Business Models

Artificial Intelligence as a Growth Engine for Health Care Startups:
Emerging Business Models

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SUMMARY

The future of health care may change dramatically as entrepreneurs offer solutions that change how we prevent, diagnose, and cure health conditions, using artificial intelligence (AI). This article provides a timely and critical analysis of AI-driven health care startups and identifies emerging business model archetypes that entrepreneurs from around the world are using to bring AI solutions to the marketplace. It identifies areas of value creation for the application of AI in health care and proposes an approach to designing business models for AI health care startups.

KEYWORDS: health care, artificial intelligence, disruptive technology, business models, innovation, entrepreneurship

An increasing number of entrepreneurs entering the health care space are harnessing old and new technologies in the solutions they take to the marketplace. One of the most active sectors is artificial intelligence (AI), which is being applied to clinical, operational, or financial solutions in health settings. In general terms, AI can be described as computer systems that perform tasks requiring human-like intelligence. Health care executives rate AI as the most disruptive technology within the industry,[1] while consumers worldwide are open to receiving AI-enabled health care solutions. The amount of data available for analysis by AI applications is growing exponentially, owing to smart wearables and other Internet of Things solutions (IoT).[2] In a 2010 global survey of executives in health care, more than 90% recognized the complexity likely to be faced by their sector in the next few years and indicated they were unprepared to deal with it.[3]

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There is little doubt that AI will revolutionize the way health care practitioners and executives gather information and interact with patients and their families, as well as with clinical and operational staff. There exists a wealth of applications that are already relevant. Several services that previously required human intervention and face-to-face interaction with patients have now moved to centralized platforms managed by messaging bots and intelligent virtual assistants. Almost 80% of organizations participating in a 2017 survey are already using virtual assistants to create better customer interactions.[4] Other applications are specific to clinicians, for example, providing platforms designed for cloud computations, deep learning in medical imaging, or optimized patient selections in clinical trials.

Current research has classified health care startups on the basis of the type of the problem addressed, for example, whether they provide telemedicine services, virtual assistance, or image recognition. However, as yet, we do not know whether startups that solve different problems share common business models. Nor do we know what value is created for stakeholders, ranging from clinicians, patients, health care administrators, insurance companies, and government agencies.[5] In this study, we answer this question by examining some of the most promising AI-driven health care startups and developing a framework for studying and tracking their emerging business models.

As AI is a rapidly developing technology, a critical question regards the emergence of archetypes of business model. Questions surrounding business models are always challenging, but even more so in health care because of context-specific systemic and regulatory aspects and because of the presence of a fluid multi-stakeholder environment.[6] A successful business model also requires a clear identification of what the value proposition is and who will be paying for such value proposition, as the party who directly benefits from the value might not be the one who pays for it. Indeed, AI-driven health care services not only promote service quality to both direct and indirect service recipients but are also tasked with providing an effective cost-revenue structure for health care providers and health care payers (i.e., insurers and governments). A deeper understanding of these aspects of AI in health care may allow for the application of these concepts to other industries with fewer restrictions in terms of regulation and who pays for services.[7]

Research Method

Technology is a driver of change in business models. Any investigation into the implications of technological change begins with a characterization of the technology's attributes and the potential business model that can be employed to effectively take the technology to the market. Here, we have reviewed the deployment of AI in the health care sector using a data set drawn from 30 health care startups around the world.

Over three years, we have explored the question, "How do entrepreneurs in health tech[8] develop business opportunities and capture these opportunities

with innovative and technologically driven business models?" We started by reviewing several academic and practitioner-oriented studies[9] into health tech in general and observing closely three AI-driven health care startups. The first uses AI in the creation of a marketplace connecting providers and patients. The second is a company operating in the digital health space. The third is developing a smart pillow solution for the detection of sleeping disorders. We also studied the literature on AI and discussed it with those in the field, ranging from researchers in both business and engineering to entrepreneurs. We then identified the set of startups to study in the health care sector using *Fortune* and *Forbes* and, in particular, the list of the top 106 startups identified as innovators within the Health AI space by CB Insights, a well-known database of startups from across the world. We manually collected information about the funding received by each of the startups in the dataset for which information was available in Crunchbase and Angel.co. We matched this information with press releases, websites, newsletters, and blogs on the development of AI, as well as health technology. We then interviewed one executive in health insurance, the CEO of a well-known AI-driven health care company (Matteo Berlucchi, Your.MD), as well as other entrepreneurs currently utilizing some form of AI (both in health care and in other industries), and a venture capitalist who has made investments in health AI. On the basis of these diverse sources, we developed a thorough understanding of the sector and business models. Finally, we presented our findings to other entrepreneurs as well as executives in the field to gauge their feedback on our research.

What Is AI

As a scholarly field, AI dates back to the 1950s. However, recent advancements and innovations in information storage and processing have enabled an explosion in the abilities and potential of intelligent systems to revolutionize industries from agriculture and finance to health care. The fundamental principle of AI is machine learning, or the ability of a computer to improve upon its own capabilities by continuously analyzing its interactions with the real world. This also includes Natural Language Processing (NLP), a form of AI that analyzes the human language, helping a machine understand, interpret, and manipulate human language (e.g., text, speech). There has been dramatic growth in the power and sophistication of machine learning and NLP in recent years due to high-bandwidth networking and cloud computing, among other high-level innovations.

In industries like health care, where human intelligence is both invaluable and increasingly in high demand, the introduction of innovative, AI-powered technologies has been lowering costs, hastening drug discovery, and improving health outcomes. More and more, the potential of AI to revolutionize the industry is catching the attention of key players in both health care and venture capital, with increasing funding allocated to the sector in recent years. But in order to better advance our understanding of such phenomena, we must further break down these disruptive new technologies into different categories.

There are three fundamental ways through which business can or will use AI: assisted intelligence, augmented intelligence, and autonomous intelligence. *Assisted intelligence* helps improve what the business is already doing by amplifying the value of current activities. This form of AI often involves clearly defined, rule-based, repeated tasks with common applications including data verification and simulation to test business decisions with less risk. Medical image classification is an example of assisted intelligence in health care services to improve accuracy over conventional processing techniques. *Augmented intelligence* is an emerging technology in AI that provides organizations with new capabilities and differs from assisted intelligence in that it alters the nature of an activity, which as a consequence requires changes in the business model. Augmented intelligence plays a critical role in shifting health care toward prevention, personalization, and precision. Precision medicine—a tailoring of medical treatment to target the specific needs of an individual based on the characteristics of each patient (e.g., a person's genetic makeup)—will greatly benefit from augmented intelligence. *Autonomous intelligence* is the advanced stage of AI that is currently being developed; this form of AI acts on its own and chooses its action on the basis of business goals. Currently, human-independent decision-making capabilities are not in widespread use beyond automated stock trading and facial recognition applications. In health care, the doctorless hospital is a future application for the autonomous intelligence system. However, this requires not only advances in AI technology but also the ability to build in enough transparency for humans to trust the technology to act in their best interest.[10] Table 1 summarizes these applications of AI in business and the examples of startups utilizing such technology.

To better understand how these types and subtypes of AI are changing the health care technology landscape, we have classified a selection of a set of 30 startups from the list of 106 that are "transforming health care with AI," according to CB Insights.[11] The selected startups operate across the health care value chain, innovating everything from in-patient care, hospital management, and medical imaging and diagnostics to patient data and risk analytics. They have received a variety of funding, and we controlled for the year in which they received the first round of financing. By analyzing and classifying the innovative AI applications of these companies, we were able to extrapolate different approaches to creating, delivering, and capturing value in the health care sector, which will provide an example for other sectors.

