Disruptive Innovation in the Healthcare Sector – The Advent of AI Chatbots

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Title: Disruptive Innovation in the Healthcare Sector – The Advent of AI Chatbots

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Abstract:
Over the last several decades, the healthcare sector has faced many challenges. These include a shortage of doctors, especially in rural areas, high clinical costs, and an increasing number of diseases needing to be treated. This thesis focuses on the potential and the limitations of an innovative way to solve problems in healthcare – use of AI chatbots. We highlight the user's perspective concerning AI healthcare chatbot technology. Based on qualitative and quantitative research, we conclude that this novel technology offers new opportunities for diagnostics, enables work to be carried out more efficiently, and gives the patient the power to "self-diagnose". AI chatbots have not yet reached their full potential due to legal restrictions, insufficient data, and the lack of capacity to integrate them into different systems. Even though the number of AI chatbot users is increasing, people trust chatbots less than doctors. To enhance user engagement and create a higher level of trust, credible entities such as doctors and the government could recommend the use of AI chatbots. The general acceptance of chatbots has to be analyzed per country since it is explained by socio-economic factors (education, age, income), personality-related factors (attitude to new things, curiosity) and communication behavior factors.

Keywords: Artificial Intelligence in Medicine (AIM), Healthcare, AI, Chatbots, Diagnosis, eHealth, Self-care

Título: Inovação Perturbadora no Sector da Saúde - O Advento dos Bate-papos da IA

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Resumo

Nas últimas décadas, o setor da saúde enfrentou muitos desafios. Nestes podem destacar-se a escassez de médicos, especialmente nas zonas rurais, custos de tratamento elevados e um número crescente de doenças a precisarem de ser tratadas. Esta tese foca-se no potencial e nas limitações de uma forma revolucionária de resolver problemas na área da saúde – o uso de *chatbots* de IA. Destacamos a perspetiva do utilizador em relação à assistência médica através da tecnologia de *chatbot* de IA. Com base em pesquisas qualitativas e quantitativas, concluímos que esta tecnologia inovadora oferece novas oportunidades para diagnósticos, permite que o trabalho seja realizado com mais eficiência e oferece ao paciente a capacidade de se autodiagnosticar. Os *chatbots* de IA ainda não atingiram todo o seu potencial devido a restrições legais, dados insuficientes e à falta de capacidade de integrá-los em diferentes sistemas. Ainda que o número de utilizadores de *chatbot* de IA esteja a aumentar, as pessoas confiam menos nos *chatbots* do que nos médicos. Para encorajar um maior envolvimento do utilizador e criar um nível mais alto de confiança, entidades credíveis como médicos e o governo podem recomendar o uso de *chatbots* de IA. A aceitação generalizada dos *chatbots* deve ser analisada por país, uma vez que é explicada por fatores socioeconómicos (educação, idade, rendimento), fatores relacionados com a personalidade (atitude perante coisas novas, curiosidade) e fatores de comportamento na comunicação.

Palavras-chave:
Inteligência Artificial em Medicina, Cuidados de Saúde, IA, Chatbots, Diagnóstico, eHealth, Autocuidado

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Abbreviations

AI	Artificial Intelligence
AIM	Artificial Intelligence in Medicine
ANN	Artificial Neural Network
APP	Application
ASI	Artificial Super Intelligence
CAGR	Compound Annual Growth Rate
CDC	Center for Disease Control and Prevention
DL	Deep Learning
EHR	Electronic Health Record
ITU	International Telecommunication Union
ML	Machine Learning
R&D	Research and Development
WHO	World Health Organization
VBHC	Value-Based Health Care

1. Introduction

Artificial intelligence (AI), Big Data and 5G are revolutionizing the health care sector by allowing providers to diagnose diseases earlier and with greater accuracy enabling more effective disease management (Anwar & Prasad, 2018). The best doctors are able to function all over the world while remaining in one place, which results in better patient outcomes at lower costs – a phenomenon known as value-based healthcare (VBHC) (Clawson et al., 2014). Automation will become more critical as specific tasks become too complex to be carried out by professionals alone. In addition, a shortage of doctors in the world means that people's needs, especially in rural areas, are not being served (Goodyear-smith & Janes, 2008). There are now over 13,000 known diseases, 6,000 drugs and 4,000 medical procedures. This is way too much information for anyone professional to master (Susskind, R. & Susskind D., 2015).

In 2018, 27.9 million people in the US lacked health coverage and approximately 60% could not afford healthcare costs (Tolbert et al., 2019). Moreover, doctors are allocated less than 15 minutes per patient, and 49.2% of this time is spent entering electronic health records (EHR) (Sinsky et al., 2016). These facts highlight why the healthcare industry needs to change.

"We are facing a global crisis, due to the increased emergence of resistant bacterial pathogens that are rendering our current antibiotics arsenal ineffective. If we don't address the crisis by 2050, annual deaths due to antibiotic-resistant infections will grow to 10 million, higher than the death of cancer." (Collins, 2020)

The need for new forms of diagnostics and treatment can be solved by Big Data (Champagne et al., 2018). The US healthcare system alone generates approximately one trillion gigabytes of data annually. Artificial intelligence, in particular machine learning (ML), can generate insights both to improve the discovery of new therapeutics and make delivery of current ones more effective (Matheson, 2018; Segler et al., 2018).

By using the available data, a computer algorithm called Healthmap predicted the West African Ebola outbreak nine days before the World Health Organization (WHO) in 2014 (Topol, 2015). Similar to Healthmap, Google Flu Trends analyzing google searches helps track and predict the spread of the flu on a global level. By comparing current search terms to data searches from past flu outbreaks, the project can predict which areas of the world are likely to experience flu outbreaks at any particular time. Nevertheless, Google stopped the project in August 2015

(Google, 2015). AI has also been used to discover antibiotics effective against untreatable diseases, signaling an essential new tool in the global fight against drug resistance (Collins, 2020). In many cases, doctors are busy diagnosing simple diseases that could already be diagnosed by AIs (Anwar & Prasad, 2018).

As in other fields, standardization in medicine will decrease costs, is more time-efficient, and can be made available and reliably sourced for everyone through the internet. Moreover, standardization helps to prevent potential errors and encourages reuse of information by establishing and utilizing norms and protocols, thus making processes more efficient over time (Susskind & Susskind, 2015). There are still way too many mistakes made by doctors who misdiagnose diseases or make mistakes during surgery. This occurs for various reasons that include missing knowledge, being stressed, and other factors. The problem of the avoidable medical error burst into the news in 1999 when the Institute of Medicine published "To Err Is Human: Building a Safer Health System" highlighting an estimated 98,000 unnecessary deaths every year due to medical malpractice (Kohn et al., 1999).

Despite large interdisciplinary studies of the healthcare industry and the effectiveness of AI (Aboshiha et al., 2019; Chen et al., 2017; Chung & Park, 2019; Horn, 2001; Laumer et al., 2019), there is a remarkable lack of research on patients' perspectives of AI (Ekeland et al., 2010). Therefore, this thesis will examine areas in which the healthcare sector already uses AI, with specific chatbots, and will discuss both the potential and limitations of medical AI's. Moreover, we will research patients' perspectives on using AI.

This paper will concentrate on three major aspects of AI healthcare chatbots:

#1 – Can AI chatbots effectively replace any kind of medical doctor?

#2 – What are the limitations of AI chatbots in healthcare?

#3 – What are user perspectives when diagnosed by AI chatbots?

The goal is to answer the research questions by reviewing the existing literature and through empirical data collection. The data collection was a twofold process. Qualitative data addressed the potential of AI chatbots. Then, a quantitative survey focused on users' perspectives when being diagnosed by AI chatbots.

2. Literature Review

This introductory chapter examines literature relevant to the research questions and provides an overview of relevant background theory. First, we must look at the status quo regarding the treatment of patients and how this developed over time. We follow with definitions of AI and discuss its potential in the healthcare sector. Finally, highlighting the major accomplishments of AI chatbots in medicine, we take a more in-depth look at the ethical perspectives on AI in medicine.

2.1 The Shift of Power in the Treatment of Patients

2.1.1 Current Healthcare Sector Challenges

Healthcare internationally is challenged by the shortage of healthcare practitioners. To enhance workforce retention, especially in rural areas, numerous interventions are being applied but these are not particularly successful (Goodyear-smith & Janes, 2008). The result is not enough general practitioners and specialists, and patients required to wait for diagnoses and treatments. Further trends include increasing healthcare needs of an expanding geriatric population and new graduates wanting a better work-lifestyle balance (Goodyear-smith & Janes, 2008).

Doctors also have gaps in medical knowledge. Pointing this out, we can allude to Black Swan Theory. Orlik and Veldkamp developed the theory in 2005 to explain how we tend to ignore uncertainty shocks (tail events) that arise when an agent is not endowed with sufficient knowledge about the probability of these outlier events (Orlik & Veldkamp, 2014). This applies to the healthcare sector since doctors tend to diagnose only common diseases and ignore more rare or outlier examples (Denecke et al., 2018). In this case, tail events fall through the cracks leading to poor patient outcomes or even death. Knowing the morphologies, etiologies, etc., of every disease in the world and considering various possibilities would result in better diagnoses. However, this is not possible for any human and will never be. AI, on the other hand, is able to diagnose diseases faster and more accurately than any doctor (Aboshiha et al., 2019; Pacis et al., 2018; Steadman, 2013). Moreover, even the same disease can show different symptoms depending on personal health conditions, genome information and lifestyle and there can be severe side effects if treated wrongly (Chung & Park, 2019). According to Sloan-Kettering, only around 20% of the knowledge that doctors use when diagnosing patients and deciding on treatments relies on trial-based evidence. Doctors would need to read at least 160 hours a week just to keep up with new medical knowledge (Steadman, 2013).

Furthermore, physicians lack time and spend on average 15 mins talking with and examining patients. Additionally, 49.2% of that time is allocated to electronic health records (EHR) and doctors also spend 1-2 hours after-work on this each day (Sinsky et al., 2016). A survey in 2016 (Shanafelt et al., 2016) concluded that 84.5% of doctors already use EHR systems, and physicians felt dissatisfied with time spent on nonclinical tasks. They are also at higher risk of professional burnout. AI helps physicians by recording diagnoses, allowing doctors to focus on clinical activities instead of doing administrative work (Palanica et al., 2019). However, EHR systems are predominately designed to make billing more manageable, not to make clinical practice more efficient (Collier, 2017).

2.1.2 The Development of Patient Diagnosing and Treatment

Nowadays, the "doctor's orders" still have the final say in a patient's treatment. Patients don't determine their treatment themselves and most follow their doctor's orders without question (Topol, 2015). Developments and advances in sharing of information through the internet have enabled new ways of diagnosing and treating patients. In particular, smartphones and other web-connected devices allow greater access to medical information, overcoming geographical, temporal, and organizational barriers for healthcare services (Laumer et al., 2019). This access to medical information gives patients much more power to diagnose themselves (Topol, 2019). Moreover, transparency in healthcare quality and pricing has increased along with the growth of online healthcare service systems (e.g., iTriage.com, ZocDoc.com), the widespread use of social media and rising numbers of hospital ranking websites (Bisognano et al., 2008). Consequently, patients have become more demanding and conscious of the services they receive (Liu et al., 2018).

In many instances people today can avoid seeing a doctor face-to-face by getting a diagnosis or treatment, especially in mental health areas, via digital communication – telemedicine (Pacis et al., 2018). Telemedicine is the application of transferring medical information through interactive digital communication to perform consultations, medical examinations and procedures, and professional medical collaborations at a distance (Dinya & Tóth, 2013). The main objectives of telemedicine are to bridge gaps of accessibility and communication in the medical field, reducing delays, and cutting costs and simplifying logistics (Pacis et al., 2018). For example, SkinVision enables patients to send pictures of a skin lesions to doctors who can

then determine whether it is benign or not (SkinVision, 2020). The general effectiveness and scope of applications are well defined by Anne G. Ekeland et al (2010) (see Table 9: Effectiveness of telemedicine). Generally, there is evidence of high patient satisfaction for telerehabilitation, but reviewers argue that more process research, case studies and qualitative studies are needed to improve understanding of these outcomes (Kairy et al., 2009). At the same time, some reviews are less confident about telemedicine's effectiveness (see Table 10: Effectiveness of telemedicine), suggesting that it is promising or has potential but that more research needs to be conducted before it is possible to draw firm conclusions. A second emerging issue concerns patient satisfaction and claims that telemedicine changes the relationships between patients and doctors (Ekeland et al., 2010).

