Innovation and Future Technology Scenarios in Health Care: Ideas and Studies

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Abstract

Innovations are turning the health care market into a technology-dominated sector. Artificial intelligence (AI), preventive medicine and all variations of upcoming technology will influence the health care market of the future. In the short term, it seems unthinkable in times when all expect higher costs in the future that we will accept that our economies need to lower health care costs by 20% or even more. People are getting older, leading to many additional treatments in the next decades, e.g. knee replacement treatments, cancer therapy treatments, coronary heart disease treatments and many other therapies that will emerge should people reach ages of, on average, 100 or more. The economy can only meet the requirements for successful international economic competition if we stop the upcoming explosion in health care costs, which are mostly financed by health insurance contributions and taxes. However, the reality is that our health care systems in Europe will not be able to deliver the best medicine to all people, especially not in those countries with demographic change, if the costs rise in the next decades as forecasts predict. We would like to present several ideas for and long-term scenarios of a health care revolution as well as present scientific studies, including the acceptance of users and patients, because we think acceptance by users and patients is a key factor for success in the future. Automation, BIG DATA combined with AI and patient cooperation are the requirements for a highly efficient and cost-effective health care system. Another key factor is preventive medicine. Let's start with the idea of logic automation in health care.

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1 Self-Driving Hospital Beds

Most hospitals in Germany will have problems recruiting enough nurses and physician assistants in the next years. The reason for this is the demographic transformation. It's not just a quantitative problem of hiring enough workforce in the future, but also a qualitative problem as these jobs also require social and emotional skills, which must reach a certain standard without exception. Care assistants and nurses are currently exhausted and the percentage of sick days is, based on Deutsche Ärzteblatt (2019), growing. So how can this problem be handled to help this workforce deliver their service to the patient?

Much time is lost in inefficient transportation of patients between different departments, for example from orthopedics to radiology and back again. As personally experienced nearly 30 years ago while working at the University Clinics of Cologne for several years as medical student help to finance my studies, the hospital bed itself is heavy, the brakes are difficult to release, transportation is slow because the bed frequently moves to the right or left, often due to worn tires, and doors need to be opened. The elevator waiting time combined with partly filled elevators is inefficient. Moreover, when you have finally arrived at the new department, it can happen that appointments have been changed, cancelled or transferred to another department, meaning you need to return with the bed and waste a lot of time. Sometimes two persons are needed to transport a hospital bed.

So, what about an efficient, fully-integrated concept of self-driving hospital beds in conjunction with self-opening doors and coordination with elevators and the schedules of all departments? The time won will lead to more time for care and less stress for the workforce. Staff sick days may decline, and employee and patient satisfaction indicators increase. The following research question is important for this idea: "How will patients accept transportation in a self-driving hospital bed?"

In a questionnaire-based multicenter study between January and December 2018, we surveyed 264 patients in two dental and two general medical clinics in North-Rhine Westphalia, Germany. The inclusion criteria were: 30–70 years old, with at least one period of inpatient hospitalization of at least one night due to a health crisis incident or for another reason. We also categorized by age groups, education, income and experience with technology, e.g. smartphone use. The exclusion criteria were: older than 70, younger than 30, no experience in hospitals and no technology experience.

The results of this quantitative empirical research study showed that overall 94.32% (n = 249) of the 264 patients interviewed would have no problem being transported by self-driving hospital beds. Even in the group of 60–70-year-old-patients, the acceptance rate was 91%. At over 85%, the three most important factors for the patients were the safety of the technology, insurance for accidents with the bed and an emergency button. Generally, there was a high acceptance rate for self-driving hospital beds in this study. With more than 2000 hospitals and hundreds of private clinics and rehabilitation centers in Germany, there is a huge market

for hospital beds. Germany has all the necessary technological components and production options, so it could develop the next big thing in health care technology.

2 Reorganization of Medical Studies with Contests and Crowdsourcing

Competition is a natural status quo, also in health care. Medical students should therefore get used to it. Contests, research projects and interdisciplinary projects all offer a good opportunity to train competition. The power of contests and crowdsourcing is a tool that can be used by individuals and organizations interested in starting new companies or pushing projects for new products and services in HC.