Among the 30 startups, none currently offer any form of autonomous intelligence as this class of AI is not yet widely available in the health care technology market. Instead, forms of assisted and augmented AI are disrupting the current health-tech landscape, predominantly through the use of limited memory machine-learning-based platforms that use a base of data stored in the computer's memory to inform the system's real-time decision making. Nevertheless, we have observed rapid advancement in autonomous intelligence technology, such as an automated hospital pharmacy at the University of California San Francisco Medical Center at Mission Bay.[12] As the AI sector in health care continues to mature, we predict that more sophisticated applications, such as autonomous intelligence, will become more widespread within the overall AI sector.

TABLE I. Three Fundamental Types of Artificial Intelligence.

	Assisted Intelligence	Augmented Intelligence	Autonomous Intelligence
Definition	AI that "improves what people and organizations are already doing" by automation based on clearly defined, rule-based, repetitive tasks to remove redundancies from business operations, improve efficiency, and boost the value of existing activity.	AI that "enables organizations and people to do things they couldn't otherwise do" through sophisticated algorithms built for natural language processing and sifting through massive accumulations data and records.	AI that "creates and deploys machines that act on their own," making decisions based on their best interests using machine learning algorithms that operate independently of human instruction or oversight
Key Characteristics of Startups	• The most basic level of application of AI, often based on pre-existing algorithms with minimum adaptation • Common usage includes data verification and simulation to assist business decision making • A great proportion of startups currently operating in the AI space utilize this form of AI • Data required for this type of AI is often in a raw form drawing from a single source	• A more sophisticated level of application of AI where the algorithm has a greater customized component • Often alters the nature of the activity and may require business model change • Common applications include precision medicine and data sifting such as finding patterns in epidemiological data • Requires more sophisticated set of data involving more than one source of data	• The greatest level of sophistication in AI algorithms, where decisions can be made independent of human participation • Only a very limited number of startups operate at this level • Autonomous system requires both advanced AI technology and a sufficient level of transparency in the algorithm that builds trust in the systems • Input data are often drawn from a number of sources and involve higher level of sophistication
Exemplar Startups	Aindra, a Bangalore-based AI-powered MedTech company has developed an AI platform utilizing medical image classification technology to facilitate faster and more accurate diagnosis of cancer.	iCarbonX provides highly individualized care through massive data set, biotechnology, and AI. iCarbonX forms a digital health alliance with heath data and personalized medicine startups around the world to gain access to a big data for its AI algorithm.	Mayo Clinic is working toward the doctorless hospital. Many of its components already exist but are waiting to be tested enough to satisfy safety standards. For example, surgeons are already using robots in the operating theater to assist with surgery.

Note: AI = artificial intelligence.

The Complexity of Value-Users in Health Care

For a solution to thrive in the marketplace, it needs to begin with a clear definition of the value that is to be created for a particular user. The question of value relates to the question of who is the user that the solution aims to address.

In the case of Your.MD, an AI-based application that helps patients find the most relevant health information, whether it be to stay healthy or to better understand their symptoms, CEO Matteo Berlucchi[13] highlights that he did not go through the deliberate process of opportunity identification to come up with the idea behind Your.MD. He was approached by a group of business executives, some of whom were from outside the health and technology fields (including bankers) to develop what became Your.MD. The idea had already envisioned a clear user value aimed at addressing a critical problem.

> With mobile phones becoming ubiquitous and providing you with computing power on your hands and an easy connection to centralized computing power, there must be a way to get people the health information they need for free when they need it . . . So mobile phones plus health equals something useful for a lot of people. The original idea was just to give information to people.

The original idea did not include a business model that outlined how taking information to the masses would work. Only after the original value creation idea was formed did the typical methodological approach of market analysis begin. One insight was realizing that the health care industry is far behind other industries when it comes to digitization and transfer of control to the end user. In many cases, using examples from other industries to solve a problem is applied consciously or unconsciously by entrepreneurs in discovering new approaches to business model innovation as well as strategies that can then be adapted to their specific industry.[14] It is at this point that Berlucchi started to think about solving the problem in a very patient-centric way. Note that health-related searches are among the most common searches in Google but also those associated with highly paid advertisements. However, search engines do not provide the most accurate information and are not a curated marketplace of health care information. It is important to make the distinction that the provision of information is only one step toward an AI-enriched use of information in health care. Startups like Jvion provide "cognitive clinical success machines" in which the company's software predicts and prevents patient-level diseases as well as financial losses for health care providers. Jvion's predictive solution looks at the patient population and predicts the risk of an illness or condition before symptoms occur.

Another important consideration at the very start of building a new venture is identifying who are the users. In many instances, there are a number of individuals who benefit in different ways from an AI-driven solution. It is thus critical to understand who the primary and secondary users are as well as who will pay for the solution. The question of who pays is particularly important in health care, where insurance providers or national health systems ultimately bear some of the costs.[15] This has already happened in relation to medical devices that

are enabled by IoT technologies. One example is a health care provider that detects potential issues in a prosthetic joint using data sensors to summarize the force distribution and pressure patterns. This helps deliver value to the patient by promptly alerting them to see a medical professional, as well as value to the provider, since unnecessary costs due to remedial treatment or prolonged recovery are avoided. When several stakeholders concurrently benefit from the solution, monetization becomes a very interesting question—are all parties involved liable to pay or should one side be subsidized, as often happens in platform business models such as gaming systems?[16]

Another case in point is the following scenario derived from a real situation. Say you have founded a health tech startup that collaborates with a university-based nano-tech research center to develop a noninvasive solution via a smart pillow to help diagnose and monitor sleeping conditions. This solution very closely resembles Beddit (which was acquired by Apple in 2017) or any of the other companies (such as Withings, Aura, or Resmed S+ sleep sensor) that have attempted this path of diagnosis and monitoring of sleeping conditions. You have identified broad target markets, including end users for at-home use, sleep clinics, airlines for monitoring of sleeping conditions on planes, hospitals, aged care facilities, and so on. Employees, especially shift workers, and health insurers would also benefit. Evidence suggests that shift work increases the possibility of mistakes, which is of critical importance in certain high-risk occupations requiring a high level of precision (e.g., complex machinery, surgeons, and nurses). You have also received interest from a robotics company, which seeks to use the smart pillow device for data acquisition, as this is useful to anyone who sees value in measuring sleep and providing insights into how to improve it. You can see enormous value in your innovation to sleepers (end users), families, medical professionals, employers, and even insurers as poor sleep is a precursor to heart disease and dementia.

Your task here is to decide *who you are really creating value for and what that value is*. Fundamentally, you need to create hypotheses to test these alternative futures. These then allow you to tweak your technology accordingly, depending on the specific value/user combination you are exploring.[17] The data is a crucial aspect in this regard. The value is not limited to the user who has a sleeping disorder but is available to other individuals. Hence, potential users for the smart pillow may be:

- patients with potential sleeping disorders, to monitor sleep and develop strategies for sleep management;
- aged care facilities, to improve quality of care and better resource management;
- sleep clinics and hospitals, to monitor sleeping disorders;
- employers, to help in decreasing mistakes due to poor sleep and shift workers' productivity and safety; and
- insurance companies, to better profile their customers and, when legally possible, adjust the premiums.

Indeed, AI is bringing a wealth of value to health care across the various stakeholders and different aspects of the health care journey, from patients to pharmaceutical companies. AI can help patients by giving them access to personalized, validated, and actionable information and data. AI can help health care diagnostics by providing a faster and more precise detection of small variations within patient's health data and comparing such variations across similar patients. AI technology also allows identification of outbreaks and pandemics much earlier than current methods, which helps to contain their spread. Future benefits could include the selection of patients for clinical trials.