2.1.3. Chatbots – Unlocking Selfcare

Another way people empower themselves via self-diagnosis and treatment is by using chatbots. A chatbot (also known as talkbot, chatterbot, Bot, IMbot, interactive agent, or Artificial Conversational Entity) is a computer program that conducts an auditory or textual conversation (Divya et al., 2018). It can be said that chatbots using a programmed database without AI, are more like a dialogue-based interface (Fürst, 2019). These chatbots were mostly used until the 1990s, whereas nowadays most chatbot core technology consists of rich data-driven statistical models. These are self-learning chatbots (which began in the 2000s), using AI, and in particular machine learning (ML), to find the right answers through conversations with people (Vogt, 2020). Both, AI and ML will be discussed more in detail in the subsequent chapter.

ELIZA was one of the first chatbots, created in 1966, and capable of mimicking human behavior in conversations. After ELIZA, several chatbot systems were developed using different algorithms of pattern matching combined with intelligent phrasing, but still without understanding semantic complexities of a real human conversation (Shum et al., 2018). One of the most known successors of ELIZA is the chatbot PARRY, which was developed in 1975. It differed from ELIZA by having simple internal affective states – fear, anger and mistrust (Wang & Petrina, 2013). One of the main goals of chatbots is passing the Turing Test. Bots successfully pass the Turing Test when they cannot be distinguished from a human being in conversation (Turing, 1950). Another famous successor is ALICE (short for "artificial linguistic internet computer entity ") created in 2001. This bot was the first to use AI markup language (AIML) allowing users to customize their bot interactions (Shum et al., 2018). A

short overview of the major steps in the evolution of chatbots is shown in Table 1: Development of AI chatbots (Shum et al., 2018).

	ELIZA	PARRY	ALICE	DARPA	SIRI	Xiaoice
Time	1966	1972	1995	2000	2011	2014
Scalability	None	None	Scripts can be customized	Limited	Scalable	Scalable
Key feature	Mimicking human behavior in conversation	Generating emotional (angry) responses	Easy customization of scripts	Language understanding and dialog management	Providing personal digital assistance	Building emotional attachment to users; scalable skill set for user assistance
Accomplishments	First chitchat bot	Passed Turing test	Won the Loebner Prize three times	Understand natural language requests and performing tasks	The first widely deployed intelligent personal assistant (IPA)	The first widely deployed social chatbot. 100MM users; published poem book
Modality	Text only	Text only	Text only	Text and voice	Text and voice	Text, Voice, Image
Modeling	Rule-based	Rule-based	Rule-based	Learning-based	Learning-based	Learning-based
Domain	Constrained domain	Constrained domain	Constrained domain	Constrained domain	Open domain	Open domain
Key technical breakthrough	Use of scripts, keyword-based pattern matching; rule-based response	Adding personality characteristics into responses	Using AIML and recursion for pattern matching; multiple patterns can be mapped into same response	Statistical models for spoken language understanding and dialog management	Provide both reactive assistance covering a wide range of domains	Emotional intelligence models for establishing emotional attachments with users
Key technical limitation	Limited domain of knowledge	Limited domain of knowledge	Size of script can be huge	Work only in domains that have well-defined schemas	Lack of emotional engagement with users	Inconsistent personality and responses in long dialogue

Table 1: Temporal Development of AI Chatbots (Shum et al., 2018)

Telemedicine and AI chatbots are still controversial. This relates to various factors including the placebo effect which skews many studies concerning efficacy of drugs or treatment protocols (Ekeland et al., 2010; Meissner et al., 2013; Wampold et al., 2005). Wampold et al. (2005) stated that well-designed psychotherapy placebos can approach the same treatment effect as actual treatments. Therefore, we need to question the effectiveness of telemedicine and AI chatbots if simply seeing a doctor face-to-face might be enough to induce patient recovery from illnesses.

2.2 Artificial intelligence in the healthcare sector

Recent advances in technology for data processing and analytics have radically changed the healthcare industry, giving rise to digital healthcare solutions and promising to transform the whole healthcare process by making it more efficient, less expensive and higher quality (Amato et al., 2017). At the present time, daily routine check-ups and diagnoses can already be effectively performed by AIs (Horn, 2001).

2.2.1 Artificial Intelligence

AI and machine learning are terms used in various domains today. Companies use these terms as a means of marketing themselves as being cutting-edge, often without even implementing these technologies at all (Kaushal et al., 2019). The Oxford Dictionary defines AI as "the theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages." (Oxford Dictionary, 2020) While the term AI is often used in a broader sense to refer to technology, it should not be mixed up with traditional business intelligence or business analytics, even though these also rely on structured data and apply classical statistics such as correlations, regressions, etc., to produce insights for business. In fact, AI harnesses diverse and unstructured data sets and employs methods such as neural networks to adapt and learn (Aboshiha et al., 2019).

On the other hand, machine learning represents a subfield of AI in which algorithms learn from data, with or without explicit guidance, to improve predictions of data (Champagne et al., 2018). In contrast to conventional programming where a computer is given explicit instructions, ML facilitates computer's learning instructions implicitly by providing data from which it can extrapolate cues. Learning methods or algorithms extract statistical regularities from data, which they represent in the form of models. These models can react to new, previously unseen data by categorizing it, predicting it, or generating suggestions. Known models are decision trees, regression curves, cluster centers, or artificial neural networks (ANNs) (Hecker et al., 2017).

In addition, there is deep learning (DL) which is a form of machine learning that uses multiple layers of neural networks with large quantities of data to optimize a host of algorithms for performing a specific task. ML has great potential for therapeutic development and healthcare, ranging from discovery to diagnosis to decision making (Champagne et al., 2018) and even talking to patients (Kaushal et al., 2019).

All these statistical techniques depend on the quality of data available to generate findings. Poor-quality data will not yield meaningful insights and no analytical method can overcome shortfalls in data representativeness even though ML is sometimes associated with the expectation that it may overcome these shortfalls (Champagne et al., 2018). Futurist Ray

Kurzweil speaks of singularity, a concept from John von Neumann in the 1950s where computers become smarter than humans (Kurzweil, 2005).

To prevent misunderstandings regarding AI, it is important to define its limits. John Searle proposed the distinction between weak and strong “general” AI four decades ago (Ramge, 2018). According to Searle, weak AI entails recognizing patterns within existing records combined with the ability to give defined commands or responses, mainly used in chatbots. Weak AI is a mathematical function, which tries to find the most probable output for a given input. Even though the human brain inspires this procedure, it cannot replace it at this point (Hecker et al., 2017; Ramge, 2018).

On the other hand, strong AI describes machines performing various tasks independently, making decisions, emulating human intelligence, and achieving broader cognitive performance analogous to how human minds work (Hecker et al., 2017). However, the emergence of artificial general intelligence or strong AI is unlikely to occur anytime soon (Hecker et al., 2017), since many processes of the human brain cannot be reproduced digitally (Hecker et al., 2017; Ramge, 2018). The main unresolved obstacle entails unclear or insufficient defined objectives, where it is not apparent what goals the algorithm should optimize. To date, a significant hurdle for AI is to deal with vaguely defined unrestricted inputs, as in the case of autonomous driving, common sense reasoning, and real natural language processing.

The prerequisite for any advanced chatbot is the ML algorithm, which collects and processes incoming data. But even if this prerequisite is properly fulfilled, there will always be the probable event of an error occurring in the ML system. Consequently, ongoing technical maintenance is required. To exploit the full potential of ML, the algorithm must be constantly renewed and improved, so the ML "product" is never complete (Hecker et al., 2017). Then there is the challenge of having adequate data and especially data that encompasses a wide range of knowledge to guarantee the best possible chatbot ML outcomes. Data of inferior quality is less likely to be processed meaningfully by the algorithm and therefore less useful for ML. High-quality data is consistent, accurate, and free of redundancies (Géron, 2019). Finally, a limited knowledge database has the disadvantage that it must always be trained, updated, and double-checked. An open-ended knowledge base, such as the internet, presents the danger of the chatbot acquiring false information.

2.2.2 Industry Structure & Market Potential - AIM

In healthcare, AI can range from simple to complex tasks, and include everything from answering the phone to medical record review, population health trending and analytics, therapeutic drug and device design, reading radiology images and making clinical diagnoses and treatment plans (Kaushal et al., 2019).

First, to define and understand AIM, we must analyze its structure. By using Porter's Five Forces framework (2008) and combining his findings with the work of Danemo (2018), we can illustrate the AI healthcare industry as follows:

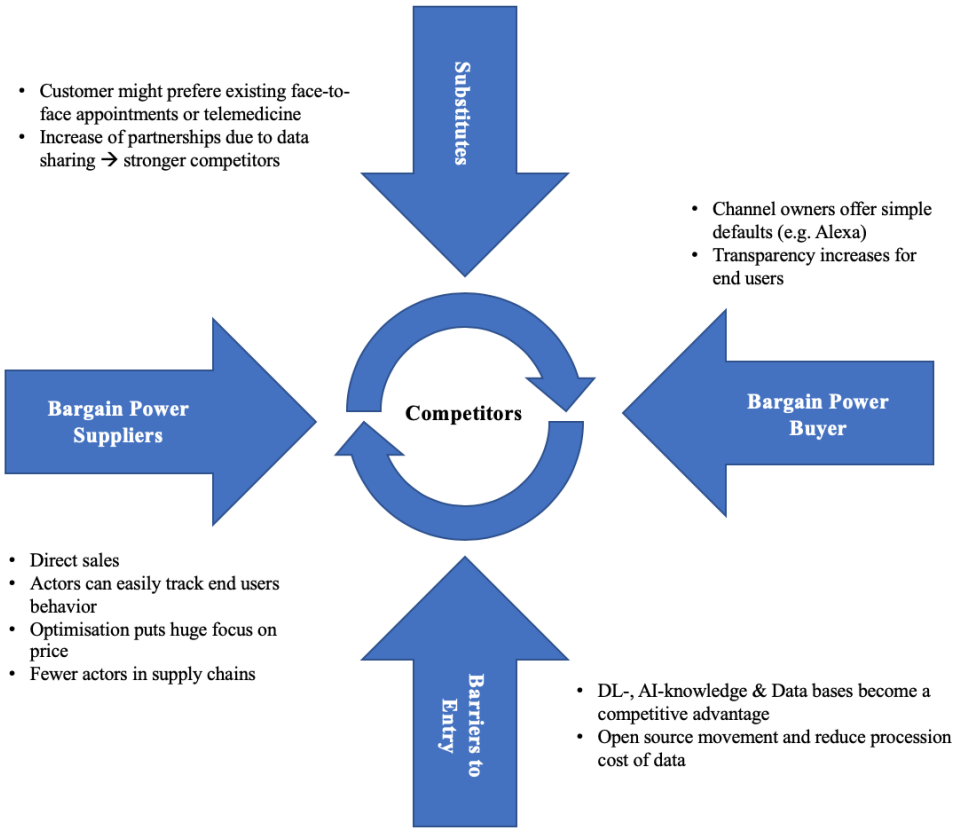

Figure 1: Porter's 5 Forces for AIM (Danemo, 2018; Porter, 2008)

AI empowers end users to diagnose and treat themselves which, in turn, provides greater transparency (Topol, 2019). Moreover, customers can use their existing devices such as smartphones, tablets, smartwatches and digital voice assistants as platforms for implementing new AI driven healthcare applications (Danemo, 2018). This is why switching costs are relatively low in this sector. Using subscription models for AI applications, on the other hand, suppliers could create switching costs (Danemo, 2018).

The open-source movement and data collection in general plays a big role in AIM (Divya et al., 2018). A well-structured and rich database can now function as a competitive advantage as well as bringing about DL and AI knowledge (Hecker et al., 2017). This reduces procession cost of the data. It may also increase partnerships due to data sharing as Kumar et al. (2017) proposed and therefore create stronger competitors (Ziegler et al., 2019). Another threat from substitutes is represented by the existing alternatives to AI applications such as face-to-face diagnoses and telemedicine. Suppliers can use direct sales channels, have fewer actors in their supply chain and efficiently track the customers behavior. Therefore, AIM focuses on pricing and availability (Danemo, 2018).

AI will provide new opportunities for technology companies to stake out major positions in the traditional healthcare landscape. Already, players such as Alphabet, Amazon, IBM and Alibaba are making significant investments in the healthcare space (Park, 2019). These companies are developing AI-driven products and solutions across all four healthcare sectors, including clinical decision support for providers, diagnosis tools that medtech companies can embed in their products, population health management for payers and target identification for biopharma. Simultaneously, smaller technology players are emerging, creating innovative AI-focused healthcare solutions (Aboshiha et al., 2019). Atomwise, for example, is developing AI-enabled drug discovery approaches and Zebra is building software for automated analysis of diagnostic imaging.

Report Ocean predicted that the global AIM market is expected to grow at a substantial CAGR of 49.6% during the forecast period 2018-2025. The market was valued at $719 million in the year 2017 and is expected to reach $18,119 million by the year 2025 (MarketWatch, 2020). Goldman Sachs estimates that the use of AI tools in medicine could save roughly $200 billion annually in the US alone. Given this potential, BCG expects that by 2022 the health care industry will spend roughly $2.1 billion annually on AI tools in remote prevention and care (Aboshiha et al., 2019).

