technology like AI but expect to receive instant or long-term benefits depending on the situation. At the beginning of development, start-ups could provide customers with AI-based services. However, as the business develops, such start-ups could

Activity system content: Market offer	Activity system structure: Delivery methods	Activity system governance: Beneficiaries
Narrow specialization Consulting services Platforms	SaaS/PaaS Service provider Transition from B2B segment to B2C/B2B2C	Physicians Patients Hospitals
Adaptation to the needs of medicine or other areas Conversion to their consumers Formation of knowledge	Integration	Pharma and biotechnology companies Insurance companies Population management

Table 3. Design elements and design frames of the study

become consumers of these services. For example, drug discovery companies may eventually move forward from the preclinical stage and start providing services to further develop molecules and clinical trials.

The main restraint in the development of this area is the use of patients' personal data. All companies declare that they do not store patient data or that the data are anonymized. However, there is a certain mistrust of other companies that sell such data. Moreover, each company prepares the available unstructured data from customers in its own way. Attempting to use data from other companies may cause errors in practice.

4.1.2 Activity system structure. The typical condition of cooperation for AI start-ups in healthcare is the Software/Platform as a Service (SaaS/PaaS) model. The proposal could be based on the number of patients, physicians, or workstations, and equipment, among other things. Hospitals infrequently acquire a product or software; however, they do pay for monthly or annual access to the service. Alternatively, the SaaS/PaaS model could be adapted to the model based on cost reduction or outcome for the patient. For Lytics, this approach requires a deeper analysis of business processes and an understanding of the customer's financial flows; a supplier receives a share of the saved funds from a hospital or insurance company in diagnostics, therapy and recovery of patients. If customers use any device, for example, sleeves from Precure, the cost is based on the device and monthly subscription cost.

An IT business that provides services for healthcare could develop from AI solutions. AI should be considered by all actors as a toolkit that accelerates work in various areas. A customer considers the possibility of obtaining value regardless of the algorithms used. Services could be claimed mainly by hospitals but also by other industry participants. AI start-ups, especially platform solutions, could penetrate the market or provide services to other companies in the market as it is offered by MMG AI. The interviewees questioned the business model based on the free distribution of devices with the goal of collecting and selling the data. This type of business is complicated by the need to fulfill services with strict procedures for the treatment of patient data.

Collaboration with major healthcare solution integrators or consulting companies could be tempting for AI start-ups. In this case, AI start-ups have a narrow area of responsibility, mostly without promoting their own brands for the customer or final user. This type of collaboration with integrators could be valuable, as it allows the start-up to concentrate on service development, provide support and spend less time on sales. Moreover, work with several large integrators could provide valuable references for further business development. However, a start-up product should be folded into the main integrator's solution—not be offered to the customer as an option.

Coverage of the B2C segment could be valuable for companies focused on lifestyle and predicting diseases. One key benefit is the permanent tracking and 24/7 access to the specialist or other support. Such solutions additionally incentivize patients to adhere to a certain diet, physical activity and other lifestyle habits. For example, physicians' conservatism forced Precure to change the focus from physicians to companies that look at the state and forecast of the key employees' physical condition. A new market and final end users of the solution became technicians at biotechnology and drug discovery companies. Employees receive recommendations depending on their performed functions, and managers receive anonymized reports forecasting the employees' physical condition. Consequently, management can avoid future complications or reduce the cost of employees' job-related injuries. Etsimo uses complementary agents as an additional channel for promoting the service. Physical trainers can use the solution to monitor the client's results and track activity outside the gym or classroom.

4.1.3 Activity system governance. Physicians are key players that encourage or block new solutions in the healthcare, including AI-based ones. The key values created for the physicians are decision support and redistribution of working time. Presently, AI helps detect

deviations at the same level as the best human specialists in a particular field, as often mentioned by representatives of diagnostic solutions. However, solutions do not aim to simply replace physicians. First, AI solutions are designed to identify deviations and deliver recommendations. Second, diagnostics and treatment impose obligations on a much more complex certification of solutions. The redistribution of working time is associated with the possibility of creating priorities based on preliminary analysis. A patient may (1) receive a message telling them that the disease has not been identified, (2) be redirected to, for example, a call center for a standard prescription, (3) schedule a visit to the physician for a personal consultation and (4) make an emergency visit to the specialist. Thus, an AI-based system can redistribute the physicians' workload and reduce visits of healthy patients and the need for temporary personnel, as offered by Etsimo.