Given these various benefits of AI technology, we propose the following classification of value drivers focusing on end users (i.e., patients and their families) as well as organizational goals and priorities. This classification of value creation is built on the original classification developed by IBM,[18] which was based on the results of a survey of health care executives across the world. While IBM's original classification focuses on health care service providers' goals with respect to the use of analytics, we further add goals related to value creation for patients. In the proposed classification of value creation, we suggest that health care startups clearly identify the target user—patient and health care provider focus—as well as the area of value they aim to create. Value creation with patient focus includes,

- patient health care accessibility, disease predisposition,[19] and lifestyle management;
- clinical effectiveness and patient outcome/satisfaction; and
- patient safety.

Value creation for health care providers and payers may focus on,

- operational effectiveness and efficiency; and
- financial and administrative performance.

Table 2 summarizes the proposed classification of value creation along with examples of startups offering each type of value creation.[20]

Emerging Business Models in AI-Driven Health Care Startups

While the business model landscape is continuously evolving, our analysis highlights the following seven business model archetypes in AI-driven health care startups, which can be useful to future entrepreneurs and managers. These business model archetypes differ in their target user, area of value creation, and value capture mechanism. We further classify these seven business model archetypes into two groups based on their value capture mechanism: information providers and connectors (see Table 3 and Figure 1). We also briefly highlight three delivery models that are of particular interest in the health tech space dominated

TABLE 2. Value Areas Provided by Data-Driven Solutions in Healthcare.

Value Area	Specific Goals/Objectives	Examples
Patient Focus		
1. **Patient Healthcare Accessibility, Disease Predisposition, and Lifestyle Management**	• Inform/guide patients on lifestyle decisions • Improve access to health information • Improve access to care/doctors • Remote monitoring • Predict predisposition to health issues • Create customized health and wellness protocols	• Your.MD • Billion to One • Symptomate • Careskore • Sentrain • ZocDoc • Clockwise.MD
2. **Clinical Effectiveness and Patient Outcomes/Satisfaction**	• Improve clinical quality of care • Generate personalized treatment plans • Improve wellness, prevention, and disease management • Reduce readmission by identifying risk factors and making adjustment to treatment plans accordingly	• Aindra • iCarbonX • Oncora Medical • Careskore • Zephyr Health • Bay Labs • Ayasdi
3. **Patient Safety**	• Reduce medical errors • Improve patient safety	• MedAware
Healthcare Provider and Payers Focus		
4. **Operational Effectiveness and Efficiency**	• Reduce costs and increase efficiency • Optimize catchment area and network management • Improve pay for performance and accountability • Increase operating speed and adaptability • Decrease nonadherence costs	• Lumiata • Atomwise • Turbine • Ayasdi • CrossChx
5. **Financial and Administrative Performance**	• Increase value-based revenue and ROI • Improve resource utilization • Improve risk management and compliance • Reduce fraud and abuse	• OncoBilling • CloudMedX • ShiftDoc • Glidian

Source: Value areas 2, 4, and 5 are adapted from James W. Cortada, Dan Gordon, and Bill Lenihan, "The Value of Analytics in Healthcare," IBM Institute for Business Value (2012).

by AI.[21] Table 3 summarizes these business model archetypes and delivery models along with examples of areas of value creation. Figure 1 illustrates the example of health care startups with their business model archetype and the area of value creation and value capture.

Information Provider Archetype

Specialized diagnostic. The specialized diagnostic business archetype provides analysis focused on one specific type of data (e.g., images). Its value is in offering more accurate insights to clinicians and health care payers through AI technology to assist them in efficiently delivering high-quality services to patients. Hence, specialized diagnostic deploys AI technology to support clinicians in diagnosis rather than prevention or treatment. It is a traditional (nonplatform) business model

**TABLE 3.** Business Model Archetypes in AI-Driven Healthcare Startups.

Business Model Archetypes and Delivery models	Description	Specificity to AI Healthcare	Examples of Areas of Value Creation
Information Providers Archetypes			
Specialized Diagnostic	Focus on using AI to analyze one type of data (e.g., images) to provide more accurate insights to clinicians and payers. The goal is on *diagnosis* rather than prevention or cure. They represent a typical linear business model, which uses inputs to solve a problem for a user further down in the value chain.	Yes	• Clinical Effectiveness (2)
Aggregator	Focus on using AI to analyze disparate data sources (e.g., EHR, images, scientific studies but also social media data) to provide more accurate insights to clinicians (e.g., assisting in the diagnosis), administrators, and payers (e.g., on population health and risk management)	Yes	• Clinical Effectiveness (2) • Operational Effectiveness and Efficiency (4)
Personal Health Companion	Use AI to reduce the information asymmetry between clinicians, payers, and patients by providing patients with evidence-based and customizable explanations to a variety of questions. The goal is to provide *an accurate and quick diagnosis* rather than preventing or curing.	Yes	• Patient Healthcare Accessibility (1)
Smart Prevention Companion	Providers that go a step further in comparison to personal health companions to give patients a nudge to change behavioral patterns. By virtue of smart prevention companions, patients are empowered to be more responsible for their health, *preventing* rather than only diagnosing and/or curing.	Yes	• Patient Healthcare Accessibility (1) • Clinical Effectiveness (2)
Connectors Archetypes			
Promotor	Provide a diagnosis of the patient's symptoms and then *recommend patients a healthcare practitioner* who is specialized in their particular disease. The AI enables *the diagnosis, and then the channeling* to the right practitioner or payer in a time-effective way.	Adapted to Healthcare	• Patient Healthcare Accessibility (1) • Operational Effectiveness and Efficiency (4)

(continued)

TABLE 3. (continued)

Business Model Archetypes and Delivery models	Description	Specificity to AI Healthcare	Examples of Areas of Value Creation
Discriminator	Allows individuals, such as patients and their families, to *share their experiences with therapies and the healthcare system; allows* clinicians to share their *medical insights on therapies.*	Adapted to Healthcare	• Patient Healthcare Accessibility (1) • Clinical Effectiveness (2)
Trusted Broker	Enable diagnosis, patient management, and treatment *by aggregating various forms of data from multiple sources* (e.g., IoT enable devices, EHR, public health records, but also social media data) and providing continuous monitoring and insights into health deterioration and the need for prompt intervention. In comparison to aggregators, trusted brokers have a more intimate relationships with the patients, often collecting data remotely and providing feedback and advice.	Adapted to Healthcare but the trust component is particularly crucial for the delivery of Healthcare solutions	• Patient Healthcare Accessibility (1) • Clinical Effectiveness (2) • Operational Effectiveness and Efficiency (4)
Delivery Models			
Platform	A platform (or multisided market) business model that creates value by *facilitating exchanges* between two or more interdependent groups, such as demands and supply or patients and doctors and healthcare payers. Network effects exist between the two sides of the market. A platform business model can exist only if both sides of the market exchange value, and come on board often at the same time.	Adapted to Healthcare	• Patient Healthcare Accessibility (1) • Operational Effectiveness and Efficiency (4)
SaaS (Software as a Service)	Primarily a Business-to-Business (B2B) approach to deliver applications over the Internet—as a service. Instead of installing and maintaining software on the client device, SaaS startups offers *access to the software via the Internet and so are a computing utility rather than the standalone software itself,* freeing clients from complex software and hardware management tasks.	Adapted to Healthcare	• Operational Effectiveness and Efficiency (4) • Financial and Administrative Performance (5)
PaaS (Platform as a Service)	Cloud computing platform that allows clients control over apps customized for them while the overall management and storage of data are still left to the service provider. As in platform approaches, a key economic aspect of PaaS models is the existence of network effects. PaaS models are also often used to offer SaaS solutions.	Adapted to Healthcare	• Operational Effectiveness and Efficiency (4) • Financial and Administrative Performance (5)

Note: AI = artificial intelligence; EHR = electronic health record.