A few years ago, we started a study on the "Willingness of German Medical Students and Experienced Physicians to Participate in Online Contests to Innovate in the Field of Health Care". Presenting the first results at the Open and User Innovation (OUI) Conference at the Harvard Business School (Boston, USA) in August 2016, we discussed the further impact of contests and crowdsourcing in health care.

Crowdsourcing can be a powerful tool to solve problems in the field of health care (Lakhani et al. 2013). In the age of digital transformation, the technologies allow individuals and networks to interact in an efficient way characterized by high-speed performance per time unit and the irrelevance of geographic distances. It even no longer seems essential to be a long-time working expert in a certain field of knowledge to create innovative solutions. The strategy of using the crowd as an innovation partner (Boudreau and Lakhani 2013) can help to find a better innovative solution in a shorter time.

The influence of users, user communities (Harhoff and Mayrhofer 2010), lead-users (Herstatt and von Hippel 1992) and producers on the innovation processes from different perspectives means that we live in times of democratized innovation (von Hippel 2005). Through online contests in the field of health care to innovate with crowds, where you can participate as an individual with your own idea or work on a special problem as part of a crowd, access to participation is generally open. In 2016, there were a range of national and international online contests in the field of health care, such as the Health Acceleration Challenge of the Harvard Business School and Harvard Medical School in the USA, the Medical Valley Open Innovation Platform Contests in Germany and the Business Plan Competition of the China Healthcare Investment Conference (CHIC). The research area we focused on in this study concerned the breadth of the crowd involved in the online contests in the field of health care because the participants are usually also experienced physicians acting in different executive capacities in clinics or in the health care industry. The specific research question we were interested in was to compare the willingness of a group of German medical students to participate in online contests in the field of health care with that of a group of experienced German physicians.

For this study, we surveyed two groups in the timeline November 2014–January 2016. The first group were German medical students ($n = 258$) from five universities

in Germany without regard to the progress in their studies. The second group were experienced German physicians of different disciplines who had worked clinically for a minimum of 10 years ($n = 184$). The research process was organized differently for both groups. The medical students were interviewed on university campus, especially at times of conferences or exhibitions on campus when we could expect to meet and interview a large number of students with a standardized question paper at one time. The second group of experienced physicians were first invited to participate in this study by e-mail with a repeated 2-week reminder e-mail. Then, if they replied positively, we sent them a standardized question paper by e-mail. Both groups were asked to name three factors which could lead to a higher willingness of their peers to participate in online contests.

Regarding the first group ($n = 258$), we found that 78.29% ($n = 202$) of the German medical students asked were willing to participate in online contests to innovate in the field of health care, compared to 30.43% ($n = 56$) of the experienced German physicians asked in the second group ($n = 184$). The three most important factors named by group 1 that could encourage their peers to participate more in online contests to innovate in the field of health care were: credit points for extra-curricular activities related to innovation (77.91%), more information from the medical and other faculties about online contests (71.32%) and interdisciplinary events on campus (57.75%). In group 2: more detailed response to the ideas submitted (60.87%), real-life meetings face-to-face with a part of the participating network (52.17%) and more interaction in sharing the final results of the contest (45.11%).

The empirical results of this study clearly showed that the group of German medical students has a significantly higher (78.29%) willingness to participate in online contests to innovate in the field of health care than the group of experienced German physicians (30.43%). Asked about factors to improve willingness to participate within their peer group, the most important factor for the German medical students was credit points for extra-curricular activities related to innovation (77.91%) and for the experienced German physicians more detailed response to the ideas submitted (60.87%). For the future of online contests regarding innovation in the field of health care, some thought should be given to widening the crowd to include a higher number of medical students. On the one hand, the contest itself would benefit from the additional perspective of this group of participants, who have less expert knowledge while studying medicine, but may in some ways have a less complex view. On the other hand, the medical students themselves would learn from their very first years at a medical faculty to think in innovative patterns.