The physicians' resistance to AI solutions is associated with the fear of losing places to work. However, none of the studied start-ups considers such a replacement in the short or long term. Interviewees from Cerebriu and Byon8 note that most diagnosticians become more positive about new solutions after a test introduction, which often lasts no more than one workday. However, respondents note the need to create solutions that require minimum extra skills, at least initially. The physician and machine have their own strengths and weaknesses; however, cooperation is complementary to each other's capabilities and creates value for many healthcare participants.

Another key participant receiving value from AI is the patient. First, solutions help evaluate the patient for the visit and prepare their data so everything happens smoothly and efficiently. For the patient, AI solutions can save time, speed up decision-making and support restoration. Second, it is possible to predict a disease in one to five years in the absence of changes in patient behavior. Third, patients could be prioritized depending on the situation. An emergency patient could get treatment without waiting too long. Fourth, new solutions can detect rare diseases and facilitate treatment even without the necessary specialists. Identifying patients with a rare disease could support the development of a solution from pharmaceutical companies. Fifth, AI contributes to the democratization of healthcare. The patient, regardless of financial condition or country of residence, could receive high-quality medical services.

The interviewees highlight that hospitals use only up to 5% of information collected; however, they tend to optimize processes and personnel in the working routine. Hospitals belong to the critical infrastructure for maintaining society's existence, which imposes certain restrictions on development and changes. Hospitals are critical to the rapid transformation and growth of breakthrough solutions in their business processes since this is associated with the risk of unsuccessful integration. However, hospitals are interested in reducing the number of admissions. As described in the physicians' section, with patient categorization and the need for emergency hospitalization, the reduction in medical errors through decision support programs are in demand in the day-to-day activities of the hospital.

The key values suggested for pharmaceutical and biotechnological companies are the reduction of time and money in discovering and testing pharmaceutical molecules. According to Synsight and Precisionlife, these processes could take one to three months instead of one to three years and could reduce funds by two to ten times. AI start-ups create value for pharma companies through massive risk reduction for product development that is widely associated with the pharmaceutical industry.

Reducing unnecessary patient visits is valuable for insurance companies. AI start-ups usually do not work directly with insurance companies; however, they create value through hospitals. The critical aspect for successful collaboration is the trust between the insurance company, the hospital and the start-up. The guaranteed safety and security of data is fundamental in this interaction. Companies using patient outcome–based methods for collaboration highlight the progress in negotiations with hospitals and insurance companies compared to the more traditional approach.

Creating a solution for population management requires many resources, often not possessed by start-ups. Moreover, using a patient's personal data requires certain additional restrictions. On one hand, there is a clear trend in the focal industry toward providing access to various data for start-ups. On the other, there is a lack of confidence in the use and sale of prepared data by other companies. Moreover, the representative from Etsimo noted the possibility of identifying a patient with a rare disease in a small country, for example, Finland. Additionally, it is difficult to adapt to population management systems when adapting to other countries. These restrictions are primarily associated with the lack of proper association standards, for example, drug names or procedures. As mentioned during the interview with MMG AI, even within the same country, hospitals may use different names for their activities and procedures.

4.2 Design themes

The data demonstrate that AI start-ups in healthcare differ in structure depending on the approach to design frames and design parameters. This section describes the design themes that unify companies. Table 4 offers a classification of three design themes based on design elements and frames.

For greater clarity of the results obtained, we used word clouds. For this, we used the transcription of our interviews and divided it into three groups: (1) Diagnostics, therapy; (2) Diagnostics and (3) Drug discovery. Figure 1 shows three word clouds that were obtained as a result of text processing.