FIGURE 1. Examples of healthtech startups and business model archetype.
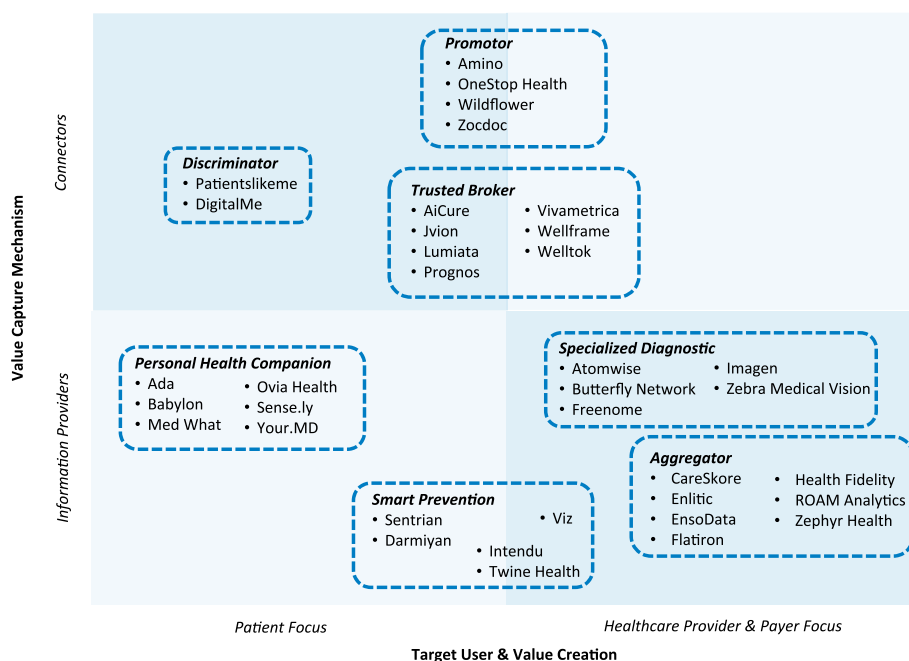
that transforms specific inputs in order to solve a problem for a user further down the value chain.

Consider Imagen Technologies, a health tech startup founded in 2015 that has raised over $21 million from leading venture capitalists as well as health systems and technology entrepreneurs. Imagen focuses on applying a state-of-the-art AI system to medical image analysis in order to detect pathologies and make early disease identification within medical images. Imagen aims to deliver value to health care providers by reducing diagnostic errors and improving patient outcomes (see value area 2 in Table 2). Its long-term goal is to identify the next set of breakthroughs at the intersection of AI and medicine to transform early disease identification and management.

Aggregator. The aggregator business model archetype focuses on consolidating data from disparate sources (e.g., electronic health records [EHRs], images, scientific studies, sleeping patterns of patients, and even social media), analyzing them, and offering insights to a variety of stakeholders.[22] Value creation of this business archetype lies in facilitating the clinical effectiveness for clinicians by providing more insightful information to help them in making more accurate decisions in diagnosis and treatment. It also involves enhancing operational effectiveness for health care providers and payers by providing more accurate information on such things as risk profiles of the patient population.

Enlitic, founded in 2014, is a San Francisco–based pioneer in medical deep learning that leverages AI to analyze a wide variety of health care data sources

(e.g., radiology images, lab test, and clinical cases) to create a clinical decision support product. It helps clinicians improve the speed and accuracy of their diagnosis, highlight patients at risk of a specific disease based on suspicious findings, and accelerate pharmaceutical research and drug trials. Enlitic creates value for health care providers through its data aggregation and proprietary deep learning algorithm that allows clinicians to fully utilize the richness of data from various sources and make fast and accurate decisions for their diagnosis and treatment.

Personal health companion. In the personal health companion archetype, AI technology is applied to assist patients in conducting a preliminary diagnosis on their own. This business archetype works on reducing information asymmetry between clinicians and patients by providing patients with evidence-based and customizable explanations for a variety of questions. Its goal is to provide an accurate and quick diagnosis rather than implementing preventive or curative measures. Hence, this archetype creates value for patients through improving access to health care information (see value area 1 in Table 2).

Both Your.MD and Ada are typical examples of startups pursuing the personal health companion archetype. Some challenge lies in identifying a way to monetize that goes beyond simply asking customers to pay for answers to their questions. One avenue is to connect them directly with a doctor for a consultation through a booking system (similar to what Babylon does). Hence Your.MD is evolving into OneStop Health platform.

Smart prevention companion. The smart prevent companion archetype goes a step further by applying AI technology (e.g., deep learning) to give patients a nudge or attempt to change their behavioral patterns based on the analysis of big data from patients with a particular disease (e.g., heart failure) and data collected through a remote monitoring system. Its emphasis is on prevention rather than diagnosis or remedial intervention. By virtue of smart prevention promoters, patients are empowered to become more responsible for their health and wellness. It can reduce hospital readmission rates by remotely detecting patients' early symptoms. Hence, a smart prevention companion aims to create value through increasing patient health care accessibility and clinical effectiveness (see value areas 1 and 2 in Table 2).

A case in point is Intendu, a health tech startup that helps people with brain impairment train their cognitive skills at home. Through the use of real-life, interactive scenarios and a motion-controlled video camera, Intendu helps patients train their thinking, memory, and attention skills. The system is adaptive and can personalize the training program in real time to a patient's performance, bio-feedback, and rehabilitation needs. It can nudge patients to change their behavioral patterns to achieve better outcomes in their training program. Intendu claims that its smart training program complements traditional therapies that address medical conditions such as traumatic brain injury, stroke, dementia, and neurological and psychiatric disorders. Other examples of startups with smart prevention companion archetype include Sentrain, which offers a remote patient intelligence system to reduce preventable hospitalization by leveraging machine

learning to remotely detect early patient deterioration, and Viz, which utilizes deep learning to identify and notify clinicians of suspected strokes.

Connector Archetype

Promotor. The promotor business archetype offers patients a preliminary diagnosis and then matches them with the relevant health care practitioner, with the application of AI technology mainly in the diagnosis phase. Startups with this business archetype aim to create value for patients in diagnosis and in directing them to appropriate practitioners, thereby enhancing accessibility to information, treatment, and doctors, as well as increasing efficiency in targeted advertising for health care providers (see value areas 1 and 4 in Table 1). While value delivery in the diagnosis phase is similar to that of the personal health companion archetype, the promotor archetype further adds value by timely and effective channeling of patients to practitioners.

An example is OneStop Health by Your.MD. Over the first year of operation, CEO Matteo Berlucchi noticed specialized clinics' demand for paid advertising to target specific customers seeking clinical consultations. Hence, OneStop Health was born as a curated network of trustworthy health care providers. Your.MD has created the first one-stop shop in digital health to empower patients to take control of each stage of their health care, from understanding their symptoms to finding the best treatment. Amino health care has also adopted the promotor archetype, but its value creation lies in channeling patients to safe, experienced, and cost-effective health care providers by utilizing its Smart Match algorithm and big data on health care spending, claims, and providers. Amino aims to deliver value to both patients/employees and their employer by matching an employee requiring treatment to a qualified doctor, and by providing cost estimates for both the patient and insurer.