The results of this first study on the topic posed the question of what results would be obtained if students of IT and engineering were asked. We therefore set up a follow-up study in 2017 and 2018 focusing on this group of students titled “Willingness of Students of IT and Engineering to Participate in Health Care Contests”. The factor of crowdsourcing was not evaluated in this follow-up-study.

We surveyed two groups in the timeline August 2017–November 2018. The first group were German IT students ($n = 114$) from three universities in Germany without regard to the progress in their studies. The second group were German

engineering students ($n = 129$). The students of this follow-up study were interviewed directly on university campus. Both groups were asked to name the main factor which could lead to a higher willingness of their peers to participate in online contests especially in the field of health care. For 87% of the IT students and nearly 90% of the engineering students, this was raising the visibility of their personal performance to industry.

Regarding the first group, the IT students ($n = 114$), we found that 90.35% ($n = 103$) were willing to participate in online contests to innovate in the field of health care, compared to 71.32% ($n = 92$) of the engineering students in the second group ($n = 129$). The empirical results of this study clearly showed that both groups have a high willingness to improve health care and participate in such contests. If we take the first study with medical students and experienced physicians and the follow-up study with IT and engineering students, it is clear that any platform open to these groups would be very successful driving solutions and innovations in the field of health care.

3 All-In-Data-Approach in Health Care for New Business Models

The future health care business model could deliver guaranteed full health care service for a certain amount of money. For private companies, one of the requirements needed to deliver this full-service business model is 100% availability of all individual data of a patient, not just medical records, but really all data, in order to deliver the best possible risk analysis to the customer. This depends on the willingness of individuals to support this "All-In-Data-Approach". I have worked in various international projects as an advisor on research into the acceptance of such a business model from the perspective of the user. In November 2015 I presented the results of my study, conducted while helping to build a new service for users for an industry partner I was working with, with a poster at the 2nd World Open Innovation Conference (WOIC) at Santa Clara/Silicon Valley (USA), which was organized by Prof. Chesbrough (Berkeley Haas School of Business, University of California, Berkeley). Titled "Users (Patients) willingness to transfer personal data to a future-IT-service of Open Innovation driven IT Health Care companies to receive an efficient service—a follow-up study", I would like to share it with you.

3.1 Introduction

It has been found that technology companies, also in the health care sector, use a limited open innovation approach (West 2003) to reduce costs in research and development, and to achieve higher profits (Chesbrough 2006). The integration of the public in research and development in health care is seen as essential for the advancement of innovation (Bullinger et al. 2012). Higher profits can only be achieved with new products and services for the market that are ahead of competitors

and meet user needs. Today this means mobile-Health (Estrin and Sim 2010) because by opening the m-Health architecture, the barriers to entry are lowered, and the development of new tools through participation of the community helps design of new m-Health apps.

These IT companies involve users and lead-users as innovators (Bogers et al. 2010) to develop new products and services. Lead-users, in particular, can help to create new products and services that are not on the radar of market research or internal innovation teams to achieve breakthroughs (Von Hippel et al. 1999). We present the high percentage of users (patients) willing to transfer their entire personal data, medical and non-medical, to a future IT service of an open innovation driven health care IT company in return for a better health care service.

3.2 Theoretical Background

In this chapter we analyze user (patient) willingness to transfer all data to a future IT service of an open innovation driven IT health care company to contribute radical innovation (Lettl et al. 2006). Although the open-innovation approach with users and lead-users has been very successful in the past under certain circumstances (Reichwald and Piller 2007; Baldwin and von Hippel 2011; Van de Vrande et al. 2009), the process of the open innovation architecture needs to be reconstructed, and there is still uncertainty as to whether the user (patient) will support a future IT service that collects not only medical data, but also non-medical data.

The results of this study can help entrepreneurs in the health care IT industry to prototype a future IT service based on an open innovation approach and to decide how open it can be (West 2003). For a holistic health care IT service approach, it helps to understand user requirements for the transfer of medical and non-medical data.