4.2.1 Improved access to healthcare. Developers representing solutions for improved access to healthcare are typically diagnostics companies. The main goal of these companies is

Table 4. Design themes based on cross-case analysis of the research

	Improved access to healthcare	Responsiveness	Privacy
Activity system content	Decision support, assistance in the absence of necessary specialists	Cost reduction	Secured data procession
Activity system structure	Case detection, patient prioritization	Pattern definition with AI-based solutions	Anonymity in data processing and secure storage
Activity system governance	*Patients* – speed of service *Physicians* – load reduction *Hospitals and insurance* – cost reduction	*Pharma and biotechnology companies* – more speed and greater reliability of the result, reducing cost and time obtaining the result *Patients* – new solutions	*Patients, physicians* – convenience, reliability *Hospitals, insurance* – cost reduction, fraud reduction
Cases	Major – diagnostics Minor – therapy	Major – drug discovery Minor – therapy	Major – therapy, diagnostics Minor – drug discovery

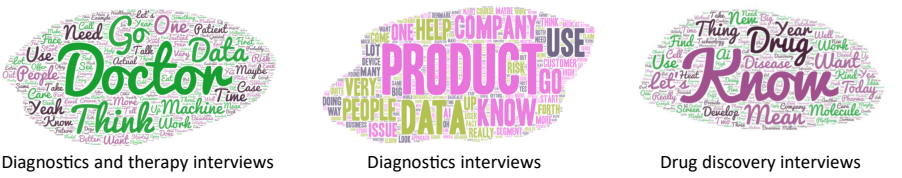

Figure 1. Word clouds based on interviews

to support those making uncertain decisions and increase the likelihood of making correct diagnoses without specialized training. In turn, patients could rely on consultations and subsequent assistance regardless of the circumstances. Hospitals and insurance companies use AI for value creation through the predictability of procedures and cost reduction through early diagnosis.

Companies using improved access to healthcare design themes can lessen physician burnout. Elypta allows physicians to devote more time to patients and less time on paperwork by working directly with electronic medical records, and they support complex decision-making through the qualitative detection of possible patient diseases. Physicians' empathy, which algorithms cannot replace algorithms, comes to the fore. According to interviewees, physicians using AI software generally see more satisfaction due to time spent with patients.

Consequently, in a unique case or fragmented data, the quality of forecasts may decrease. Physicians should decide on the focal case, but the AI algorithm may not recognize a potential disease and may decrease the priority of the patient.

4.2.2 Responsiveness. Drug discovery companies emphasize that value is created for the customers, particularly in the pre-clinical and clinical stages, by reducing financial and time costs. Companies that work with responsiveness design typically make few changes.

AI companies compete with companies that do not use AI. Establishing an algorithm for unstructured data takes most of the project's time. However, the subsequent analysis of big data and the search for patterns far exceed human capabilities. AI allows work to be done with data that were previously not available for processing. For example, Precisionlife processed data that provided little commercial interest to other companies during a business day. This value is primarily important for patients that receive previously inaccessible benefits.

Additionally, having such working methods requires constant process updates. A developer must understand and be able to reconfigure the program over time. Difficult decisions also require time to adjust and adapt to new data. AI providers must constantly monitor the accuracy of medical advice in terms of race, gender, age and other aspects. Interviewees noted the possibility of deviations from the standard, which were detected both in healthcare and in other industries. Such responsibility requires additional staff, for example, lawyers, especially when training on new unprepared data. It is necessary to account for errors and consequences on the lives of patients. Inaccuracy in providing support for physicians could be explained by the information source. For example, a patient may be unaware of a family predisposition to a disease, or they may not want to admit that they cannot stop smoking.

Simultaneously, AI has certain limitations; for example, it is associated with the scaling of processes. Patient care is the primary concern of physicians, not programmers and engineers. On one hand, each incorrectly recognized patient may significantly harm the healthcare industry and future AI implementations. On the other, a patient's individual characteristics could be recognized as a disease. Therefore, the human–algorithm collaboration is an important approach toward value creation in healthcare.

4.2.3 Privacy. Privacy and trust between different participants in healthcare and the use of AI in business processes are important design themes for therapy and diagnosis. Communication between patients and physicians changes with emerging technologies. However, healthcare participants adapt to AI differently. For example, developers of AI solutions provide software but do not seek to collect or store data. Moreover, developers say they cannot determine any processed cases to identify the patient or the final user. Hospitals and insurance companies should be entrusted to process important patient and cash flow information. Most often, patient information is stored and not used in hospitals, but attempts to access and process it may cause distrust, especially from the start-up companies.