Discriminator. The discriminator business archetype is a platform composed of online communities. Discriminators create value for both patients and clinicians by allowing individual patients and their families to share their experiences with the health care system as well as allowing clinicians to share their medical insights on therapies. Through the use of big data drawn from multiple sources of health data and deep learning algorithms, the aim of discriminator business archetype startups is to apply AI technology to increase patients' access to health care information and enhance clinical effectiveness (see value areas 1 and 4 in Table 1).

Patientlikeme.com, named one of *Fast Company*'s most innovative companies in 2017, is an online community of over 500,000 patients who have agreed to share their profiles with other individuals. As they describe themselves on the site:

> Patientslikeme is a clinical research platform that can provide real-world, real-time insight into thousands of diseases and conditions. Our research professionals have completed studies with real-world data that have helped refute and

pre-empt traditional randomized clinical trials, modeled Parkinson's Disease, validated epilepsy quality measures, shed new light on medication adherence in patients with multiple sclerosis (MS) and organ transplants, and added validated patient reported outcomes in psoriasis, autism and MS research.

Patients can share their health data on this free website to track their progress, help others, and offer this data to researchers for advancements in the medical field. Patientslikeme hence creates value for patients by providing them with information on how to live with specific conditions and improve treatment outcomes, at the same time creating value for clinicians by allowing them to learn directly from patients' real-world experience in real time on thousands of diseases and conditions.

Similar to Patientslikeme is DigitalMe,[23] which combines multiple sources of health data (including experiential, environmental, biological, and medical information) to create a digital version of a patient. Individuals visit a nurse for a routine blood test and then, through machine learning, Patientslikeme examines RNA, DNA, proteins, antibodies, microbiome, and metabolites. DigitalMe pays for the costs of the blood tests as well as sequencing patients' data, with an overall goal to one day create a Health Learning System that provides comprehensive answers to participants' medical questions. As DigitalMe is a recent innovation, it is too early to determine its monetization engine. However, we can reasonably predict that the insurance and/or pharmaceutical path is the most likely monetization mechanism.

Trusted brokers. The trusted broker business archetype focuses on utilizing AI technology to diagnose, manage, or treat patients through the aggregation of several forms of data (e.g., text, images) from IoT enable devices, social media, and other sources (e.g., claims data, electronic health records, and public health data). One of the applications of a trusted broker is the remote monitoring of patients (e.g., aging individuals) by aggregating relevant data from a disparate set of IoT-enabled devices. These startups offer continuous remote monitoring, which alerts patients and clinicians to any sign of health deterioration and consequent need for prompt intervention. Hence, trusted brokers create value for patients (and their families) by equipping them with real-time information on their health condition and allowing clinicians to promptly generate personalized treatment plans, further increasing the operational effectiveness and efficiency of health care providers (see value areas 1, 2, and 4 in Table 1).

Prognos's DxCloud exemplifies a health tech startup adopting the trusted broker archetype. It provides an end-to-end solution with historical and ongoing clinical insights for health care providers to interpret and identify patients' conditions for better management and to optimize risk adjustment. The ongoing monitoring and early detection of health symptoms are important for better care and reduced medical costs for patients, as well as for increasing operational speed and treatment adaptability for clinicians. Other companies, such as Billy Care and

eCare21, are using sensors to monitor environmental and health conditions of older patients and to provide on-time care in case of emergency, as well as to provide valuable data to health insurance companies.

Delivery Models

Platforms. A platform is a multisided market model that creates value by facilitating exchanges between two or more interdependent parties, such as demand and supply, consumers and producers, and patients and doctors. Successful platforms often facilitate exchanges by reducing transaction costs and/or by enabling externalized innovation. With the advent of connected technology and network effects (see following), these platforms are also able to scale in ways that traditional businesses cannot. Importantly, a platform is a business archetype, and should not be confused with the concept of a platform as a piece of technology. A platform may often use a piece of software, an app, or a website, but a platform business archetype is much more than that as it creates value by bringing together the two sides of a market (e.g., consumers and producers) who otherwise would use alternative places to meet, often at higher costs (e.g., eBay and Uber). Where SaaS (Software as a Service) companies claim a complete "platform" for a certain solution, they are using a marketing term rather than a business archetype as discussed here, as they still transfer goods or services across the value chain. The concept of platform has been adapted to the health care service sector to deliver value to both patients (by increasing their accessibility to health care information) and clinicians (by increasing their operational effectiveness) (see value areas 1 and 4 in Table 1).

Network effects are the ways in which a platform's customer base impacts the value of the platform itself. More specifically, the more people engage with a platform, the more useful and valuable it becomes. There are two types of network effects that can be enabled. Direct network effects happen when the greater number of members on one side of the market leads to a direct increase in value for other members. For example, the greater the number of patients on a platform that connect them with doctors, the greater the incentive for other patients to join and benefit from the interaction. On the other hand, an indirect network effect occurs when the greater the number of members on one side of the market attracts an increased number of members on the other side of the market. In effect, the greater the number of patients joining the platform, the greater the chance to attract a larger number of doctors.[24]

An example of health care startups adopting the platform model is Wellframe. As with the earlier examples of SaaS companies, Wellframe uses a remote monitoring system to collect data. However, it fundamentally relies on recruiting both patients and care teams to improve care management through a tech-enabled, data-driven, and patient-centered approach. The app is available for free to patients who are eligible through their health care plans. The platform model can increase productivity among care managers, improve engagement and retention in programs among members, and, ultimately, maximize medical cost savings.

SaaS. SaaS is a way of delivering applications over the Internet as a service. Instead of installing and maintaining software on the client device, SaaS startups license software online on a subscription basis, freeing clients from complex software and hardware management tasks. The SaaS provider manages access to the application, including security, privacy availability, and performance (e.g., speed). Hence, startups with the SaaS delivery model aim to create value for health care service providers by increasing their operational efficiency, reducing costs, and increasing value-based revenue (which aligns with value areas 4 and 5 in Table 1).

A critical aspect of the SaaS delivery model is a reliance on monetization through subscription services, including the purchase of additional ancillary or premium features. Examples of existing SaaS provide insights into methods for monetizing data, which include engaging with pharmaceuticals or insurance companies as further sources of revenues, in addition to charging clients for services.

CareSkore, Enlitic, and Welltok are examples of health tech startups adopting the SaaS delivery model. They utilize machine learning, NLP, and other AI applications in a service platform to streamline the process of data-driven patient population management, risk assessment, and monitoring. Insurance companies are often the primary customer segment for these startups using an SaaS delivery model. The focus on continuous risk assessment and patient population management reflects a shift within the health care market, across providers and payers, toward preventive care and thus an increase in demand for intelligent patient data analytics and risk management.

Platform as a service (PaaS). PaaS is a form of cloud computing platform that allows firms to develop (i.e., customize) and manage applications and services without the cost and complexity of buying and managing software licenses, infrastructure, and development tools and resources. Put simply, PaaS provides a framework for firms to manage and customize applications while having the platform provider manage the storage, server, and networking. Compared to SaaS, PaaS gives startups more flexibility and control in customization and management of the application. In the health care context, PaaS is adopted by health tech startups aiming to create value by allowing health care providers to operate more efficiently while minimizing operating costs (see value areas 4 and 5 in Table 2).

Datica, a cloud-based digital health platform, is an example of health tech startups adopting the PaaS delivery model. Datica offers compliance tools for health care providers to integrate their EHR and other records such as radiology information systems (RIS), and picture archive and communication systems (PACS) for interoperable health care data. The Datica platform provides a secure, compliant Kubernetes managed service that integrates with cloud services. It delivers value to health care providers by reducing operating costs and by boosting operational and administrative efficiency.