AI will not only cause shifts in healthcare value chains but will also affect players traditionally outside the industry as well consumers. When looking at the four different major constituencies -- Providers, Payers, Biopharma and Medtech -- Biopharma is a clear immediate beneficiary thanks to AI-driven efficiency improvements in R&D and manufacturing (Aboshiha et al.,

2019). Moreover, diagnostic and treatment selection algorithms will improve outcomes and reduce waste. Providers will therefore retain some quantum of improved efficiency through fewer hospital readmissions and lower hospital overhead costs. As in the other sectors, AI will yield major efficiencies in claims handling and other operations, including improved fraud detection, waste reduction, and recognition of abuse. Finally, AI will improve overall medtech efficiency, including within supply chains and marketing and sales operations. On the downside, technology companies will increasingly offer competing products and solutions that potential confuse the medtech landscape (Aboshiha et al., 2019).

2.2.3 Use cases of AI in Medicine

In the health care industry, ML is a fast-growing trend given the vast amounts of data coming in from various sources (e.g., R&D, physicians and clinics, non-physician clinical workers, wearables, patients, etc.) (Hoermann et al., 2017). While wearable devices have been available in various forms, the more recent popularity and complexity of wearable devices like smart watches and exercise trackers has resulted in much larger sets of real-time personal health data that can be tracked and assessed (Pacis et al., 2018). The current problem is that all of these sources of healthcare information cannot easily be reconciled into one central hub. ML can help find ways to effectively collect and analyze this data for more effective prevention of illness and better treatment of individuals (Kaushal et al., 2019).

Mobile technology will further decrease the need for hospitals. Remote monitoring, conference calling and smart pillboxes that track medication use will enable people to monitor their health from the comfort of their homes. The Montefiore Medical Center in New York, for example, has eleven floors, twelve operating rooms and no beds, because no one needs to stay there overnight (Topol, 2015). Lunit is developing a diagnostic system for lung diseases and breast cancer using AI image-recognition technology for chest and breast X-rays. The system, which is based on a deep-learning algorithm, is able to check chest X-rays and mammographic images, make a diagnosis, detect the position, size, transformed cells, and specific tissues of a tumor, which are very difficult to observe using the naked eye (Chung & Park, 2019). IBM's Watson even states that it is better at diagnosing cancer than human doctors (Steadman, 2013).

In fact, wide-ranging feasibility and acceptability studies show that current technologies are not limited to Web-based synchronous text-based interventions as substitutes for face-to-face

interactions. In fact, most studies show the use of at least one additional technological element to support or augment human interventions (Hoermann et al., 2017). “If you need to be right before you move, you will never win. Perfection is the enemy of the good when it comes to emergency management - speed trumps perfection.” (W.H.O. Executive Director, Dr. Michael Ryan, Corona Conference Geneva, 2020) Dr. Ryan was speaking during a briefing about COVID-19. However, what if speed and perfection could be combined using AI? If there were a well-structured database to find drug therapies, speed would no longer be an impediment.

2.3 Chatbots in the Healthcare Sector

Chatbots provide a new avenue for overcoming problems in the healthcare sector, while also being a scalable solution (Robinson et al., 2017). They can be viewed as a disruptive innovation (Christensen, 1997) and also fit the rubric of Schumpeter’s theory of creative destruction across business cycles. Schumpeter also suggests that employees with "Unternehmergeist" (entrepreneurial spirit) are indispensable for long cycle value creation through innovation (Schumpeter, 1942). The real challenge is the process of integrating new technologies themselves, described by Raynor as the strategy paradox (Raynor, 2007). The literature on chatbots tends to focus on the advantages and disadvantages of chatbots per se, while often ignoring the key matter of customer perspectives when being diagnosed by chatbots.

Many chatbots help patients with symptom-based diagnoses, allowing patients to receive instant feedback regarding general health questions (Furness, 2016). Chatbots can learn from previous interactions to increase the accuracy of disease recognition. The vision is for chatbots to be cheaper and more rapid than consulting a medical professional (Topol, 2019). Early experiences with this technology began around 2014 and are currently expanding with great interest from both the medical and the computing communities (Pereira & Díaz, 2019). Chatbots bring several benefits, such as scalability, anonymity, asynchronicity, personalization, authentication and consumability (Klopfenstein et al., 2017).

First, chatbots provide users with immediacy (prompt answers) and asynchronicity (notifications and reminders). When combined with social platforms, chatbots offer a powerful tool, not only to reach but also to engage with patients regarding illness prevention and care (Klopfenstein et al., 2017). In some cases, chatbots need to be readily consumable, for example when drug cravings appear in addiction treatment. Regarding consumability, chatbots

outperform previous technologies in multiple ways including: installation (it is easy to add the chatbot to the list of contacts), platform independence (Android, iOS, Linux) and learning (Abashev et al., 2017). When it comes to sensitive healthcare issues, the possibility of interacting anonymously is also positive. Patients feel less shame and are more open when interacting with computers, showing positive sentiment overall towards the chatbot which is perceived as being more private and anonymous compared with speaking to a doctor (Fogg, 2002).

The process of verifying patients' identities can be facilitated through built-in smartphone mechanisms (Madhu et al., 2017). Chatbots can be secured using many of the same security strategies used for other mobile technologies: login credentials or two-factor authentications (Klopfenstein et al., 2017). Meeting patients' idiosyncrasies more effectively yields increasing user satisfaction which leads to better treatment engagement. Smartphone sensors are a transparent mechanism to collect patients' behavior, which can later feed AI algorithms (Klopfenstein et al., 2017). Chatbots also have the potential to target large audiences cost-effectively and are therefore highly scalable (Klopfenstein et al., 2017).

Awareness and tracking of bad habits are certainly the first steps for changing behavior. Chatbots can benefit from external data capture through a wealth-sensor infrastructure: blood pressure, stress level, weight or amount of physical activity can all be monitored to encourage healthy behavior (Jungmann et al., 2019). Chatbots do not stop at tracking and informing patients. They can go a step further by influencing behaviors. Chatbots can help through reminders, gamification or removing potential barriers (Amato et al., 2017).

Chatbots can further play a role in empowering users by educating them to understand the implications of health conditions (Klopfenstein et al., 2017). Empathy, understanding, acknowledging people's emotional states, etc., are essential for sustained patient involvement. Combining personality and emotional aspects in dialogues, such as introducing social dialogues like small talk, can improve patients' satisfaction and engagement with the bot (Griol & Molina, 2015).

"The future of healthcare lies in a much more patient-centric model where individuals have actionable insights at their fingertips, and doctors and artificial intelligence work together to support patients throughout their healthcare journey," said Daniel Nathrath in 2017, CEO of

Ada Health. Ada is an AI based chatbot which tracks symptoms and conditions and is easily accessible via a smartphone APP. According to Ada, the chatbot is used every 3 seconds to diagnose symptoms and has already received over 40 € million of funding (Gruenderszene, 2017).

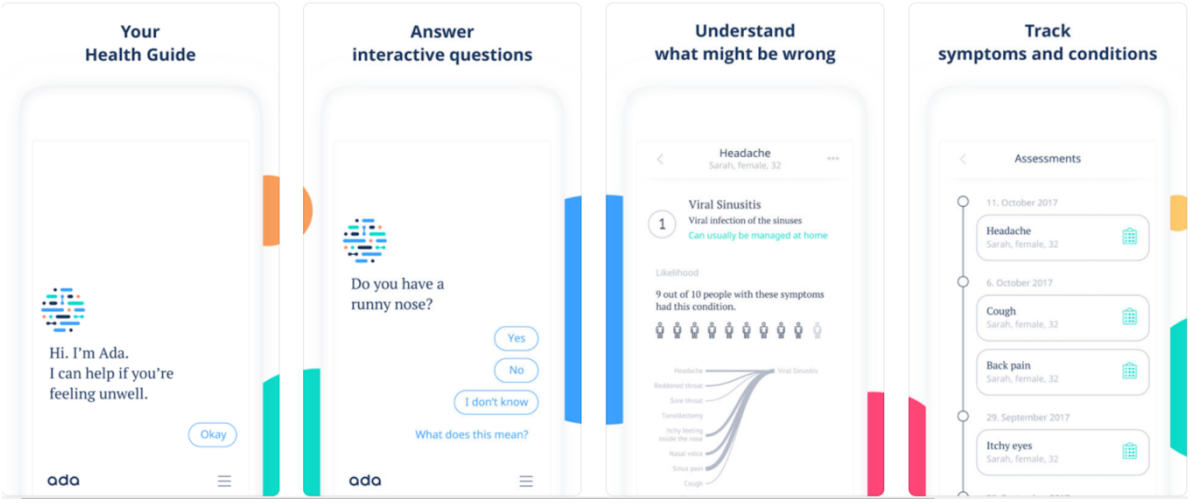

Figure 2: Ada Health - Smartphone Application (Ada Health, 2020)

Companies like Ada Health are hoping that AI will offer significant improvements over merely googling symptoms or decision-tree-based symptom checkers like WebMD (Jungmann et al., 2019). Ada can now identify over 1,500 clinical pictures and 200 rare diseases (AdaHealth, 2020). Since legal requirements have so far forbidden definitive remote diagnoses by apps, Ada currently only offers a suggestion, in which case physicians should be consulted (Laumer et al., 2019). The goal is not to replace doctors, but rather to provide a more robust first step on the healthcare journey (Laumer et al., 2019).

The vast majority of already successful chatbots in the healthcare sector are displayed in Figure 3 (Appendix) – (there are for mental-physical-wellness, language disorders, neurological disorders, addictions, rare diseases, cardiovascular-disorders, sexually transmitted diseases, nutritional-metabolic-disorders) (Pereira & Díaz, 2019).

2.4 Ethical & Cultural Perspectives on AIM

Medicine has become less humane with disastrous effects. The doctor-patient relationship is broken since doctors are often too distracted or overwhelmed to truly connect with their patients (Amato et al., 2017). In *Deep Medicine* (2019), Eric Topol, a leading physician,

reveals how AI can help. AI has the potential to transform a doctor's work environment away from notetaking and medical scans and towards diagnoses and treatment, which will result in significantly cutting costs in medicine and improving human mortality (Topol, 2019).

Nevertheless, we have to consider ethical perspectives when implementing AI since algorithms may also mirror human biases in decision making (Char et al., 2018). There are, therefore, both positive and negative aspects of implementing AIM. Gender biases are a problem in the medical field as well. For example, women are frequently left out of medical trials (Criado Perez, 2019). According Criado Perez (2019) and Olson (2017), women's bodies were seen as too complex and costly, and hormonal changes made them "inconvenient subjects".

Medical students still recite the Hippocratic Oath, which states that only people who have sworn to do no harm should be entrusted with medical knowledge. Other standards echo this sentiment, such as the American Medical Association's Code of Ethics which states that doctors may treat patients only with their consent (Topol, 2015).

Two widely used smartphone APPs, AliPay and WeChat, have replaced cash in China. They allow the government to keep track of people's movements and even stop people with confirmed infections from traveling (Kupferschmidt & Cohen, 2020). Being transparent and providing health data to the healthcare industry is a double-edged sword with respect to privacy concerns and human rights. So, while AI potentially provides more personalized treatments, on the other hand insurance companies may use this data to charge higher fees for preexisting conditions or predispositions to certain illnesses (Lamberton et al., 2017). An intrusive level of surveillance allowed China to keep track of the spread of COVID-19, tracking new infections and people's every movement in a totalitarian manner.

Trust in the provider plays a decisive role when it comes to AI, determining whether customers use the chatbot or not. In Laumer's et al. (2019) interviews, the authors identified that trust was frequently mentioned in addition to other acceptance factors such as privacy, risk and performance (Laumer et al., 2019). "Chatbots are a non-judgmental way to find help and provide personal, trackable, scalable conversations and insights directly from the target audience." (Saba Khalid, Co-founder, Raaji, October 2018, ITU News)

It is critical that AIs do not obscure the human face of medicine, though the biggest impediment to AI's widespread adoption is public hesitation to embrace an increasingly controversial technology (Buch et al., 2018). For artificial intelligence to successfully establish itself, it needs both extensive and well-structured databases (Wang & Petrina, 2013) along with acceptance by patients who are willing to share health data (Jungmann et al., 2019). Furthermore, cultural, political as well as ethnic differences relating to acceptance of digital solutions are relevant. National differences are displayed in the following study conducted by Bertelsmann Stiftung.