Interviewees noted that healthcare participants quickly adapt to new algorithms, for example as diagnostic tools, implying the security and safety of such decisions by default.

Thus, the value created in the privacy design theme could be ongoing, starting during the process. As mentioned in the interviews, successful installations in other hospitals could contribute to that. The interviewees noted that age-related patients may be a concern if their cases are handled by the algorithms rather than a physician. Moreover, patients consider their cases to be unique and tend to trust a meeting with a physician. Also, the technology is now far ahead of the pace of legislative change. Technically, several operations can already be automated, but the law requires the presence of a human.

For full trust in critical healthcare procedures, AI applications must be trained not only in medicine but also in understanding the real world. One Cerebriu interview mentioned that the algorithm must recognize and understand the difference between a nevus, which is permanent, and a pen mark, which can appear and disappear over time. Common sense and trust are not formed through the collection of specialized data as they were before. When AI solutions can pass real-world exams, they can transform into significant companions for humans in updating healthcare.

It was very interesting for us to confirm our findings based on the podcasts at www.emerj.com, for example in "AI in the Hospital Setting–Challenges and Trends Is Partially in Tune with the Section of Activity System Governance," where the presenter studies the value creation for beneficiaries (hospitals, administrative staff, physicians and patients). The author of this podcast also separates the use of AI in medicine from the pharmaceutical industry, which is in line with our research. Another podcast that definitely caught our attention is "How Healthcare Leaders Can Get Started with Artificial Intelligence," which considers whether to use AI in a hospital. It was interesting to consider the conditions for making decisions on the part of the service buyers, namely, looking at the design themes (Improved access to healthcare, Speed and accuracy, and Trust) of our study. The motivation for making decisions on the part of the customer undoubtedly affects the formation of the company's business model. It was also interesting to listen to the "Artificial Intelligence in Life Sciences–Vendor Landscape and Use-Cases" podcast on exactly how to support AI integration in healthcare. The authors generally discuss activity system content and activity system structure in accordance with our findings.

5. Discussion

5.1 The impact of AI on global healthcare

The classical scheme of interaction inherent in the healthcare system "physician–patient" is undergoing changes that AI solutions introduce. The new "AI solution-specialist-patient" scheme is increasingly beginning to reflect current trends in healthcare. The new approach is characterized by a change in participants' roles. First, the patient becomes a source of value and also receives benefit from value. Patients not only become consumers of services but they also have a great responsibility for monitoring health status and preventing disease. AI solutions allow them to automatically monitor their states in familiar conditions such as during sleep, work, etc. The AI software can independently assess and predict patients' conditions, remind them about medical procedures and call for help in urgent moments. Second, the role of nurses is changing. The need for routine procedures to assess and analyze a patient's condition, etc. is reduced, and the demand for interaction, support and empathy is growing. Certain physician responsibilities may be reallocated in favor of nurses, such as routine visits, prescribing medications and parts of the functionality of technical workers who can remotely assess the condition of faulty equipment and recommend solutions. Third, AI solutions will also affect hospitals and training centers for medical personnel. The reduction in both patient visits to physicians and the need to maintain narrow specialists will

affect capital investment in constructing and equipping new health centers in the long term. Reducing the need for narrow specialists and the possibility of training personnel remotely will change the approach to training medical professionals at universities and throughout the practice. Requirements for IT training for beginners will increase, and the basic student training program may be revised. Developed countries can reduce spending on healthcare, while developing countries can use AI applications to increase the availability of medical procedures, bypassing to some extent the stages of building infrastructure and training a significant number of personnel.

Therefore, the key factor that allows us to talk about significant change, not just adaptation in the healthcare industry, is the change in physicians' working procedures. Changes in the work of this stakeholder group will lead to a gradual transformation of the functionality of all other participants, namely patients, other medical and service personnel, hospitals, training centers, insurance companies and others.