Discussion and Implications for Management Theory and Practice

Our discussion of the application of AI in health care startups offers several implications for both management theory and practice. While the application of AI technology is our focus, we acknowledge the importance of the availability of data and its structure and quality as a key ingredient for the application of AI in health care; this is outside of the scope of our article, which instead focuses on the application of AI for decision making. That is, our focus is on how data facilitates and enables decision making for patients and clinicians.

Implications for Theory Development

Our investigation raises three critical questions for scholars working at the intersection of business and technology.

Entrepreneurial top management teams. First, our study contributes to the top management team literature by providing a taxonomy of the different business model archetypes emerging in health care entrepreneurship. This serves as the foundation for future research in an analysis of the possible relationship between founders, background characteristics, and the ability to raise funding, as well as startup performance.[25] More specifically, we expect that some team compositions, in terms of medical versus IT/technical versus business backgrounds, are better suited to the development of some archetypes than others, as well as in terms of their ability to raise funding. Our preliminary analysis of the background characteristics and funding suggests that teams raising the greatest amount consist of individuals with at most two different backgrounds (e.g., business and IT). As the number of backgrounds in team composition grows, it appears that the amount of funding decreases (controlling for other company characteristics). This may be due to conflicts among the funding team or the loss of focus in terms of the new venture's mission and vision. This is an avenue for future research.[26]

Entrepreneurial opportunity creation. Entrepreneurial opportunities, whether discovered by systematic analysis or created through an enacting process, are one of the most discussed topics in entrepreneurial research.[27] A wealth of research has gone into identifying the preconditions of opportunity recognition, including the importance of prior knowledge and external conditions,[28] as well as the thought processes that transform knowledge and observations of the environment into opportunities and the impetus to act upon them.[29] We predict that AI will transform research in opportunity creation as it opens up the possibility to identify opportunities more easily and to a greater number of individuals. For instance, whereas in the past doctors have had access to some data points on patients, AI enhances data accessibility by providing a stream of information available to relevant decision makers more often or in real time and also more structured because of greater data points from health records and previous conditions. These will also be available not only to doctors and nurses but also to others, such as pharmacists and administrators, with implications for the effectiveness of drugs and therapies.

Open innovation. Models of data openness in health care are still in its emerging stage. A delay in the adoption of data openness in health care can be attributed to several reasons. Health care data are traditionally restricted to relevant parties (e.g., patients and clinicians) due to its confidential nature. Patients have privacy and security concerns, making the enrollment in electronic health records a concern for most governments. In addition, the lack of reliability and standards of data across multiple sources also poses a challenge in the wide acceptance of data openness in health care. The concept of open data in health care also suffers from the difference in the level of sophistication in the way data are collected, organized, and managed across stakeholders (e.g., from data available from wearable devices, general practitioners' patient's records, health medical records, and radiology images), which make a seamless integration of health care data across sources much more difficult. The motivation of stakeholders is another crucial factor that needs to be considered in order to promote data openness in health care.

However, openness of data is critical for the application of AI in health care as it allows extraction of more accurate and insightful information from AI technology. Several business archetypes discussed earlier operate based on a foundation of open access to big data. Startups such as Lumiata and Flatiron are working across a multiplicity of data sources to bring insights to various partners (including academics, hospitals, and employers) at both the patient and population level. Further questions arise regarding the management of these models and the incentives to be provided in order to maintain stakeholder engagement with the platform, both for stakeholders within organizational silos and stakeholders from outside the organization.[30] This area of research is very much connected to questions of emerging models of partnerships between companies providing models and algorithms (such as IBM Watson, Microsoft Azure, and so on) and startups providing industry solutions (such as those noted in this article). Future research can examine how data availability may affect the survival of resource-constrained startups.

Implications for Practice

Our research points to three major recommendations for entrepreneurs and managers. Ultimately, the question is not whether AI in health care will create profitable business models or whether AI will benefit a business incorporating it into existing operations. The question is how to best start and manage a transition from "analog" to AI-powered digital solutions.

How to get started. The first two key decisions in getting started are an identification of the health care issue that a startup attempts to address, and the strategic evaluation of how the application of AI may enable the solution within an existing business by analyzing the landscape of applications. Our work clarifies the five examples of value propositions (see areas of value creation in Table 1). For a new business, we recommend looking at low-hanging fruit, such as improvements in operational effectiveness and solving inefficiencies. It is exciting to solve big problems, such as optimizing patient treatments, but they also carry important

regulatory hurdles, difficulty in acquiring patient data, and data cleaning. Instead, for example, robots (such as Dinsow by CT Asia Robotics and Pepper by Softbank) have been shown to provide substantial benefits in delivering supplies to different parts of hospitals or in assisting elderly patients. These provide a learning opportunity, as well as a quick win, that can accelerate the development of solutions aimed at solving bigger problems. As shown in our discussion on Your.MD, getting started may be more important than focusing on monetization—which usually comes later, funding permitting.

How to select the most suitable AI-technology development strategy. Startups need to evaluate whether the most appropriate approach to their value creation goal is to build solutions by leveraging existing AI platforms (e.g., Google AI, Microsoft Azure, Amazon AI on AWS, or IBM Watson) or develop their own AI technology. For example, Microsoft Cognitive Services allows the building of applications that range from image recognition and text recognition to voice recognition without much prior knowledge of AI. The alternative is to instead build an algorithm from scratch.

Based on our discussions with entrepreneurs and executives, we have identified four critical questions in deciding which technology path to follow. First, what stage is the company at? If a company is at the prototyping stage and trying to understand how AI can solve its problem and whether there might be a market for its solution, there is little reason to spend extensive resources in developing its own AI. Instead, there is much better value in quickly prototyping a solution and testing it with potential users to gain valuable feedback for iteration and improvement. Hence, at the prototyping stage, the emphasis on value creation is understanding the time needed to identify the problem to solve, and how value is created to potential users.

The second question relates to technology and whether the effectiveness of insights from AI relies more on the available data or on the algorithm that can be built. For example, solving a very narrow problem may require an incredible amount of data to generate an effective solution. An effective pilot solution may be developed in a very short period of time, such as during a hackathon. A case in point is Arsenal Health, originally called Smart Scheduling and bought by Athena Health in 2016 for $1.7 million. Smart Scheduling was started in 2012 by a team who met at the Massachusetts Institute of Technology hackathon. The startup utilized more than 700 variables and machine learning to investigate the question, "What if you could use data science to determine which patients are likely to show up and which ones will be no-shows and manage office appointments around those tendencies?" and it quickly achieved accuracy of over 70%. This is an example of a new breed of health care startups that leverage big data to offer a solution to a specific area of customer need, rather than attempting to solve the big issues in health care, such as population health, which is better suited to larger organizations like IBM Watson. In doing so, this new breed works to streamline processes and increase efficiencies.[31]

The third question is what does the company sell? For example, there is little value in investing resources in developing an algorithm from scratch if a clinical trial company intends to use the insights from AI to better select patients and profit by selling a report with a key actionable insight. Instead, to sell a medical AI technology to facilitate faster and more efficient diagnosis (e.g., analyzing highly specific digital images), it makes sense to allocate resources to developing an ad hoc algorithm.