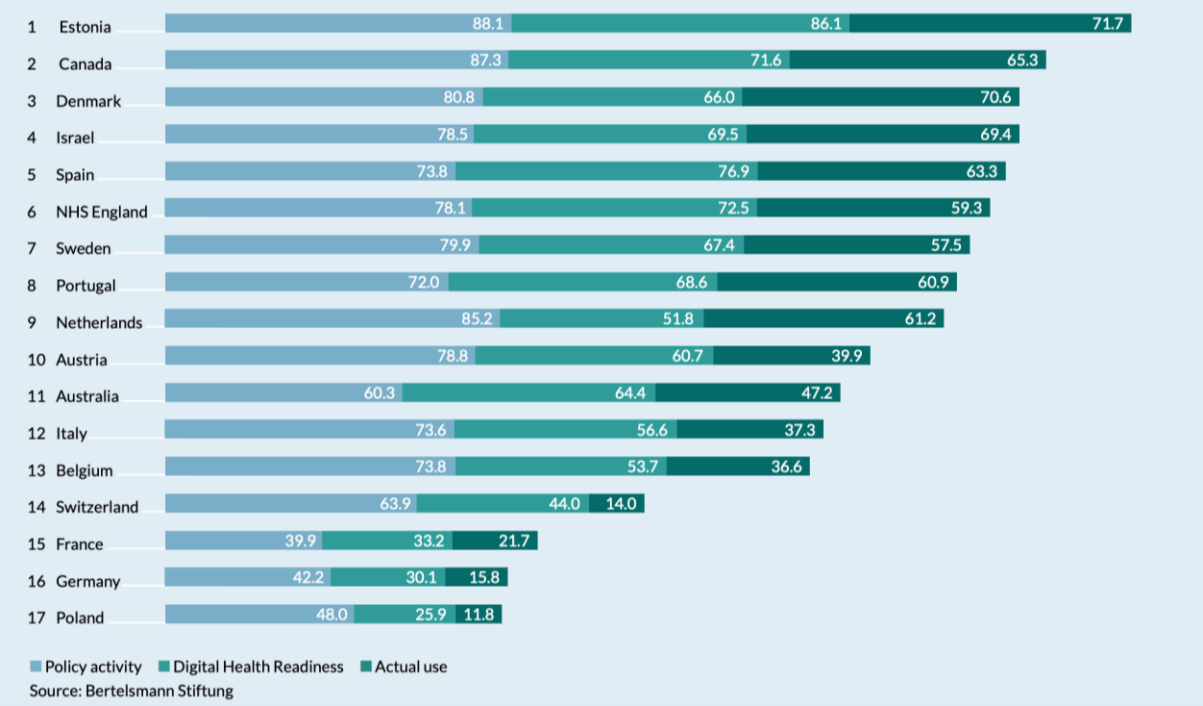

Figure 3: Digital Health Index as the sum of sub-indices, per country (Thiel et al., 2018)

The study shows that the differences even within Europe are tremendous and therefore affect the way new technologies such as AI gain traction. Estonia leads the Digital Health Index with 82.4 points, well ahead of all other countries. Digitalization there was a political process that began in the 1990s and has affected all areas of the public administration and state apparatus, including the healthcare system. Other countries are hindering AI from developing to its full potential due to regulations and personal attitudes (Thiel et al., 2018).

3. Methodology

The purpose of this section is to explain the research strategy in this work, research design and the rationale behind the chosen methodology. In addition, this section details how data were collected and analyzed, and finally the reliability and validity are discussed.

This dissertation's methodological approach includes a mixed-method, employing qualitative and quantitative research to respond to the posed research questions. According to Molina-Azorin, Bergh, Corley & Ketchen (2017) the mixed method approach enables a more integrated comprehension of intricate research subjects. Edmondson & McManus (2007) in addition claimed, that a mixed approach can enhance the understanding of present mechanisms of quantitative findings for mostly undeveloped fields of research. After analyzing the primary data, the secondary data collection of the literature review will serve as a means to further interpret the findings. Aside from secondary data gathered for the literature review, other reports and sources were collected and consolidated on an as-needed basis throughout the analysis chapter (Malhotra, 2010).

3.1 Qualitative Interviews

In this study, we used semi-structured expert interviews as it provides a vast range of advantages such as: allowing the informant the freedom and therefore flexibility to express their views in their own terms, having a better response rate than mailed questions and giving the interviewer the analyze non-verbal behavior (Cachia & Millward, 2011; Laumer et al., 2019). The definition of an expert in this research was evaluated by the first questions of the interview:" *How long have you been working with AI related topics and in specific AI in the healthcare industry?"* Due to the relatively immature and emerging field (see interview with Matteo Berlucchi (CEO of Your.MD): "We started this project with the idea of AI in the spring of 2015… when you look at the history, we were the first. We built the first AI Chatbot…" we defined an expert as a person who has been working with AI chatbots for at least two years. We interviewed not only experts specializing in AI chatbots in healthcare but also people in AI chatbots in general to get a broader overview of the limits and the potential of AI chatbots.

The following table illustrates the experts who were interviewed for purposes of this research:

#	Name	Expertise
1	Matteo Berlucchi	Chief Executive Officer & Founder at Your.MD
2	Thiago Marafon	Chief Technology Officer & Co-Founder at Youper
3	Marc Iops	Chief Revenue Officer at Onlim
4	Nicola Vona	Director of AI Strategy at Ada Health
5	Vanessa Lemarié	Lead Rare Diseases / Business Development Life Science at Ada Health
6	Dr. Dhini Nasution	Medical Doctor & Clinical AI Researcher at Babylon Health
7	Johannes Schröder	Vice President of Product and former CTO at Ada Health

Figure 4: Table of Expert Interviews

The main goal of the expert interviews was to get primary data that highlights the limits and potential of AI chatbots within the healthcare sector. We first started with a generic question with regard to work experience and when subjects first came across AI in healthcare. The potential of the technology was discussed by asking if there were any kind of doctors who could be effectively substituted by AI chatbots. This was followed by interviewees personal assessment of what might be possible in the future. We then discussed limits and therefore also the current challenges AI chatbots are facing. Even though the survey focused on user perspectives, we asked the experts for their opinion on the current level of trust people exhibit when using AI chatbot systems.

All interviewees work in healthcare and two also founded leading companies (Ada Health, Your.MD & Babylon Health) in the AI chatbot healthcare industry. To round this up, we also interviewed Dr. Dhini Nasution who is a medical doctor and specializes in clinical AI research. For a broader look at the limitations and the potential, we interviewed Marc Iops, ´Chief Revenue Officer at Onlim, a specialist in AI chatbots' customer service.

A detailed version of the interviews is displayed in the Appendix (Interviews).

3.2 Quantitative Survey

A quantitative survey was conducted with regard to research question #3 and to gain insights into users' perspectives on AI chatbots in healthcare. This survey focused on people who have already been using AI chatbots for diagnoses along with potential future users. The reason for including not only existing users in the sample was to get a broader and unbiased overview of what people feel about interacting with healthcare chatbots. Public acceptance and trust in systems like AI chatbots determine their success. Consequently, data about customer expectations and experiences are relevant. Therefore, we defined a clear goal and posed questions accordingly. The survey began with a general question if the participant had ever googled his/her symptoms and how satisfied he or she was with the result to determine a general digital health index. Subsequent questions posed were see whether people trusted AI chatbots along with how much they trusted doctors' assessments in general.

4. Findings and Limitations

The following chapter summarizes and discusses the main findings. Then managerial implications are discussed in addition to research limitations and recommendations for future research. Finally, there is a concluding statement.

4.1 Findings & Empirical Results

4.1.1 Interviews: Potential and Limits of AI Chatbots in Healthcare

The following table summarizes the main findings for each question posed in the semi-conducted interviews. The questions sought to gain better understanding of current limitations and the potential of AI chatbots in the healthcare sector. A more detailed version of the interviews is displayed in the Appendix (Interviews).

Question	Key Finding	Respondent
Have AI chatbots the potential to effectively substitute any kind of medical doctors?	Yes • In the long term chatbots replace them – it's inevitable • Radiologists & pathologists might be substituted No • In fact, they will make doctors more efficient. Moreover, it is not the goal to substitute doctors, not even in the long term. • For now, they are not able to replace them but have the potential	• (2) • (6) • (1) | (4) | (5) | (7) • (2)
(1) Matteo Berlucchi, (2) Thiago Marafon, (3) Marc Iops, (4) Nicola Vona, (5) Vanessa Lemarié, (6) Dr. Dhini Nasution, (7) Johannes Schröder		

Table 2: Interview Question #1

The first question dealt with the potential of AI chatbots effectively to displace medical doctors. The majority (1,4,5,7) stated that AI chatbots will not substitute any kind of medical doctor but make them more efficient. The interviewees explicitly stated that the goal is "not to replace doctors, but rather to work with them and, therefore, focus more on actual diagnoses and treatment." (Vanessa Lemarié, 30.04.2020) On the other hand, Thiago Marafon was certain that in the long term chatbots were going to replace doctors, but for now they are not able to replace them. Nevertheless, the potential is there and in the long term it is inevitable (2). Dr. Dhini Nasution expressed the probability that AI chatbots could effectively be a substitute for doctors who don't need physical contact with patients such as radiologists and pathologists.

Question	Key Finding	Respondent
What is / will be possible with AI chatbot in healthcare?	Is possible: • Giving a suggestion what you should do and what you might have • A qualitative initial assessment which is comparable to a human on the phone • Can find patterns on image and data and predict outcomes • Higher diagnose quality when doctors are combined with AI systems • Supporting the doctor with administrative tasks Will / might be: • Giving prescriptions to patients • Better understanding of what the patients say • Has great potential and has not yet reached its limits • A general system that integrates different applications (text and image recognition) • Technologically not much more potential with alogorithms	 • (1) | (4) • (1) | (4) • (1) | (2) | (5) | (7) • (1) | (5) | (6) • (1) | (4) | (5) • (1) • (1) | (2) • (1) | (2) | (3) | (4) | (5) | (6) | (7) • (4) | (5) | (7) • (7)
(1) Matteo Berlucchi, (2) Thiago Marafon, (3) Marc Iops, (4) Nicola Vona, (5) Vanessa Lemarié, (6) Dr. Dhini Nasution, (7) Johannes Schröder		

Table 3: Interview Question #2

The second question tackled the state of the art of chatbots along with their future potential. AI chatbots already offer initial assessments of users' symptoms by analyzing data provided in the form of text as well as pictures (1,2,5,7). They are able to support doctors in administrative tasks and allow examinations to occur that are comparable to those of a human on the phone via telemedicine.

All the interviewees were certain that AI chatbots in medicine possess great potential which has not yet reached its limits (1-7). AI chatbots could also give out prescriptions in the near future when regulations allow for this (1). When more people begin using AI chatbots and chatbots are permitted to use and store data, this will enable them to have a better understanding of patients (1,2). Regarding the algorithms chatbots are using, J. Schröder stated that technologically there is not much by way of greater potential to be gained since most algorithms are already developed (7).

Question	Key Finding	Respondent
In which ways are AI chatbots limited?	• No face-to-face interaction (seeing things that the chatbot does not know) • Chatbots cannot reason and therefore cannot replace a therapist • Cannot teach itself everything without human interaction – supervised learning • Only as good as it's database (need for regular updates) • Depends on the correctness of the information of the patients	• (1) | (4) • (2) • (3) • (3) | (5) | (6) | (7) • (4) | (6) | (7)
(1) Matteo Berlucchi, (2) Thiago Marafon, (3) Marc Iops, (4) Nicola Vona, (5) Vanessa Lemarié, (6) Dr. Dhini Nasution, (7) Johannes Schröder		

Table 4: Interview Question #3

Question #3 discussed the limitations of chatbots. The majority (3,5,6,7,) pointed out that chatbots strongly depend on their databases and need frequent updates or a database that updates itself. Biases in databases will persist through further interactions with the chatbots. Chatbots do not engage in human face-to-face interactions so they need to ask more questions, something that takes less time with a physical assessment (1,4). Also related to the potential of

chatbots to substitute for medical professionals, one respondent said they cannot replace the skills of a therapist (2). Chatbots were also held to depend on the correctness and accuracy of patient information (4,6,7).

Question	Key Finding	Respondent
Do you think there is a type of placebo effect when using a chatbot?	• Depends on the level of trust • Has the same placebo effect as seeing a doctor • Might have a similar effect even though the effect might be stronger when seeing a doctor	• (1) | (6) | (7) • (2) • (4) | (6)
(1) Matteo Berlucchi, (2) Thiago Marafon, (3) Marc Iops, (4) Nicola Vona, (5) Vanessa Lemarié, (6) Dr. Dhini Nasution, (7) Johannes Schröder		

Table 5: Interview Question #4

The interviewees had differing opinions on whether there might be a type of placebo effect associated with chatbots. Some interviewees stated that this depends on the level of trust (1,6,7). Alternatively, two interviewees said there might be a placebo effect, though the effect might be stronger when seeing a live doctor (4,6). Thiago Marafon was convinced that AI chatbots have the potential to produce the same placebo effect induced by doctors (2).