5.2 Start-up's value creation

Overall, design themes offer the following key areas of value creation in healthcare: improved access to healthcare, responsiveness and privacy. Improved access to healthcare includes solutions to problems in diagnostics and to support of specialists' decisions; reduces factors that have a negative impact on medical care; and provides hospitals and insurance companies with predictable results and reduce costs. Companies developing solutions in this direction prioritize reducing physician burnout and workloads with AI solutions. Responsiveness value creation primarily aims at the drug development industry by reducing costs. Value is generated by data processing speed and those areas that have not previously been analyzed. Therapy and diagnostics offer values formation in the privacy direction. However, this is a lengthy process whose results may not be clearly demonstrated to stakeholders. The value may differ depending on a patient's age and status, as well as the training of the AI solution and the developers' experience.

The findings assist us to better identify and analyze how start-up companies create value for their customers. Most start-up companies target a narrow niche that has been chosen based on the founders' backgrounds, networking and more. Cooperation with an interested physician can become the basis for testing and approbation of a new AI solution. The additional involvement of hospital administration representatives or C-level executives helps to improve communication and project promotion. However, it is worth noting that different stakeholders may have different priorities and may receive different benefits from a project. Companies may seek to expand their offerings to an existing customer in the case of a successful integration. Adding a new medical specialization usually requires little effort among developers. A comprehensive or platform offer creates value and increases customer lock-in. However, delivering value to the customer can be even more difficult than just creating it. The most common way to deliver value is a test access to the AI solution in a workplace or training center. Physicians will positively assess the possibilities of a new approach to work, reducing the fear of job losses in most cases.

A new identified aspect of value creation for the healthcare industry is the work with the collected data. The information collected is simply stored, not automatically analyzed, in the vast majority of cases. Nevertheless, developers and the whole industry are interested in using it for work. Existing regulations do not allow trust building between the participants in the collaboration, which is the most important factor in project success. The increase in the generated value will depend on the efforts being made to define rules for market participants. We can generally say that the balance of supply and demand in the market of AI solutions in healthcare is formed based on the trust in and experience of developers. New companies offer the market different types of value based on AI solutions. However, customers have doubts

about the success of start-ups and demand proof of success that they consider relevant. A company's growth and gaining of credibility are most often associated with successful integrations, but not all start-ups are able to demonstrate that. Successful start-up companies can grow on their own or be acquired by larger companies in the healthcare market. Thus, the value generated by the company will be complemented by an already existing larger company in the industry.

6. Implication for theory and practice

6.1 Theoretical contribution

The research makes two key contributions to the business model and business model innovation theory, which are important for understanding AI in healthcare.

First, we clarify the value creation of using AI by analyzing business models that develop healthcare solutions. We propose a systematic approach to analyzing the unique and common parameters of companies as well as the following: (1) a way to present value to the market (narrow specialization, consulting services, platforms, adaptation to the needs of medicine or other areas, conversion to their customers and formation of knowledge), (2) a method of delivering value to the consumer (SaaS/PaaS, service provider, transition from B2B segment to B2C/B2B2C and integration) and (3) communication with consumers (physicians, patients, hospitals, pharma and biotech companies, insurance companies, and population management programs). The company's specialization and its collaboration with customers are especially crucial in shaping value and business development. By identifying design elements and frames in the activity system, we contribute to research on how AI is transforming healthcare, especially in value creation (Yu *et al.*, 2018; Topol, 2019). We continue Garbuio and Lin's (2019) study, offering an in-depth and systematic approach to the study of business models for AI startups in healthcare. In particular, we add pharma and biotech companies for the customers, and we study in detail methods of delivering value to customers and options for creating it.

Second, along with unique parameters, we declare that there are common design themes. Specialized start-ups basically focus on a particular theme. We suggest that the key themes are improved access to healthcare, responsiveness and privacy design, and we systematize their use. These results are important for understanding the role of AI and other emerging technologies in transforming modern industries (Jiang *et al.*, 2017; Li, 2020; Boneva, 2018; Xu *et al.*, 2019; Kulkov, 2021). Companies working with improved access to the healthcare theme are mainly focused on developing solutions for diagnostics and therapy. In this case, AI solutions aim to support decision-making, which is beneficial for both patients and other industry participants. Companies devoted to responsiveness strive to reduce the costs for industry participants, thereby creating value where it did not previously exist or where it was insignificant compared to costs. Thus, the privacy design theme provides new opportunities for market participants to communicate, reduce costs and assist in personalization. With this finding, we emphasize the importance of accounting for the AI company's specialization when choosing a development direction. Previous studies paid little attention to identifying priorities to develop AI solutions in healthcare. However, the evidence argues that differences in company goals may be based on the adoption of one of three common themes. The qualitative data, in particular, demonstrate that customers could benefit from different perspectives, and their prioritization depends on the solution's specialization.