The fourth consideration involves a company's available resources. Developing AI solutions can be extremely time consuming and resource intensive. Again, if AI is only part of the solution, then there is little reason to devote extensive resources to developing an algorithm from scratch. Given an undersupply of data scientists, most startups should consider standing on the shoulders of the giants.[32]

Governance and decision-making responsibility. Another contribution to practice relates to responsibility in terms of decision making for AI-driven health care startups that are on the augmented or autonomous intelligence spectrum. In the case of decision-making errors, we need to pre-emptively consider the following question: Is an error the responsibility of the clinician ordering the test and allocating the task to an AI solution, of the clinician looking at the results (who may be the same person), of the machine, or of the startups that has created the AI-solution? For example, consider an image analysis tool that looks at X-Rays. If that tool makes a mistake, is it the fault of the company that made that tool and do they need medical malpractice insurance? If a radiologist looks at an X-Ray and misses evidence of cancer, the fault lies with the individual, but if a computer looks at it and misses evidence, is it the fault of the computer, the physician who ordered the test, or the company that built the computer? This will ultimately be worked out in a courtroom, as with accidents involving self-driving cars, and blame will likely be apportioned to the startups providing the AI solution. However, a startup's counterpoint may be in highlighting the number of positive cases missed by a radiologist versus the number of positive cases missed by the AI solution, just as an autonomous car has fewer accidents than a human driver. These are complex legal areas that will play out in multiple industries. Recent pronouncements by the U.S. Food and Drug Administration in permitting AI to make medical decisions on its own (e.g., interpreting medical imagery for detecting eye disease diabetic retinopathy) further emphasize the importance of the governance and decision-making responsibility we discuss here.[33]

Adopting two business model archetypes within the same entity. Another critical question raised by startups such as Your.MD is should the startup play with two business models at once or should it "spin-out" one of these models?[34] No "right" or "wrong" answer has been identified in the academic or practitioner literature, not even for larger corporations. For startups, the common advice is to focus on, develop, and improve one business model at a time. Ultimately, it is a question of balance between integration and separation and remains an open question in the AI context.

The question of duality of business models is also strictly related to funding. If a startup is attacking a big problem, such as population health, which requires a variety of data, funding constraints may impede the collection and analysis of sufficient data for meaningful insights. In that case, a more effective path to follow might be focusing on specific data (e.g., image recognition) and taking advantage of partnerships with hospitals and other providers.

How to get managers and clinicians to embrace AI: Managing parallel systems. Innovation in health care is sometimes only discussed at the level of digitalizing what we are already doing rather than reinventing for what will do in the future. AI requires a major change in the way a doctor or administrator thinks about work, their role, and the processes of the organization. Just as it took years for keyhole surgery to replace open surgery, the adoption of AI will take place in parallel with other approaches. It is critical, therefore, to clearly identify those who can lead the transformation while making sure that others do not fail to keep up with the amount of information that is constantly being generated, and which can only be dealt with by an AI-driven system.

Conclusion

There is no doubt that AI in health care will reduce information asymmetry between health care providers, payers, and patients as it redefines the health care landscape. While an incredible amount of work is indeed done by technology providers, the real power of AI is in opening up opportunities for startups to solve specific problems with applications and verticals.

Currently, patients are the objects of a value chain system; AI empowers them to become more responsible for their health. AI has the potential to revolutionize the way clinical staff access information and how administrative staffs manage resources and financial outcomes. However, the design of business models in health care—and, in particular, in data-driven health care—is the fundamental piece in the puzzle of how to take useful technologies to the market.

New entrants and established companies are continuously finding innovative solutions to security and privacy issues that allow them to more easily deal with large volumes of digital data (as well as IoT-generated data) and integrate information from within and external to current health care systems. The startups that manage to do so will be in an optimal position to carve out new opportunities within health care as well as meet the challenge of working with traditional companies that have not yet embraced digital transformation.

Acknowledgments

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Notes

1. See https://www.pwc.com/gx/en/industries/healthcare/publications/ai-robotics-new-health/ai-robotics-new-health.pdf.
2. See "Understanding the Four Types of AI, from Reactive Robots to Self-Aware Beings," *The Conversation*, November 14, 2016, accessed October 26, 2018, https://theconversation.com/understanding-the-four-types-of-ai-from-reactive-robots-to-self-aware-beings-67616.
3. James W. Cortada, Dan Gordon, and Bill Lenihan, "The Value of Analytics in Healthcare," IBM Institute for Business Value, 2012, https://www-935.ibm.com/services/us/gbs/thoughtleadership/.
4. See Accenture Consulting, "Digital Health Technology Vision 2017," accessed October 26, 2018, https://www.accenture.com/t20170524T014807__w__/us-en/_acnmedia/PDF-49/Accenture-Digital-Health-Technology-Vision-2017.pdf.
5. Startups are not the only entities struggling to design innovative business models. Other health care institutions, including hospitals, are dealing with the question of how to design and implement dynamic capabilities to reshape the internal configuration of resources in order to maintain competitiveness in dynamic environments. See Andrew Agwunobi and Paul Osborne, "Dynamic Capabilities and Healthcare: A Framework for Enhancing the Competitive Advantage of Hospitals," *California Management Review*, 58/4 (Summer 2016): 141-161; David Teece, Margaret Peteraf, and Sohvi Leih, "Dynamic Capabilities and Organizational Agility: Risk, Uncertainty, and Strategy in the Innovation Economy," *California Management Review*, 58/4 (Summer 2016): 13-35.
6. Shin-Horng Chen, Pei-Chang Wen, and Chih-Kai Yang, "Business Concepts of Systemic Service Innovations in e-Healthcare," *Technovation*, 34/9 (September 2014): 513-524.
7. This can be done with analogical reasoning. On the importance of analogical reasoning in business model generation, see Luis L. Martins, Violina P. Rindova, and Bruce E. Greenbaum, "Unlocking the Hidden Value of Concepts: A Cognitive Approach to Business Model Innovation," *Strategic Entrepreneurship Journal*, 9/1 (March 2015): 99-117.
8. We use the term "entrepreneurs in health tech" to refer to both health care entrepreneurs (e.g., physicians, scientists, and nurses) who successfully apply technology into health care settings and technology entrepreneurs who successfully bring technology into health care business. We use these terms interchangeably throughout the article.
9. Of particular relevance are the work of Michael Porter and Clayton Christensen related to health care innovation and disruption. See Michael E. Porter and Thomas H. Lee, "The Strategy that Will Fix Health Care," *Harvard Business Review*, 91/10 (October 2013): 50-70; Michael E. Porter and James E. Heppelmann, "How Smart, Connected Products Are Transforming Competition," *Harvard Business Review*, 92/11 (November 2014): 64-88; Erich Joachimsthaler, Abhijit Chaudhuri, Mike Kalthoff, Anthony Burgess-Webb, and Alok Bharadwaj, "How Smart, Connected Products Are Transforming Companies," *Harvard Business Review*, 93/1-2 (January/February 2015): 20; Clayton M. Christensen, Richard Bohmer, and John Kenagy, "Will Disruptive Innovations Cure Health Care?" *Harvard Business Review*, 78/5 (September/October 2000): 102-112.
10. See Anand Rao, "A Strategist's Guide to Artificial Intelligence," *Strategy + Business*, 87 (Summer 2017): 46-50.

11. See here https://www.cbinsights.com/research/artificial-intelligence-startups-healthcare/.

12. "UCSF Robotic Pharmacy, San Francisco," accessed October 26, 2018, https://www.pharma-ceutical-technology.com/projects/ucsf-robotic-pharmacy-san-francisco/.

13. Massimo Garbuio, personal communication, November 2017.

14. See Massimo Garbuio, Dan Lovallo, Joseph F. Porac, and Andy Dong, "A Design Cognition Perspective on Strategic Option Generation," in *Advances in Strategic Management*, ed. Giovanni Gavetti and William Ocasio (Bradford, UK: Emerald, 2015), pp. 437-465.