Question	Key Finding	Respondent
What are the biggest challenges of AI chatbots in the healthcare sector?	• Convincing people that you can trust chatbots • User engagement • Integration of different systems • Involvement of different processes (integration) • Can only use information a patient provides (no physical examination) • No third party quality checks yet → WHO / ITU • Mapping of all different diseases (no scaleability) • Legal restrictions	• (1) | (4) • (2) | (4) | (7) • (7) • (3) | (4) | (5) • (4) | (6) • (5) | (7) • (5) | (6) • (1) | (4) | (5) | (6) | (7)
(1) Matteo Berlucchi, (2) Thiago Marafon, (3) Marc Iops, (4) Nicola Vona, (5) Vanessa Lemarié, (6) Dr. Dhini Nasution, (7) Johannes Schröder		

Table 6: Interview Question #5

The next question tackled the biggest challenges of AI chatbots. Most respondents (1,4,5,6,7,) viewed legal restrictions as a major challenge. The technology itself is already primed to do more than it does at the moment but its efficacy is limited by regulatory hurdles such as laws surrounding data protection. Moreover, a general oversight function such as a third-party organization which monitors all chatbot providers and sets quality standards is yet to be created (5,7). Another challenge is the integration of different systems such as picture scanning as well as text analyzing. Both technologies are already being used though not in a single system (7). Trust and user engagement play an important role since the systems rely on up-to-date data which includes willingness of users to be forthcoming with information (1,2,4,7). Dependence on patients to provide the chatbot with correct information is a challenge (3,4,5). And the

chatbots' database has to be updated regularly due to the diverse and the constantly growing number of diseases (5,6).

Question	Key Finding	Respondent
Do you think people are already trusting AI chatbots?	• Yes, you can see that more and more people are using our APPs • Not sure if you can generalize this (cultural & ethical differences between countries)	• (2) | (6) • (4) | (5) | (7)
(1) Matteo Berlucchi, (2) Thiago Marafon, (3) Marc Iops, (4) Nicola Vona, (5) Vanessa Lemarié, (6) Dr. Dhini Nasution, (7) Johannes Schröder		

Table 7: Interview Question #6

In terms of trusting AI chatbots, the interviewees stated that you cannot generalize about people trusting AI chatbots because of differences in cultures, ethics and tech-savviness between countries and individuals (4,5,7). On the other hand, you can see a positive trend that more and more people are using AI chatbot APPs which could imply an increasing in the level of trust (2,6).

Question	Key Finding	Respondent
Do you think there is a difference in trusting chatbots diagnoses depending on the level of the disease?	Yes • But chatbots should only be used for minor diseases • But there cultural technological and ethical aspects need to be considered No • Depends on the past experiences & level of education	• (1) • (2) • (4) | (5) | (6) | (7)
(1) Matteo Berlucchi, (2) Thiago Marafon, (3) Marc Iops, (4) Nicola Vona, (5) Vanessa Lemarié, (6) Dr. Dhini Nasution, (7) Johannes Schröder		

Table 8: Interview Question #7

Similar to the previous question, one respondent pointed out that it is not necessarily the severity of the disease that matters, but rather ethical and cultural differences (2). Other interviewees said that this also depends on past experiences and levels of education (4,5,6,7). One respondent said chatbots should only be used to do a initial assessments and for treating minor diseases (1).

4.1.2 Survey: AI Chatbot Acceptance in Healthcare

A pre-test was executed with 20 randomly chosen participants to test the relevance and accuracy of the questions. Irrelevant details were eliminated, and more relevant questions were added before conducting the survey.

The survey had 173 completed responses in total. The sample's demographic breakdown was 53.18% female and 46.82% male, which is well-balanced in terms of gender variety. The majority (62.27%) of the respondents were aged between 23-27, whereas 6.36% were between

18-22 and 12.72% were aged between 28 – 40. Of the total respondents, 19.65% were older than 40. The survey was predominantly answered by European respondents (95.37%) and more specifically by 67.63% Germans, 10.98% Portuguese, 4.62% Italians and other European countries (see Appendix).

The majority of respondents (83.24%) stated that they had Googled their symptoms when feeling sick. The level of satisfaction of those who had used Google to check symptoms had a median of 4.53 on a scale from 0-10 (0 = not satisfying at all, 10 = really satisfying) with a standard deviation of 2.2. The level of satisfaction related to seeing doctors had a higher mean of 7.73 with a smaller standard deviation of 1.59. The majority (27.78% in every case, 70.83% sometimes) went to see a doctor regardless of their Google results. Only 2 respondents (1.39%) stated that they never went to a doctor after Googling their symptoms. In most cases (50%) the doctor's diagnosis was not the same as the Google research. Eleven respondents (7.64%) stated that it was the it was the same and 57 respondents (39.58%) said it was almost the same. Only 4 respondents (2.31%) had already used an AI chatbot to self-diagnose their symptoms and 169 (97.69%) had not used one yet.

The respondents had to imagine a situation in which (1) they felt a little sick and (2) were really sick for 2 days. In both cases the healthcare chatbot told them that they had a common cold and suggested they drink a lot of water and rest. In case (1) 26.01% said they would not go to see a doctor, 46.24% said they probably would not see a doctor, 16.18% were not sure, 8.09% would probably see a doctor and only 3.45% would definitely go and see a doctor. On the other a hand, in case (2), 6.36% would not go to see a doctor, 10.98% would probably not see a doctor, 15.61% were not sure, whereas the majority would (probably) see a doctor 67.06%.

The respondents were also asked about their level of trust when being diagnosed by a doctor or a chatbot. The respondents scored a mean of 8.05 with a standard deviation of 1.32 on a 0-10 scale (0 = no trust at all 10 = I completely trust my doctor/the chatbot), though the chatbot only reached a mean of 4.51 with a standard deviation of 1.83. Concerning the statement: "AI chatbots are going to replace doctors in most areas," 15.03% of the respondents strongly disagreed, 46.82% somewhat disagreed, 15.61% neither agreed nor disagreed, 19.65% somewhat agreed and only 2.89% strongly agreed.

The survey ended with the following statement:" I can imagine being diagnosed by a chatbot instead of seeing a doctor.". The most frequently selected option was "somewhat agree" with 43.93%, followed by "somewhat disagree" with 28.32%. The neither agree nor disagree category was 10.40% whereas 12.14% strongly disagreed and only 5.20% strongly agreed.
There were no significant differences between the male and female respondents about the level of trust assigned to doctors (male: 8.05 / female: 8.03) and to chatbots (male: 4.65 / female: 4.38). Moreover, we could not find a significant difference between the averages of people between 18-27 and people between 28-(>40) when looking at the level of trust assigned to doctors (18-27: 8.05 / 28-(>40): 8.04) and to chatbots (18.27: 4.51 / 28-(>40): 4.45).

4.2 Limitations

Despite the insights gained this study has limitations. It focused only on AI chatbots in diagnostic medicine despite the large number of other instances of AI usage. As stated in many studies (Horn, 2001; Pacis et al., 2018; Topol, 2019), AI already has many use-cases in medicine and therefore its potential needs to be dealt with in other studies in a granular manner.

In the interviews and the survey we need to consider the margin of error associated with respondents' abilities to accurately answer the questions posed. Moreover, the study was conducted during the COVID-19 pandemic, which might have skewed responses about trust since they were focused more on convenience during a lockdown. Attitudes towards chatbots might also have changed due to recommendations from doctors or the government to use them. Therefore, we recommend conducting a similar study to track differences in patients' perspectives towards AI chatbots.

Regarding the survey, respondents often answer in a way that is socially acceptable and do not follow their own opinions but instead conform to group norms. There is also the obvious limitation associated with sample sizes, however, we believe that our samples were in fact representative of general trends from which we can produce plausible extrapolations. Finally, as stated in 4.1.2, the majority of the respondents were from Germany where people are generally more skeptical about new technologies in the healthcare sector (see Figure 3: Digital Health Index). Therefore, this study mainly uncovers the trust level of the German public when it comes to AI chatbots in healthcare.

5. Discussion

This section discusses the research questions in light of information from the literature and in combination with the empirical research findings from the interviews and survey.

5.1 AI Chatbots and their Potential for Substituting Doctors

The first research question of this study is: Can AI chatbots effectively replace any kind of medical doctor? To successfully answer this question, we conducted semi-structured interviews with 7 AI chatbot experts in the healthcare industry and combined those insights with the secondary research of the literature review.

We must first look at what chatbots are able to do at present and then what they might be able to do in the future. Most chatbots in the healthcare sector help patients with symptom-based diagnoses, allowing patients to receive instant feedback regarding general health questions and unlocking "self-care" (Matteo Berlucchi, CEO & Founder of Your.MD, Interview (09.05.2020)). By unlocking self-care, patients are able to self-diagnose their symptoms and therefore are no longer limited by their location and doctor availability. Regulations drastically limit the development of AI chatbots, whereas they actually could also provide prescriptions to patients. Chatbots can further learn from previous interactions to increase the accuracy of disease recognition.

Moreover, chatbots offer a variety of benefits such as anonymity, asynchronicity, personalization, authentication, consumability and scalability (Klopfenstein et al., 2017). Chatbots can further play a role in empowering users by educating them about health conditions (Klopfenstein et al., 2017). They are capable of understanding the variety of ways in which person ask questions and do so without being explicitly trained and while learning from real interactions. It is easy to bootstrap chatbot training with historical data.

Even though all experts were confident that AI chatbots still have considerable potential, most of the interviewees stated that chatbots are not going to replace medical professionals. Only one expert stated that it is inevitable that doctors will be substituted (2) and another (6) said that doctors can be disintermediated when a physical examination is not needed, as is the case for radiologists and pathologists. However, the CEO of Ada Health and the CEO of Your.MD both stated that the goal is not to substitute doctors in the long term but to build an augmented

intelligence of human plus AI. “The future of healthcare lies in a much more patient-centric model where individuals have actionable insights at their fingertips, and doctors and artificial intelligence work together to support patients throughout their healthcare journey,” (Daniel Nathrath, Research 2 Guidance Interview, 2017, CEO of Ada Health).

With that said, AI chatbots are systems with great potential which are already being successfully used in many ways. Doctors who do not conduct physical exams and who mainly rely on data such as x-rays would be most affected by this innovation. Nevertheless, a doctor’s job is not only to diagnose people but also to treat them. In many cases this also entails building a relationship of trust with the patient. AI-based chatbots are and will in the foreseeable future remain dependent on human interactions. They rely on deep learning algorithms, which are primarily computer codes and chatbots become more effective only through manual data input and feedback. Since future success depends not only on specific beliefs about the future but also on strategy and uncertainty, we focus on its limitations in the next chapter (Raynor, 2007).

5.2 Limitations of AI Chatbots

The second research question of this study is: What are the limitations of AI chatbots in healthcare? To successfully answer this question, we conducted semi-structured interviews with 7 AI chatbot experts and combined those insights with the secondary research of the literature review. We need to point out that companies often use the expression “Artificial Intelligence” without actually deploying a genuine AI. The differences between weak and strong AI are disregarded in the use of the term, whereas in most instances we are really speaking about weak AI, such as in the case of chatbots in this study.

First of all, AI chatbots depend on interactions with patients, which has its limitations. Data patients provide needs to be accurate and patients need to be able to express their symptoms correctly. Furthermore, chatbots must be built upon a well-structured and broad database that is regularly updated. However, information in healthcare is often poorly structured and dispersed among multiple players who have different standards. Chatbots are only as good as their databases. The database also needs to be checked for biases which will be adopted by the chatbot. Another limitation is that chatbots need human interaction and cannot teach themselves and this requires supervised learning.

The two biggest challenges chatbots face are user engagement and legal restrictions.
Without user engagement and trust in this technology, people are not going to use chatbots regardless of their high quality and availability. Therefore, chatbots need to have user-friendly designs, allowing them to add value to the diagnostic journey while also being trustworthy. How people trust AI chatbots in the healthcare sector will be discussed in the next Chapter – 5.3.

Because of legal restrictions, chatbots are not allowed to access personal data, even though this would enhance their performance and efficiency. Additionally, chatbots tend to be solely seen as a symptom-checker, whereas they have the potential to provide suggestions on what to do and also to match symptoms with prescriptions. As Dr. Dhini Nasution stated, countries like Indonesia do not have many regulations regarding data protection, which enables new treatment methods. On the other hand, data restrictions have many positives and are used to prevent companies from misusing data. The use of data with AI enables medical insurance companies to track healthcare users' behavior and to offer user-specific contracts. With this process comes another challenge, that of integrating the new technology itself.