Our findings fit seamlessly with Porter and Lee's (2013) study, which added the value of AI in healthcare, yielding increased outcomes by AI or decreased costs of delivery outcomes. Some companies that have chosen the improved access to healthcare and privacy design themes focus their value on the growth of outcomes for their consumers. In their strategy, these companies focus on benefits for patients, doctors, hospitals, etc. Healthcare value could

also be generated by integrating AI solutions in places where such solutions have not previously been used. Therefore, the value that was previously created by the doctor is replaced by the value of the doctor with AI algorithms. The threat of job loss in the healthcare industry, which is shaped more by our understanding of AI than by our work experience, is somewhat exaggerated. Companies that develop solutions for areas that did not previously exist or were inaccessible, such as rare diseases, maximize the outcomes in the Porter and Lee (2013) formula. The second group of companies considers cost reduction as the primary benefit of their value. Such companies primarily operate with financial and time costs in the discovery and development of drugs, and as a result, patients get new opportunities faster or cheaper than before. However, hospitals or insurance companies are more likely to be interested in this parameter, which explains the go-to-market strategy for companies in this direction.

Additionally, our design approach lets us view the business models for the AI companies in healthcare. Thus, we contribute to the emerging requests for research on the role of AI in industry transformation and the development of theoretical substantiated methods for analyzing these activities (Pan, 2016; Ransbotham *et al.*, 2017; Ustundag and Cevikcan, 2018). Our theoretical approach to the analysis of business models and system activity helps identify elements and design themes for the current state and future development of the companies. The design approach allows for the analysis of the companies' structure, classification of models and identification of development features and trends. We specifically demonstrate that companies with different specializations can increase and decrease their priority of design themes. For example, in the focal cases, diagnostics prioritize improved access to healthcare and privacy, therapy–privacy and drug discovery–responsiveness (see Table 4 for more details). The approach offers great opportunities for subsequent theoretical research and offers tools to study the role of AI.

We contribute to entrepreneurial and AI research. Many researchers work to identify opportunities and use knowledge to form technology companies and conditions for business development (Ransbotham *et al.*, 2017; Plastino and Purdy, 2018; Lee *et al.*, 2019). We assume that AI, like other emerging technologies, could accelerate developments and adopt new opportunities for mature industries (Kulkov *et al.*, 2021). AI applications in therapy and diagnostics can create real-time value for physicians, patients and other market participants. Moreover, AI can create value where it previously did not exist and can benefit from unstructured data, such as in drug discovery (Noorbakhsh-Sabet *et al.*, 2019; Fleming, 2018; Jing *et al.*, 2018).

6.2 Practical contribution

We offer two main recommendations for healthcare participants on how to start using the opportunities offered by AI and how to upgrade the business model and procedures in the most efficient way.

First, we propose targeting a specific problem: providing support for physicians who want to cooperate in developing and testing the solution. Such decisions may be the acceleration of standard medical procedures or decision support. It is not recommended to start competing with large companies that offer solutions in population management due to high risks and costs. Companies having used medical IT solutions and are eager to use AI for development should address why it is necessary. Other options could provide alternatives and require fewer resources for development and integration. Identifying issues where AI strengths will be used is an important transition factor. Companies planning to adapt solutions for healthcare needs should choose the application closest to the existing business in another industry. Such companies will definitely face opposition from new customers, but they could develop a solution faster through adaptation. After developing and successfully

implementing AI solutions, new markets and solutions to larger issues within healthcare could be developed, as references are critical to this market. We recommend that all companies use the domestic market for prototyping and product testing. The difficulties and risks of entering foreign markets could be reduced by creating joint projects with local players.