3.3 Research Design

This follow-up study is based on the first study presented in 2014. The first study analyzed user (patient) willingness to transfer medical data to an innovative health care app. This follow-up study analyzes willingness to transfer medical and non-medical data to an open innovation app in return for a better health care service.

3.4 First Study

Reporting on the first study on the willingness of users (patients) to transfer medical data to a health care app at the 12th Open and User Innovation (OUI) Conference at Harvard Business School (HBS) from July 28–30, 2014, we presented our view that there will be various future scenarios of interaction between the user (patient) and health care IT companies and their applications, as depicted in Fig. 1. The future

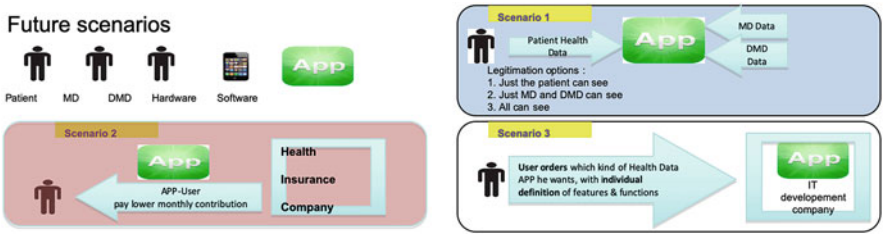

Fig. 1 Three future scenarios as presented at the 12th OUI Conference in July 2014. Source: author

scenarios and prototypes help to understand and involve the users and create new products and services (Kanto et al. 2014; Parmentier and Mangematin 2014; Steen et al. 2014):

First future scenario: The user (patient) decides if the medical and dental doctor may enter information into the app in addition to the patient himself and who is legitimated to view the data and the results of data input in dependence on the IT application. Second future scenario: The health care insurance company (or other service delivery companies in the health care industry) offer app users a lower monthly premium/price if they use the company's app. Third future scenario: The IT development company provides and the user orders which kind of health care data app he wants, with individual user definition of features and functions.

These three future scenarios and the results of the study on user (patient) willingness to open personal health data to an innovative app in return for a more efficient health care service were presented in July 2014. The material and methods were in that from January–December 2013, two groups of patients totaling 528 with a history of periodontal disease were interviewed in Germany in a multicenter study (four dental clinics). In the first group ($n = 244$), no user had a prior general disease (e.g. diabetes, coronary heart disease), while in the second ($n = 284$), they had a minimum of one general disease or more.

We found that 93% of the second group would significantly ($p < 0.02$) open their individual health care data to such an innovative app, allow the MD and DMD to enter certain medical parameters and would also enter information daily/weekly on, for example, how they feel, what they eat and if they still smoke. In the first group, 32% would open their individual health care data to such an innovative app.

3.5 Follow-Up Study

The first study merely determined the flow of health data from the patient, MD and DMD in interaction with software (app) and use of a mobile device. Following the very high rate of user (patient) willingness (93%) to open personal health data to an innovative app in return for a more efficient health care service in the first study, the next question was what would be the case if data collection were expanded to a

holistic approach. The holistic approach to deliver a better health care service to the user (patient) would need medical and non-medical data on the user. The influence of such a future user community and the potential results of the research data based on the future IT service could also help develop open innovation processes and future research in the open innovation field (Chesbrough and Bogers 2014).

Research Question We prototyped a future IT health care service that would be offered by an open innovation driven health care IT company. This IT product (service) would collect all the individual medical and non-medical data it could obtain with the permission of the individual and depending on electronics and sensor system technologies. The research question was whether the user would transfer all medical and non-medical data to a future IT service of an open innovation driven health care IT company. Would such a future IT service prototype meet the users' needs and lead to a high percentage of willingness to transfer all data to an open innovation driven health care company that offers this service?