Besides legal restrictions and user engagement issues, chatbots are yet not able to integrate different systems such as picture recognition and text analysis at the same time. The long-term goal is to build a system that can process all types of data, text, pictures, audio and video. Also, there is a need for an independent company that regularly checks the quality of each chatbot. At the time, companies state that they are the leading chatbot provider using the latest technology, even though you cannot really compare products because no company is fully transparent about data processing and their algorithms.

AI chatbots are readily availability but require frequent updates of their databases especially in a rapidly changing industry such as healthcare. However, as Porsche Consulting stated in their paper "Leading the Way to an AI-driven Organization" the biggest challenges a business faces in terms of AI is know-how and expertise (Ziegler et al., 2019). Therefore, companies are partnering with specialist companies to consult for them on AI projects (Appendix Figure 5 & 6).

5.3 Perspective of AI Chatbot Users

The third research question of this study is: What are user perspectives when diagnosed by AI chatbots? For this question, we conducted a survey with 173 respondents. We combined those insights with the experts' views on this topic. It is useful to examine the product life cycle of AI chatbots to illustrate users' perspectives.

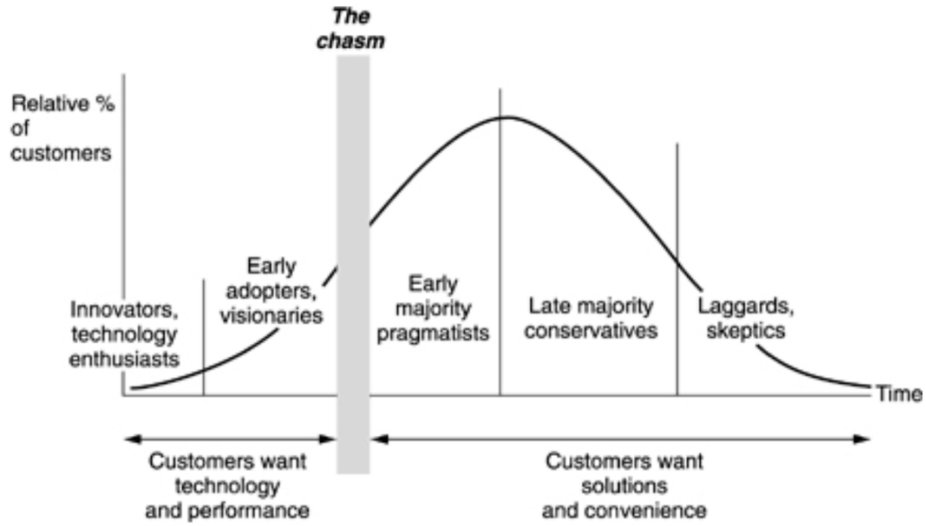

Figure 5: Product Life Cycle (Rogers, 2003; Treloar, 1999)

New products and innovations can generally be modeled according to Roger's product life cycle. The decision-making process is divided into different phases and different types of adopters are defined (innovators, early adopters, early majority, late majority and laggards). These various species of users are only ready to consider adoption at the phase associated with their level of user comfort (Rogers, 2003). At the start of diffusion, only innovators and tech enthusiasts can be assumed to be adopters. They are interested in the strategic competitive advantage the technology can provide and seek breakthroughs, not minor improvements to the status quo (Moore, 2012). The next group of early users usually only consider adoption when a large number of innovators have adopted the new technology. Christensen (1997) prefers to look at the phenomenon of technology take-up from the perspective of the level of performance required by average users. He argues that once technology products meet customers' basic needs, they are regarded as 'good enough' and customers no longer care about the underlying technology enhancements (Treloar, 1999).

The early majority also tends to wait and see how early users behave and if they are satisfied. For this reason, we maintain that AI chatbots are still in an early adaption stage. Although the

number of AI chatbot users is rising, many people still have not even heard of AI chatbot diagnoses. Therefore, AI chatbot providers could benefit from the support of entities such as the government and doctors who can recommend use of chatbots. Recommending usage might work through a halo-effect (Nisbett & Wilson, 1977). This would further support the diffusion process and could help overcome trust issues experienced by people at the moment.

Willingness to trust new systems such as AI chatbots can be explained by socio-economic factors (education, age, income), personality-related factors (attitude to new things, curiosity) and communication behavioral factors (type and quality of interaction and communication with the social unit) (Treloar, 1999). The decision to adopt is followed by implementation, application and use. Depending on the experience with the product, the decision may be confirmed or revised. Sociologist Everett M. Rogers cited factors such as relative advantage (a perceived improvement over the status quo), compatibility (compatibility of technology with experience, values and needs), complexity (subjective complexity that promotes or inhibits the adoption decision of new technologies), trialability (testability and access to test applications) and the communicability of innovation (Treloar, 1999).

To conclude, based on empirical findings and the foregoing product life cycle analysis we can state that most people in Europe are not yet ready for full adoption of AI chatbots in the healthcare sector. There are people successfully using them but these are early adopters. As stated earlier, the perspective of chatbot users strongly depends on various factors which determine perceptions. So, one cannot generalize for all users without more detail about the adoption demographic to which users belong.

Due to the COVID-19 situation, the number of users of telemedicine, in particular Teledoc, has increased significantly. Currently, over 20,000 virtual doctor's sessions are held every day. This corresponds to an increase of 100% compared to the first week of March 2020 (15.04.2020) (Betschinger, 2020). This bodes well for chatbot adoption.

6. Conclusion

While AI is already being utilized to varying degrees in the healthcare environment, its use will become increasingly important (Aboshiha et al., 2019). AI enables personalized medical treatments by leveraging analytics to mine the vast amounts of noncodified clinical data that

currently exists (Kaushal et al., 2019). AI chatbots, specifically, offer a way to unlock self-diagnosing, in accordance with the paradigm of acquiring as much knowledge from experts as possible and making this available to less experienced people to support decisions (Horn, 2001). Moreover, AI chatbots improve clinician productivity as well as the quality of care. They enable an effective online presence in order to generate leads and book appointments which nowadays is helpful for every modern medical practice. The versatile usability of chatbots ranges from simple appointment booking to self-diagnosis. The number of healthcare chatbot users is rising significantly and this trend is expected to continue (Betschinger, 2020). The use of themed chatbots also enables greater reach and the ability to generate new leads based on topicality. After entering data, the prospective customer receives the latest information directly on his or her smartphone (e-bot7, 2020).

Nevertheless, AI-based chatbots are and will in the foreseeable future remain dependent on human interactions. They rely on deep learning algorithms and become intelligent only through manual data input and feedback. They learn inductively by calculating correlations, data consistency and probabilities, which still needs to be monitored by humans. Furthermore, they strongly depend on databases which also needs to be updated by humans.

Based on the qualitative and quantitative data analysis, this study elaborated the potential and limitations of AI chatbots as well as the perceptions of people concerning chatbots. Perceptions that AI chatbots and AI in general are threatening doctors' jobs is unfounded since the technology is not a substitute for doctors but aims to support professionals in diagnostic and administrative tasks. AI chatbots possess considerable potential, which is now limited due to legal restrictions and lack of integration into other systems. There is also a need for an independent company to carry out quality checks to tackle the problem of incomparability.

Weak user engagement could also be strengthened by recommendations from doctors and other credible entities to make people trust chatbots more. Attitudes towards AI chatbots strongly depend on socio-economic factors, personality-related factors, and communication behavior, which is why we cannot generalize perspectives on the usage of chatbots.

AIM in specific Chatbots, is already successfully used in many cases, saving time, money and most importantly lives. We need to challenge the inertia of hospital business models which have pretty much stayed the same for over the years. Christensen (2008) came up with the idea

of separating treatment and diagnostics within hospitals. Physicians are usually responsible for four areas: diagnosing & treating ailments associated with acute pain; overseeing patients with chronic diseases; conducting physicals and providing disease prevention; and preliminarily identification of diseases. With far too many potential diseases for the human mind to keep track of, no doctor can simultaneously juggle all those responsibilities. Therefore, people should challenge the healthcare status quo and use chatbots to their full potential which is also a way to tackle the innovator's dilemma in the healthcare industry (C. M. Christensen, 1997). "People who are crazy enough to think they can change the world are the ones who do." (Steve Jobs)

7. Future Research

Despite a considerable number of interdisciplinary studies of the healthcare industry that show the effectiveness of AI, there is room for further research. New technologies such as 5G are going to offer new ways of diagnosing patients. The emergence of novel diseases is also inevitable which is why rapid methods of drug testing and treatment are essential. AI could offer a wide range of use cases to tackle these issues. Ethical guidelines need to be created to parallel advances in the development of machine learning and artificial intelligence. Physicians who use machine-learning systems can become more educated about their construction, the data sets they are built on, and their limitations. Remaining ignorant about the construction of machine-learning systems or allowing them to be constructed as black boxes and could lead to ethically problematic outcomes (Char et al., 2018).

Nevertheless, one should look at the trade-off between improvements in the healthcare system and completely "transparent customers". The term "transparent customers" derives from a German metaphor that describes the negative attitudes people have about being increasingly monitored by the state with regard to their personal information/data. There are also questions surrounding the aggregation of knowledge from hundreds of medical specialists into a single system such as an AI chatbot. Making that system readily available to anyone, who will be liable if the system fails? Who owns the intellectual property rights?

Future research could look at AI chatbot usage and telemedicine that have become increasingly prevalent due to the outbreak of COVID-19. Did this change people's mindsets related to AI chatbots? Lastly, it is interesting to point out how many symptom checkers were created during

the COVID-19 crisis and how the number of users increased during that time. The level of trust could also have increased based on media acceptance. Clearly, AI chatbots are a growing phenomenon in healthcare that is here to stay.

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Appendix

Usefulness	Area	Author
Effectiveness	Mental Health	Reger and Gahm (2009) Barak et al. (2008) Spek et al. (2007) Hyler et al. (2005)
	Diabetes	Tran et al. (2008) Jaana et al. (2009) Demiris and Hensel (2006) Martinez et al. (2006)
	Carido-vascular	Neubeck et al. (2009)
	Smoking cessation	Myung et al. (2009)
Promising	Mental Health	Bee et al. (2008) Griffiths and Christensen (2006)
	Diabetes	Jackson et al. (2006) Azar and Gabbay (2009) Polisensa et al. (2009) Sintechenko et al. (2007)
	Stroke	Crosbie et al. (2007) Henderson et al. (2007) Wu and Langhorne (2006)
Limited and inconsistent	Mental health	Postel et al. (2006) Linton (2007)
	Diabetes	Farmer et al. (2005) Verhoeven et al. (2007) Mathur et al (2007)
	Asthma	Sanders and Aronsky (2006)
	Stroke	Crosbie et al. (2007)

Table 9: Effectiveness of telemedicine (Ekeland et al., 2010)

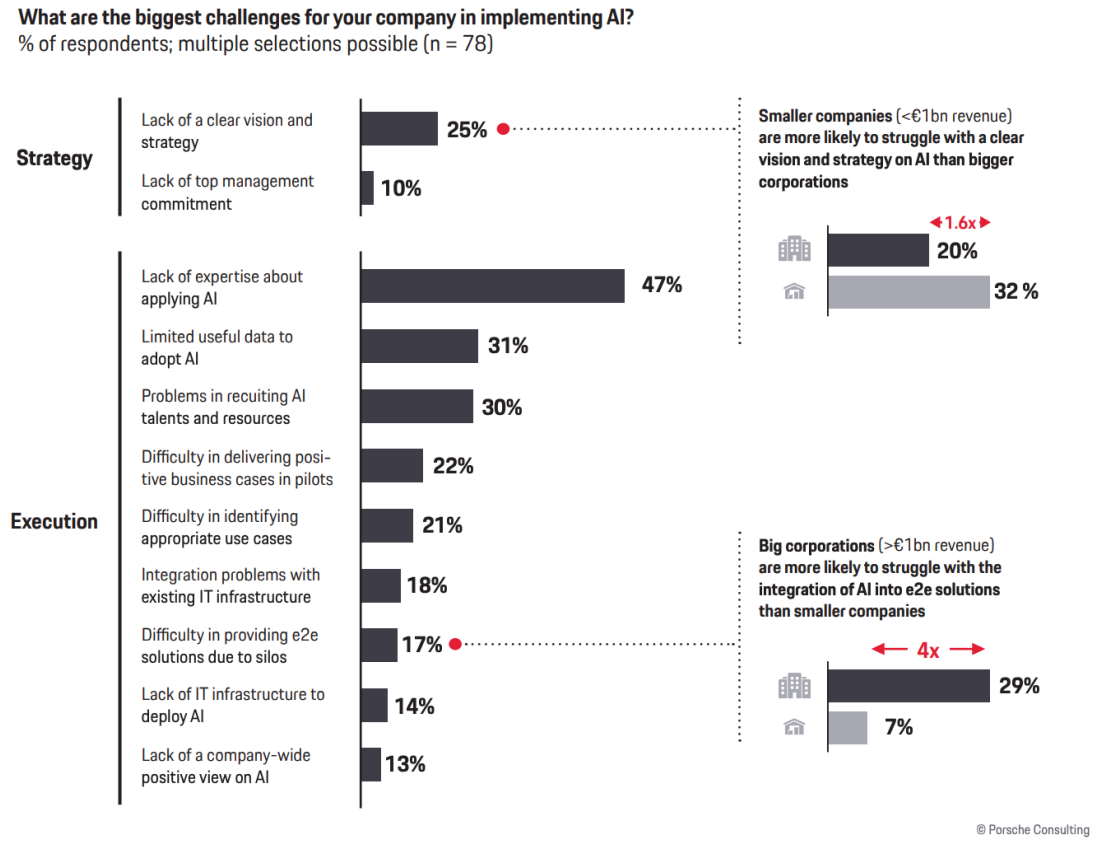

Figure 6: Biggest challenges for companies in implementing AI (Ziegler et al., 2019)