Second, access to data could be a decisive factor for developing an AI solution and entering a particular market. Preparing unstructured data takes a disproportionate amount of time in comparison to writing the algorithm. Data owners, such as hospitals, may store and use minimal patient data, and they may deny access in the absence of market reputation and trust. Moreover, the solution to a specific problem may require access to heterogeneous resources that do not coincide, for example, in the diagnostic market. An AI solution cannot achieve a high standard in identifying a problem if there is limited access to the necessary data for training. The empirical data do not align with researchers' claims that developing the AI solution itself takes a very long time. Interviewees say that, on average, the minimum valuable product could be produced by two or three programmers in six to twelve months. On one hand, companies could build businesses using AI algorithms from the very beginning and could create an AI solution from scratch. On the other hand, companies can adapt their medical IT solutions and apply AI as the next step for development. Furthermore, after improvement, non-medical companies could start applying AI solutions in healthcare.

The study demonstrates the difficulty for physicians to adopt AI solutions. Physicians fear losing their significance in healthcare. However, one of the most effective methods of promoting a solution is testing it in real conditions at the physician's workplace. Most often, the benefits of AI in diagnostics are immediately visible, so physicians adapt to the new procedures. In therapy, implementing AI may take longer, possibly due to personal willingness to use new technologies at work or unwillingness to study the new options. Thus, pharmaceutical customers pay little attention to how the result is obtained. AI drug discovery companies use new technologies to increase the benefits of developing a product that will then be offered to the customer.

Design elements and themes could be used by novice entrepreneurs to determine business models and market entry strategies. The design focus could be convenient for consultants, mentors of business incubators, investors, academics, and university students seeking practical knowledge and subsequent applications in business. Since AI and its practical applications are one of the modern growth methods in the knowledge economy, universities and regional policymakers may want to develop such a business for novel entrepreneurs. The study demonstrates that a clear vision of business formation and development strategies could be important in achieving business success.

7. Limitations and future research

Like all studies, this research has a number of limitations that could become a continuation and in-depth study of the subject. We explore start-ups developing AI solutions in Europe. However, design elements and themes may vary in other developed and developing countries. European countries and market participants may differ in their openness to and perception of innovation, legislation, type and quantity of market participants.

Further research should study the business models of companies that are no longer start-ups. Researchers may be interested in using a design lens to compare elements and themes of start-ups and advanced companies. Additionally, it may be relevant to compare the business models for start-ups and corporations to assess effectiveness and identify benefits and free niches in the market. It will be important to identify limitations for AI start-ups in various specializations at different stages of development.

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Appendix

Design elements	Design frames	Design parameters
Activity system content		
	Narrow specialization	"We thought about [adoption for other industries], but we want to concentrate on our specialization" (SYN) "Typically, our customers are radiologists in public and private hospitals and diagnostic centers" (CER) "That is our target [to stay in healthcare]" (LYT)
	Consulting services	"Start looking at data in the context of areas of pain . . .. Next, have a look at your workflows and talk to the organization that works in this particular area. Discussions involve C-suite executives as well as the board of directors. AI is not a plant wall" (LYT) "We are a hybrid of a product and consultancy company" (LYT)
	Platforms	"Our platform benefits from several emerging technologies such as AI, robotics, and chemical informatics" (SYN) "Fast integration of a platform solution [is tailored to] the needs of a specific client" (EST) "[Our platform has] an open API for integration of other industry players into our system as drug stores, laboratories, etc.. . ." (B8)
	Adaptation to the needs of medicine or other areas	"We want to concentrate on drug development . . .. Other possible applications could be in therapy" (SYN) "We could provide companies with analytical insights on the health of employees and recommend preventive solutions for well-being plans" (ETS) "We are planning to concentrate 100% on healthcare even if there is green grass on the other side of the fence" (ETS) "We will adapt our application to other areas of application like stroke or bleeds" (CER) "Originally, we planned to sell our products to physiotherapists, but we found that this sector is quite conservative . . . and we had to move to pharma companies" (PRE)
	Conversion to their customers	"We hired additional staff, created a database of molecules, and began to compete with our former customers at the preclinical stage" (SYN) "We could answer questions related to issues with the core production operations . . ., [creating] value for the partner and later for the customer" (PRE) "You need to add value to your collaborator immediately" (ELY)
	Formation of knowledge	"The collected data can become the development of a business model of the company as it may be of interest to various participants . . . selling not a service, but knowledge" (ETS)