15. James Barlow, Steffen Bayer, and Richard Curry, "Implementing Complex Innovations in Fluid Multi-Stakeholder Environments: Experiences of 'Telecare,'" *Technovation*, 26/3 (March 2006): 396-406.

16. Mathias Cousin, Tadashi Castillo-Hi, and Glenn H. Snyder, "Devices and Diseases: How the IoT Is Transforming Medtech," September 11, 2015, accessed October 26, 2018, https://dupress.deloitte.com/dup-us-en/focus/internet-of-things/iot-in-medical-devices-industry.html.

17. Note also that a payer's willingness to pay is a variable to consider in business model design. For example, in platform businesses, it is unrealistic to charge the most price sensitive side of the market. See the discussion in the following section.

18. Cortada et al., 2012, op. cit.

19. We thank a reviewer for pointing out the importance of social determinants of health and the use of social media and other largely nonmedical information to help make predictions about predispositions to many health issues and create customized health and wellness protocol. For the use of Instagram photos to make predictions about depression, see Andrew G. Reece and Christopher M. Danforth, "Instagram Photos Reveal Predictive Markers of Depression," *EPJ Data Science*, 6/1 (2017): 15.

20. We have developed this classification based on IBM's classification of value areas for analytics in health care and then tested and refined it over time with health care executives. In addition to their three business goals identified (value areas 2, 4, and 5), our interviews focused on the value of artificial intelligence (AI) in health care have highlighted the emergence of two further areas: accessibility and lifestyle management on one side (value area 1) and patient safety on the other side (value area 3), as well as several new items within IBM value areas. See Cortada et al., 2012, op. cit.

21. Scholars and practitioners from different fields have referred to platforms PaaS and SaaS as both business models and delivery models. In this study, our classification of business model archetypes implies that these are possible delivery models that startups may adopt as an alternative approach to reach the market. We thank the reviewers for this insight. See Andrea Giessmann and Christine Legner, "Designing Business Models for Cloud Platforms," *Information Systems Journal*, 26/5 (September 2016): 551-579; Thomas Eisenmann, Geoffrey Parker, and Marshall W. Van Alstyne, "Strategies for Two-Sided Markets," *Harvard Business Review*, 84/10 (October 2006): 92.

22. We borrowed some of the terminology for the business model archetypes, such as Aggregator, Promotor, and Discriminator from a study of digital disruptive intermediaries. See Kai Reimer, Uri Gla, Jakob Hamann, Ben Gilchriest, and Martim Teixeira, "Digital Disruptive Intermediaries: Finding New Digital Opportunities by Disrupting Established Business Models," The Australian Digital Transformation Lab, The University of Sydney Business School and Capgemini Australia, 2015, accessed October 26, 2018, http://hdl.handle.net/2123/12761.

23. See DigitalMe at https://www.patientslikeme.com/research/digitalme, accessed October 26, 2018.

24. Two further aspects of the platform need to be mentioned. First, network effects imply a chicken and egg problem—that is, which side of the market do you need to attract first in order to convince the other side to get on board. Second, which side of the market do you price, or do you price more. This goes back to the question of which side of the market is more price sensitive and which side is bound to provide quality. See Eisenmann et al., 2006, op. cit.

25. Jin Linlin, Kristen Madison, Nils D. Kraiczy, Franz W. Kellermanns, T. Russell Crook, and Jing Xi, "Entrepreneurial Team Composition Characteristics and New Venture Performance: A Meta-analysis," *Entrepreneurship Theory and Practice*, 41/5 (September 2017): 743-771.

26. Interestingly, Berlucchi was brought in to bring a fresh perspective. As a serial entrepreneur with eight companies under his belt and a PhD in theoretical physics, he had a wealth of knowledge in technologies and markets even if not in the health care market. According to

Berlucchi, the first big separation in health care innovation and entrepreneurship is whether the innovator comes from the health care business or not. Are you an insider or an outsider? If you are an insider, you understand the market, understand the deficiencies and the shortcomings, and come up with an idea to improve the system. If you are an outsider, you do not know how the system works from the inside, so you just look at it from the outside, and you think of ways to improve it for the end user, disregarding the dynamics of the internal system. Therefore, when you are stuck in understanding the value that is brought to the customer or how value can be delivered, it might be the time for you to engage with industry outsiders to bring that perspective. For further thoughts on the cognitive aspects of healthcare entrepreneurship, see Massimo Garbuio and Nidhitda Lin, "Entrepreneurial Opportunities in Healthcare: A Cognitive Perspective," in *Healthcare Entrepreneurship*, ed. Ralf Wilden, Massimo Garbuio, Federica Angeli, and Daniele Mascia (New York, NY: Routledge: 2018), chap. 9, pp. 199-220.

27. Sharon A. Alvarez and Jay B. Barney, "Discovery and Creation: Alternative Theories of Entrepreneurial Action," *Strategic Entrepreneurship Journal*, 1/1-2 (November 2007): 11-26.

28. Scott Shane, "Prior Knowledge and the Discovery of Entrepreneurial Opportunities," *Organization Science*, 11/4 (July/August 2000): 448-469; Dean A. Shepherd and Dawn R. DeTienne, "Prior Knowledge, Potential Financial Reward, and Opportunity Identification," *Entrepreneurship Theory and Practice*, 29/1 (January 2005): 91-112.

29. Joep P. Cornelissen and Jean S. Clarke, "Imagining and Rationalizing Opportunities: Inductive Reasoning and the Creation and Justification of New Ventures," *Academy of Management Review*, 35/4 (October 2010): 539-557; Deniz Ucbasaran, Paul Westhead, and Mike Wright, "The Extent and Nature of Opportunity Identification by Experienced Entrepreneurs," *Journal of Business Venturing*, 24/2 (April 2009): 99-115; Robert A. Baron, "Opportunity Recognition as Pattern Recognition: How Entrepreneurs 'Connect the Dots' to Identify New Business Opportunities," *Academy of Management Perspectives*, 20/1 (February 2006): 104-119; Dimo Dimov, "Beyond the Single-Person, Single-Insight Attribution in Understanding Entrepreneurial Opportunities," *Entrepreneurship Theory and Practice*, 31/5 (September 2007): 713-731.

30. A critical question is how to reallocate resources and create new forms of stakeholder collaboration. See Sebastian Kortmann and Frank Piller, "Open Business Models and Closed-Loop Value Chains: Redefining the Firm-Consumer Relationship," *California Management Review*, 58/3 (Spring 2016): 88-108.

31. Michael B. Farrell, "Data-Driven Scheduling Predicts Patient No-Shows," *Boston Globe*, July 14, 2014, https://www.bostonglobe.com/business/2014/07/13/high-tech-cure-for-doctors-scheduling-pains/ylLD4Fwar8EElFJ32frI9I/story.html.

32. Cade Metz, "Tech Giants Are Paying Huge Salaries for Scarce A.I. Talent," *New York Times*, October 22, 2017, https://www.nytimes.com/2017/10/22/technology/artificial-intelligence-experts-salaries.html.

33. See, for example, accessed October 26, 2018, https://www.fda.gov/newsevents/newsroom/pressannouncements/ucm604357.htm and https://www.fda.gov/newsevents/newsroom/pressannouncements/ucm596575.htm for the official pronouncements by the US FDA.

34. Constantinos Markides and Daniel Oyon, "What to Do against Disruptive Business Models (When and How to Play Two Games at Once)," *MIT Sloan Management Review*, 51/4 (Summer 2010): 27-32.