Figure 7: Strategy for obtaining and deploying AI skills across the organization (Ziegler et al., 2019)

Reference	Illness type	Detail	Competences
Callejas, 2014	mental-physical-wellness	mental-physical-wellness	ia, ac, ub, pe
Vuuren, 2014	language disorder	aphasia	mm
Griol, 2015	neurological disorders	Alzheimer	ge, mm
Lisetti, 2015	addictions	alcoholism	pe, an
Atay, 2016	neurological disorders	dementia	mm, ge
Beun, 2016	neurological disorders	insomnia	ia, ac, ub
Caballero, 2016	rare-diseases	rare-diseases	ub
Elmasri, 2016	addictions	alcoholism	an, pe
Kimani, 2016	cardiovascular disorders	atrial-fibrillation	co, ub
Miner, 2016	mental-physical-wellness	physical-health	mm, an
Brixey, 2017	sexually transmitted diseases	HIV-AIDS	an
Cameron,2017	mental-physical-wellness	stress	mm, pe, ge
Cruz-Sandoval, 2017	neurological disorders	dementia	mm, ge
Dubosson, 2017	addictions	smoking	sc, pe, as
Fadhil, 2017	mental-physical-wellness	healthy-habits	pe, ge
Heerden, 2017	sexually transmitted diseases	HIV-AIDS	an
Hoa, 2017	mental-physical-wellness	mental-well-being	pe, as
Hsu, 2017	nutritional-metabolic-disorders	food-allergies	pe, ub
Jeong, 2017	mental-physical-wellness	mental-well-being	mm, ub
Kowatsch, 2017a	nutritional-metabolic-disorders	obesity	sc
Kowatsch, 2017B	nutritional-metabolic-disorders	obesity	sc
Oh, 2017	neurological disorders	obesity	mm, ub
Cheng, 2018	nutritional-metabolic-disorders	diabetes	mm, ge, as, ub, pe
Chung, 2018	nutritional-metabolic-disorders	obesity	pe, as
Fernandez-Luque, 2018	nutritional-metabolic-disorders	obesity	as, pe
Gabrielli, 2018	mental-physical-wellness	healthy-habits	ub, pe
Huang, 2018	nutritional-metabolic-disorders	obesity	ub, as, pe
Inkster, 2018	mental-physical-wellness	mental-well-being	ub, as, pe, sc
Kobori, 2018	sexually transmitted infections	syphilis	an
Roniotis, 2018	neurological disorders	depression	mm, ub, ge
Enablers: Accessibility (ac), Anonymity (an), Asynchronicity (as), Gentle learning curve (ge), Instant availability (ia), Multi-modal-input (mm), Personalization (pe), Scalability (sc), Ubiquity (u)			

Table 10: Scope of chatbot usage in medicine (Pereira & Díaz, 2019)

Question	Key Finding	Respondent
Have AI chatbots the potential to effectively substitute any kind of medical doctors?	Yes • In the long term chatbots replace them – it's inevitable • Radiologists & pathologists might be substituted No • In fact, they will make doctors more efficient. Moreover, it is not the goal to substitute doctors, not even in the long term. • For now, they are not able to replace them but have the potential	 • (2) • (6) • (1) | (4) | (5) | (7) • (2)
What is / will be possible with AI chatbot in healthcare?	Is possible: • Giving a suggestion what you should do and what you might have • A qualitative initial assessment which is comparable to a human on the phone • Can find patterns on image and data and predict outcomes • Higher diagnose quality when doctors are combined with AI systems • Supporting the doctor with administrative tasks Will / might be: • Giving prescriptions to patients • Better understanding of what the patients say • Has great potential and has not yet reached its limits • A general system that integrates different applications (text and image recognition) • Technologically not much more potential with alogorithms	 • (1) | (4) • (1) | (4) • (1) | (2) | (5) | (7) • (1) | (5) | (6) • (1) | (4) | (5) • (1) • (1) | (2) • (1) | (2) | (3) | (4) | (5) | (6) | (7) • (4) | (5) | (7) • (7)
In which ways are AI chatbots limited?	• No face-to-face interaction (seeing things that the chatbot does not know) • Chatbots cannot reason and therefore cannot replace a therapist • Cannot teach itself everything without human interaction – supervised learning • Only as good as it's database (need for regular updates) • Depends on the correctness of the information of the patients	• (1) | (4) • (2) • (3) • (3) | (5) | (6) | (7) • (4) | (6) | (7)
Do you think there is a type of placebo effect when using a chatbot?	• Depends on the level of trust • Has the same placebo effect as seeing a doctor • Might have a similar effect even though the effect might be stronger when seeing a doctor	• (1) | (6) | (7) • (2) • (4) | (6)
What are the biggest challenges of AI chatbots in the healthcare sector?	• Convincing people that you can trust chatbots • User engagement • Integration of different systems • Involvement of different processes (integration) • Can only use information a patient provides (no physical examination) • No third party quality checks yet → WHO / ITU • Mapping of all different diseases (no scaleability) • Legal restrictions	• (1) | (4) • (2) | (4) | (7) • (7) • (3) | (4) | (5) • (4) | (6) • (5) | (7) • (5) | (6) • (1) | (4) | (5) | (6) | (7)
Do you think people are already trusting AI chatbots?	• Yes, you can see that more and more people are using our APPs • Not sure if you can generalize this (cultural & ethical differences between countries)	• (2) | (6) • (4) | (5) | (7)
Do you think there is a difference in trusting chatbots diagnoses depending on the level of the disease?	Yes • But chatbots should only be used for minor diseases • But there cultural technological and ethical aspects need to be considered No • Depends on the past experiences & level of education	 • (1) • (2) • (4) | (5) | (6) | (7)
(1) Matteo Berlucchi, (2) Thiago Marafon, (3) Marc Iops, (4) Nicola Vona, (5) Vanessa Lemarié, (6) Dr. Dhini Nasution, (7) Johannes Schröder		

Table 11: Interview Key Findings

Interviews

Disclaimer: Three of the interviews were translated into English and were originally in German (Marc Iops, Vanessa Lemarié, Johannes Schröder).

1. Interview: Matteo Berlucchi, CEO & Founder of Your.MD, Interview (09.05.2020)

- *How long have you been working with AI related topics and in specific AI in the healthcare industry?*

We started this project with the idea of AI in the spring of 2015 – so we have been working with it for five years and this was the first time I have been working with AI. It was not even called AI back then – when you look at the history, we were the first. We built the first AI Chatbot so there was nobody to look at. We were trying to solve the problem which was: Helping people and understanding what initially wrong with you. Can you build a symptom checker which is not necessarily as good as a doctor but which can be used in a number of situations where the doctor is not available. We never thought about being AI or not being AI. If you want to understand what a person has you need to ask them a lot of questions. So, we thought that a chat is a better platform to interact that a normal webpage. How do we select the best answers? We had to use advanced algorithms that in a way simulate the thought process of a doctor. We never called it AI in the first place. What is the definition of AI? I don't think there is a proper definition of AI. I never like this term that's why we call it Augmented Intelligence (AI). A lot of people are getting confused with ML and AI. In my opinion AI is the wrong term. There are all parts of software engineering.

I disagree with the structure of ML being a subtopic of AI and DL being a subtopic of ML. AI is too broad.

- *Are there any kind of doctors in healthcare that can be effectively substituted by AI chatbots?*

No. In reality, no. AI Chatbots are not going to replace anything. I think there are going to take away a proportion of the work done by doctors. If a doctor sees 10 patients a day. They could take away a proportion, like 30%, which could be done with chatbots. You still need a doctor to diagnose 70%. The chatbot is not taking anyone's job. It is just freeing up the very limited resources of primary care. Because if you look at it in a demand and supply problem. The demand "us – people" - everyone needs healthcare, some more some less. But everyone needs it. The problem is that the demand is at 100% and the supply is really low. Can we increase the supply? No, because it takes really long to educate people to become a doctor. You can make the doctors more efficient – yes, maybe. Telemedicine is making is just a little bit more efficient

because when you think about it. A doctor needs to see you for 10 min anyway – face to face or on the phone – same thing. Doctors in telemedicine don't see more patients.
So, the only way is to lower the demand. How do you do that? Self-care. You need to give people the tools to self-care. Because a lot of times you go to the doctor to be told how to self-care.
This is our idea behind the chatbots and this is our vision. We very much focus on self-care. We call it "unlocking self-care". Some other chatbots are more supporting the diagnosis, but we think that is not the right thing. We don't think that the chatbot should diagnose because it's very difficult. It's about managing expectations. In many cases you need more information.
We changed our main focus not long ago. Like 1,5 years ago. First, we also focused on a symptom checker – thinking about virtual diagnosing. Then we realized that the thing you can do really well with a chatbot is "to triage" – deciding the pathway. Rather than saying: What's wrong with you? – Which is the original symptom checker. We think, Your.MD, that a chatbot should focus more on: What to do. This is where I think chatbots can be really beneficial.

- *What will/might be possible?*

For now, they just give your suggestions, but I think it will be possible that it can do more. If you have an eye infection or similar basic things you just need an antibiotic. You could have an AI that produces the prescription and you go to the pharmacy or they can even send it to you. I think doctor will relinquish all the easy stuff. If you have a symptom checker that give you 3-4 options, that is not useful. You need something that definitely tells you what you have to do.

- *In which ways are AI chatbots limited?*

The limits of chatbots are a few. One is the comprehension of what the user really said. Because there is a knowledge gap. If someone has a headache you can be as smart as you like – the problem is that people cannot really describe their symptoms and where the pain comes from. Then the language processing might not understand it correctly.
There is also no face to face interaction with a doctor which is clearly better because they can see that you are nervous, tired or other things. So, they can get a lot of information that a chatbot needs to ask for first. You could potentially do it one day with image recognition.
The other thing is that I think in terms of accuracy and safety they can be better than anything that is out there today. Because it a little bit like games theory here, it's about probabilities. So, you can code everything in the system. It's like a game – you can put in all the rules, every symptom, every variable, everything. The foundation of the best chatbots used in medicine are

using the Bejing approach - probability model. It is a very old mathematical that helps to calculate the probability of certain things being true. Thomas Bayes wrote it in the 17th century. If you want to want to understand what I am talking about look at the Monty Hall Problem – it a classic example of how your brain cannot compute Bayesian probability. Our human brains don't do Bayesian probability. But this is the type of probability calculation you need to do, to do a diagnose or a triage decision. This shows you how a human being is not ideally positioned to do that. This is why I think a computer is handy/useful.

- *Do you think there is a type of placebo effect when using a chatbot? Since the placebo effect as a significant role when seeing a doctor.*

I think it goes back to my point that you should not use it as a replacement. Chatbots are only going to tackle the simple stuff. Because then I cannot completely answer your question because you are going to see the doctor in my scenario. I look at it more as a challenge for a chatbot – which is trust. In reality it is the same because the placebo effect is a consequence of trust. Because you go to the doctor because your trust the doctor. He says you are fine even if you are not and you still believe him. But why do you believe the doctor. Because you trust him. Because they went to university, they have a certificate on the wall behind them and they are wearing a white coat.

- *What are the biggest challenges of AI chatbots in the healthcare sector?*

I think that the biggest challenge for this upcoming technology is how do you convince people that they can trust a chatbot. And the answer is: it's difficult. You have to win the trust over time, you have to show that the service is good and has a high quality. Moreover, you need some credible trusted brands, the government or doctors endorsing it. Doctors could tell the patients to use a chatbot in a case like when having a blocked nose. I think there won't be a breakthrough until the medical systems starts prescribing this to the patients.

- *Do you think people are already trusting AI chatbots?*

We did not do a survey yet because don't trust surveys anyways. There is the very famous problem of people not telling the truth when being asked if they read the economist. We got a large investment by the company which is behind Durex which is a company most people trust and that's also what we wanted people to link us with – trust.