(*continued*)

Table A1. Design elements, frames and parameters of the study

Design elements	Design frames	Design parameters
		"Companies use only 1% of data according to statistics" (MAI)
Activity system structure		
	Software/Platform as a Service	"We sell our services for a fixed monthly fee based on the size of the company" (EST) "[Services can consist of] monthly subscription plans or [can be] based on outcome for a patient" (LYT) "First, we will have consultancy fees . . ., [then the] licensee is based on the size of a clinic or per patient . . .. It could be a Service-Level Agreement" (B8)
	Service provider	"[We had several years providing services], and we use AI as a new tool . . . to find new drugs" (SYN) "You have to adapt to the market, be very creative and flexible: the company itself penetrates the market or provides services to other companies penetrating the market" (MAI) "We sell a physical product and a service" (PRE)
	Transition from B2B to B2C\B2B2C	"We can tell what you should [or should not] due to reduce chances of getting diabetes . . . we can change the lifestyle in small steps" (ETS) "Our business model could be adapted to a client: B2B, B2C, or others" (MAI) "We started looking at the B2B segment and also the consumer market" (PRE) "B2B customers think very practically" (PRE)
	Integration	"One of the ways for market penetration is to become a supplier for the big four consulting group that offers solutions in healthcare" (MAI) "It is hard to be alone for a start-up. We have to find somebody who is big and show that we have value for them" (MAI) "Strategic partnerships will be used for future development" (CER) "If you are a personal trainer and want to offer services for our consumers, you will receive a small percentage of that" (EST)
Activity system governance		
	Physicians	"[We choose] the most appropriate doctor's specialization for the patient and [rank] patients according to the urgency of admission" (ETS) "Let the doctors do work that they do best, like being empathetic, and let the machines do their work" (ETS) "Accuracy in the forecasts in our case is 95%; a doctor can evaluate with a probability of 80–95% depending on qualification" (CER) "We do not want to exclude radiologists, but we want to prepare super radiologists . . .. Our software is a tool that helps in the daily routine" (CER)

(*continued*)

Table A1.

Design elements	Design frames	Design parameters
	Patients	"If you are only one patient and have your rare disease, nobody wants to treat you . . .. But we can help" (SYN) "[We predict] the risks that a patient could have a chronic disease in the next three to five years" (ETS) "We can slow the progress of the disease and combat the spiraling readmissions so patients will feel more safe" (LYT)
	Hospitals	"[There are] less patient visits to the hospital, increased recovery, and keeping people healthy instead of treating sick people" (ETS) "Day-and-night contact care improves people's coverage and satisfaction of a patient, supports quality and sequence at scale, and declines physicians' errors" (ETS) "Sort patients into four categories: operator support or self care, unsynchronized care, remote care, regular face-to-face visits" (ETS)
	Pharma and biotechnology companies	"Accelerate, secure your research and development processes, and reduce costs" (SYN) "We collaborate with pharma to postpone the start of irreversible and chronic circumstances and, therefore, help patients maintain a high quality of life" (ETS) "If you have the right compound with the right safety and the right commercial potential, you have four times the advantage of getting your drug through phase three" (PCL)
	Insurance companies	"We decrease the number of needless visits that lead to the reduction of payments and speeding up recovery through well-timed medication, resulting in less costs" (ETS) "This is a trust business. [Insurance companies] should trust that we are medically compliant, and data is secured" (ETS) "[The] outcome approach could help insurance companies optimize structures and the work with hospitals" (LYT)
	Population management	"It should be a shift in two to three years related to access of the secondary medical data . . .. Now, start-ups are seen as consumers of such data because of the reduced likelihood of sanctions in case of failure" (ETS) "It is very hard to adapt the system to a new country: language, its own drugs, procedures, names" (MAI) "It could be good for us [population management solution], but it will take a huge amount of time" (LYT)

Table A1.

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