Secondary Data We interviewed 821 patients in a multicenter study in Cologne and Bonn (four dental clinics and six medical practices) from February 2014–February 2015 and asked them about the importance of several factors. Of more than 2439 patients, just 821 met the inclusion criteria. These were: history of dental and medical illness in the past; age 20–75 years; at least one chronic medical disease (e.g. diabetes or coronary heart disease); experienced in using IT; and a positive attitude to IT services.

Data is defined in this study as all data that can be collected in a way that make sense for a holistic health care IT service approach: e.g. food, food preparation, weight, sport, health data and history, stress profile, genetic risks if test available, environment, sleep time and quality, regeneration profile, hygiene profile as well as sun exposition and protection. Connection of various electronic tools is required for this. We asked 67 directors of small and midsized technology companies in Germany and Belgium from the health care industry by e-mail for interviews. Just 17 answered and 8 accepted an interview.

Primary Data For this follow-up study, we chose a multicenter study in two steps. First, we applied a qualitative research method, in which we interviewed eight directors of small and midsized German and Belgian technology companies from the health care sector about their view of future scenarios of technological products and services for patients based on present or future technologies and concepts. At the same time, we interviewed 16 patients with a combined history of dental and medical illness about their expectations of such products in the future and their willingness to transfer their personal data to an open innovation driven health care company.

After clustering the interviews in three main sectors each on the industry and patient side, we designed a prototype IT model and presented it in step 2 of the study to patients who met the inclusion criteria of our study and asked them (quantitative

research method) questions with a standardized question paper, designed on the experiences of the interviews.

Data Analysis The interviews (step 1) were followed by writing the main subjects on paper. Later the main subjects of the interviews were coded. This coding helps to identify patterns and to develop a list of standards from the point of view of the industry and of the user.

The question paper for step 2 was based on the results of the interviews and covered the most important subjects that emerged from the interviews. Finally, the answers of the users to the standardized question paper were analyzed with the statistical software IBM SPSS 22.0.

3.6 Future Health Care IT Service Prototype Model

This future health care IT service prototype model included IT applications available at present in combination with sensor systems technology and electronics available at present. The combination concept, however, is currently not available and is a future technology approach. This future concept allows users (patients), as the legal owner of their data, to transfer all dental, medical and other data that they and the company define as relevant to the health care company (consulting need of the user) in return for an efficient health care service.

The open innovation process allows every single user to see anonymized data of other customers, to participate in research results based on an outcome of the common data pool of this specific user community and to interact directly with the company to communicate user wishes, which can be used to serve as an individualized evolutionary model in a very short time to meet user needs.

3.7 Findings

The results showed that the most important factor for users (patients) at 91.1% ($n = 748$) was the ability to influence the future IT service in health care through an open innovation process. The security of the IT data came second at 89.4% ($n = 734$), followed by the possibility to benefit from the scientific research results based on the data pool of the future IT service community at 86.6% ($n = 711$). If these three important standards of open innovation process, IT security and scientific results from the data pool of the community would be guaranteed, overall 87.8% ($n = 721$) of the patients would transfer their entire medical and non-medical data as mentioned above in return for an efficient service in health care.

3.8 Conclusions of the Study

The results of the study showed that patients fulfilling the inclusion criteria named three important factors as a necessary standard before they would transfer their medical and non-medical data: open innovation process which integrates the user and his thoughts, IT security and a benefit from the data pool (research results) of the users of this service. If these three standards are met, the empirical study showed clearly that there is a high user (patient) willingness to transfer personal medical and non-medical data to a future IT service of open innovation driven health care companies in return for an efficient health care service.

This chapter makes a contribution to what relevance the user is and his willingness to participate in the open innovation process (Von Hippel et al. 1999), what standards are expected in the open innovation process from the users' perspective (Chesbrough and Bogers 2014) and how far companies themselves have to open up in the open innovation process (West 2003) to succeed in the future health care services market.

4 Drone-Supported Emergency Concepts in Combination with Automotive Health Systems

One of the most vital factors when a person suffers a heart attack or stroke is how quickly a physician or qualified help can intervene. The new automotive health concepts and systems will implement and integrate health services, meaning companies like Audi or Bosch could combine their competencies in sensor systems technology and offer this additional service. Depending on where you have your heart attack, it could save your life. Usually the first 15–30 min after a heart attack decides on the prognosis of the patient surviving. This can be a very short time if you are driving in a rural area, where much time can be lost in communication, transportation and finally treatment.

First of all, therefore, sensors in the car must be able to detect a significant problem and interact with the driver if there is a need to start an emergency process or the user himself can call an emergency hotline. If the driver is unable to make the call himself because his condition is getting progressively worse, then the car sends the emergency signal. The big questions are what happens next:

1. Can the car interact with other cars to ask if there is a physician nearby, who could maybe come to help even if the physician has a day off and is not on duty?
2. Is a drone dispatched by a hospital with medical equipment, drugs and technology the fastest way of getting the package to where it is needed? The speed of the fastest drones is currently 200–300 mph. The advantage of a drone is that it can start immediately from the hospital or another place. A helicopter needs preparation time, the pilot must get to the helicopter, it must get starting permission and needs a certain take-off time. Landing zones for helicopters are

also limited. There are, therefore, many arguments speaking for use of drones in the whole process of patient rescue following a heart attack or stroke.

3. If there are individuals nearby or in the car who could help, should the car have drugs and medical equipment on board so that a physician could, via telemedicine, instruct the individuals on what to do until professional help arrives?

There is a combined approach of cars (autonomous driving, emergency status, sensor systems, new medical technology such as the "in-car stethoscope"), drones (speed, weight, autonomous flying), hospitals (telemedicine, drones), physicians, availability of patient data, legal requirements and digital health crisis management that could help save lives in the long run. Further, this kind of holistic approach needs 5G communication and powerful servers and computers, an infrastructure which could possibly be shared by a group of hospitals and car manufacturers.

It is also an option to let a drone land on a fast autonomous vehicle driving to a hospital so that the people in the vehicle with the person suffering a health crisis can help with first steps until arrival at the hospital. There are various new business models for use of drone technology in health care, also for delivery of medications and other health care items (Scott and Scott 2019) or to exchange lab samples as a service innovation for hospitals and clinics (Mion 2019).

5 Conclusions

For investors with venture capital or a mergers and acquisition strategy, it is clear that the health care market is one of the most interesting fields both at present and in the future. The health care market in the G20 countries is growing, people are getting older and the procedures for diagnosis and therapies are improving every year.

The car industry, the sensor systems technology industries, the drone industry, the high speed computer processor industry, the communications industry, BIG DATA companies and the software development sector will lead this future health care market, which will be completely different to anything we have known so far. Even if the big players of Big Data such as Apple, Amazon, Facebook and Microsoft do not seem so strong in this market at present, it is clear that they will also lead this market and maybe become the health care management deliverers of tomorrow.

Ideas such as self-driving hospital beds, companies that guarantee a certain health status if you go "all-in" with your data, and students who participate in contests to innovate health care are scenarios of the new horizons, which will be realized. The question is which countries and companies will dominate this health care market.

Further, it is necessary to consider that the domination of the health care market will have a long-term impact on the technology domination of space travel because, besides the transportation and construction problems, the main challenge in space will be how to keep our human species alive and healthy in this endless universe as we travel to new horizons with new environments that will test endlessly the biology

and mental fitness of humankind. The knowledge for the health care market on earth is the key factor for domination of research and travel in space.

It is not just about infection prevention during human space travel (Mermel 2012), alterations of sympathetic control by space travel (Eckberg 2003) or the mars colonization (Levchenko et al. 2019), it is also about the combination of collecting and analyzing tons of data at high speed on the technology side and healthy and innovative individuals on the human side. This means that without outstanding health care in space travel and planet colonization, there will be no long-term innovation.

Digitalization, transformation as well as technological and pharmaceutical innovations are already a big step for humankind to enable us to deal with the challenges and problems awaiting us in space and the colonization of planets. The health care market on earth today is a part of space travel tomorrow.

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