- *Do you think there is a difference in trusting chatbots diagnoses depending on the level of the disease?*

Yes, I think so. Like I already said I think that chatbots should only be used for minor diseases.

If you google your symptoms there is the problem that google gives you options and you can click on many different links. But even the same pain could be different between you and me because google does not know about our age, gender and other important factors such as chronic diseases.

2. Interview: Thiago Marafon, CTO & Co-Founder of Youper (12.05.2020)

- *How long have you been working with AI related topics and in specific AI in the healthcare industry?*

I've been working with AI-related technologies for many years. More recently, in 2016, I started to dedicate my time exclusively to develop AI products. Youper is the first AI product for the healthcare industry that I have developed.

- *Are there any kind of doctors in healthcare that can be effectively substituted by AI chatbots?*

We are living a moment when AI chatbots are still not able to replace health providers. But this is just the beginning. The current goal of chatbots is to supplement healthcare solutions. We are seeing chatbots in many sectors, mainly in mental health and general medicine. The next step will be to compete with traditional solutions. Then, finally, replace them. It is inevitable. The hard question is when this is going to happen.

- *What will/might be possible?*

Chatbots can partially and artificially understand natural language and search in a knowledge base for a good enough answer. Machine Learning algorithms can find patterns on images and data and predict outcomes. This is what AI can do today and what can be used to build chatbots.

I can see chatbots understanding more and more natural language. This will allow them to better personalize their conversations.

- *In which ways are AI chatbots limited?*

Chatbots still can't reason. Don't expect a chatbot to create conversations or inferences just like a therapist does. Everything that a chatbots says has been programmed by a human or it is random. What we envision is that, with time, many situations will be programmed so chatbots will artificially do many things a therapist can do. Until we reach the moment when you can't say the difference. At that point, it doesn't matter anymore if it is reasoning or not.

- *Do you think there is a type of placebo effect when using a chatbot? Since the placebo effect as a significant role when seeing a doctor.*

From the technology point of view, if talking to a chatbot has potentially the same placebo effect as seeing a doctor, at least you can talk to a chatbot anytime you need. At Youper, we are building is a chatbot that is better than placebo. Users feel better not only because they are talking to someone (or something) but because they are receiving science-based input that can change their thoughts.

- *What are the biggest challenges of AI chatbots in the healthcare sector?*

User engagement.

- *Do you think people already trust AI chatbots?*

Absolutely. There are many people that trust Youper and have been talking to Youper for years.

- *Do you think there is a difference regarding trusting chatbots diagnoses that is dependent on the disease?*

I think so and it totally makes sense. There are cultural, technology and ethical aspects that still need to be addressed before chatbots become a go-to solution for any kind of diagnosis.

- *Do you agree with the following statement: "The goal of AI chatbots is not to replace doctors but provide a more robust first step on the healthcare journey."*

I currently agree. But ask me again in 10 years and I might have a different answer for that.

3. Marc Iops, Chief Revenue Officer at Onlim, Interview (17.05.2020)

- *How long have you been working with AI chatbots?*

The company Onlim was founded in 2015. In 2016 we decided to go more in the direction of conversational AI. Onlim emerged from a spin-off from a university project at the University of Innsbruck from the Institute for Semantic Technologies. We therefore have great expertise in semantics and machine learning.

- *Do AI chatbots have the potential to effectively substitute any kind of medical doctors?*

Yes, of course. Every new technology has the potential to endanger jobs. On the other hand, new jobs are being created that are not even thought of at the moment. However, we see very strongly from our customer projects that the worry that employees will be cut in customer service is entirely unfounded. It is just that hardly any company can or does not want to afford 24/7 support. Customer inquiries are often repeated and can be clarified quickly and easily using the chatbot. In addition, none of our customers ever had the idea of replacing jobs.

- *How do you rate the potential of Chatbots AI?*

A lot more is possible. It starts with a better understanding of language - as far as the whole topic of natural language is concerned. It consists of the complexity of the dialogues that can be handled. I see great potential here. We are still in the early stages of AI topics, how do I prepare my data in the company so that it is automated and machine-readable. I also see the potential that in the future the dialogue as it takes place between two people can also be represented by a chatbot.

- *Where do you see the limitations?*

There is an illusion that a machine can teach itself everything without human interaction - we are still a long way from that. The question is when and if it will ever be possible. One always speaks of a supervised or also learning controlled by humans - supervised learning. Unfortunately, I am also not enough data scientist to be able to make statements about the technical limitations. What we apply to in our daily work is that there is sufficient data. Here the different industries vary significantly from one another. We currently have a large customer who is concerned with data modeling and data integration. They use over 500 different systems that cannot communicate with each other. Employees do not know that information that is available in one tool is missing in another. Accordingly, there are gaps in information that are ultimately reflected in communication. In general, you can observe that the data is often not prepared so that it can be used for a chatbot.

- *To what extent do you deal with the topic of trust in the area of AI chatbots?*

You have to be transparent and honest. The first rule is that the customer knows whether he is typing with a machine or with a human. It helps to classify expectations. The machine has certain capabilities and functions, such as accessing data quickly and at any time. However, if it is about empathy, then probably not. I think it depends on the use case. When it comes to very personal data, there will be people who prefer to talk to someone, although others would prefer not to share this information with anyone. However, I currently see no problem of trust if clear transparency is ensured.

- *What do you think is the biggest challenge related to healthcare chatbots?*

With regard to diagnostics, I could imagine that a chatbot does not want to be informed about a severe illness. However, I do not know whether this is a challenge or whether it is the point to offer something like that. I see that there are similar problems in the healthcare sector as I do in business. Be it in communication with each other, communication with customers through FAQ pages or in the hiring process. I see the great challenge that different processes are involved in each of these areas and that different types of chatbots have to be used for this,

since it makes a difference whether text or video material has to be used. I think the healthcare sector is an exciting area for chatbots, which is why we now want to focus more on this area.

4. Nicola Vona, Director of AI Strategy at Ada Health (20.05.2020)

- *How long have you been working with AI related topics and in specific AI in the healthcare industry?*

I work for Ada (Health) for almost 6 years now and I started working with AI when I started working for Ada. I am a physicist and have a mathematical background and also have a PhD in physics. I never worked on AI before I joined the company (Ada).

- *Have AI chatbots the potential to effectively substitute any kind of medical doctors?*

I don't think that doctors can be substituted by AI chatbots and also more generally by AI systems. Sure, there are lots of tasks that can be delegated to AI but doctors cannot be substituted. Doctors at the moment are overwhelmed because there are too few doctors compared to the needs of the society and doctors are requested to do a lot of repetitive and administrative work that is not really meaningful to the doctors work and that kind of things are very likely to be automated and substituted in the near future by AI systems. I think that AI and chatbots will replace the parts that the doctors don't like.

- *What will/might be possible?*

Concerning chatbots specifically: Now it's already possible to do quite much. Ada itself and other companies as well are able to perform an initial assessment of the patient with a safety and accuracy level that is comparable to a human on the phone.

In the future, there is lots of potential for improvement. The chatbots now are relatively constrained to tiny and specific tasks. Also by the fact that they not widespread yet. They are still a niche in a sense. You use very different approaches when you analyze text or when you analyze data / Images. There are fundamental differences in the approaches, but it would still be already possible to build a system that can put together different modalities of applications – looking at images and text at the same time.

I don't think that any system on the market has managed to do that yet but it's a lot of practical difficulties like uploading data. Should that be a picture or some data of a medical lab. If it is a picture taken by the user there are lots of variabilities in the conditions in which the pictures are taken. It is difficult to get good results from that. And on the other hand, if you are uploading data from a professional lab means you are already very far in the diagnostic journey. You have already been to the doctor and testing facilities. It's not that relevant anymore in a sense.

I believe that integrating lots of different modes such as analyzing video, picture and text will help a lot and will be done by most companies in the future.

- *In which ways are AI chatbots limited?*

Well, the biggest limitation of a chatbot is that it is a chatbot. It can only interact by talking to the use or asking the user to give specific answers. This limitation is severe because you cannot compare talking to a human face to face to a human or talking to a chatbot. You can do and achieve a lot just by talking to the patient. But of course, the physical exam will always be missing. Some papers show how you could make some physical tests at home for example with the phone or there are also companies that produce devices which can do physical exams in a sense. That would overcome some of the limitations. But the conversation is still very limited. The chatbot does not always get the full meaning of you wanted to say.

- *Do you think there is a type of placebo effect when using a chatbot? Since the placebo effect as a significant role when seeing a doctor.*

I think with a chatbot it is comparable for sure. I am sure that the effect of seeing a doctor in person is much stronger but I also believe that interacting with a chatbot already has some sort of placebo effect or other positive effects on the patient. This is also visible from the feedback we get from our users. We often get messages where people say: " I was very worried but now I feel better because I know what it could be and I feel relieved."

When the user makes an assessment with Ada we ask in the end to give feedback about the experience. Was it useful, was it not useful and we also leave space for a message. And we don't analyze those messages.

- *What are the biggest challenges of AI chatbots in the healthcare sector?*

Trust is a big issue and we cannot use our database to check for this because it is biased. If they already made it so far and interact with Ada they are more open to technologies like that. It's just a partial view.

The biggest challenges are of course adoption and building trust. Finding the right balance between the complexity of the actions and results. Now there are several products on the market but I believe that nobody got it right in terms of having a product that is really used as a standard way of interacting with the healthcare system. It's not the first thing you do. We still need to create the need for people to use chatbots in their day to day lives.

- *Do you think people already trust AI chatbots?*

We get a lot of positive feedback from our users. In the very beginning, users were confused whether they are talking to a doctor or a chatbot.

But I am not sure if people are trusting such systems on more widespread and regular bases. If don't know if society is ready to move towards using such systems as a standard way of interacting in the healthcare systems.

- *Do you think there is a difference regarding trusting chatbots diagnoses that is dependent on the disease?*

That's an interesting and difficult questions – I am not sure. I think that people tend to trust chatbots with easy issues. When they don't feel that well and not sure what's going on. If the chatbots tells them that it's fine and they just should stay home. I guess trust goes down when the issue is more serious. But on the other hand, some people might have had terrible experiences with their healthcare journey and have rare conditions that stay undiagnosed for a long time. I think those people would also trust systems like Ada or AI Chatbots. I think it's also a solution for people who are not satisfied with the doctors examination.

5. Vanessa Lemarié, Lead Rare Disease Initiative & Business Development Life at Ada Health (30.04.2020)

- *How long have you been working with AI related topics and in specific AI in the healthcare industry?*

About 4-5 years ago through my job at Bayer. The beginnings were initiated by the progress of digitization and accompanying new ways of data acquisition and structuring of this data.

- *Do AI chatbots have the potential to effectively substitute any kind of medical doctors?*

Ada's goal is not to replace doctors, but rather to work with them and thereby focus more on the actual diagnosis and treatment. Individual activities are therefore replaced and not the entire profession.

Even radiologists who deal a lot with the analysis of image material will not be replaced entirely in my opinion but will be very strongly supported by artificial intelligence. This will undoubtedly result in new professional fields.

- *What will/might be possible?*

In the field of image analysis in particular, there have been many new opportunities to recognize diseases at an early stage. A study that we are currently carrying out shows that the quality of the diagnosis of doctors varies greatly. This quality could be increased in the long term if chatbots work with doctors. At the moment, doctors still spend too much time on administrative tasks. You can achieve more efficient work through chatbots. Especially in the

area of rare diseases it is helpful to get a second opinion. Rare diseases are often disregarded and another disease is concluded. Many diseases are so rare that most doctors will never see these diseases. If you do see them, they can often not be clearly assigned.
I think there will be generalist systems on the one hand and systems that specialize in certain areas on the other. I think that both are justified and make sense. I could also imagine that different systems integrate with each other.

- *In which ways are AI chatbots limited?*

There are a number of limitations. On the one hand there is the database. If the database is bad, the result is terrible. Chatbots have the same problems as other algorithms. For example, one could simply take over an existing bias. If, for example, the database is suitable for white men aged 20-50, it does not mean that it is also suitable for African-African women aged 20-40.
Another limitation is undoubtedly the breadth of the clinical pictures that can be mapped. For example, Ada tries to map all diseases, whereas other providers may only specialize in one disease group. This effort to map all clinical pictures is not easily scalable and therefore requires a lot of resources. Another limitation I see is that some chatbots are at most digital screeners who present their results based on the decision tree, but are of little medical value.

- *Do you think people already trust AI chatbots?*

On the one hand, there are country differences, cultural differences, i.e. how open cultures are in general to digital solutions. Germany is generally much more reserved and critical of all digital issues than many other countries. I think that here (Germany) attitudes and acceptance develop towards the positive. I think there is hardly anyone who says that they will not be used in the future. The Bertelsmann Stiftung has published a study that examined 17 countries for their degree of digitization and found massive differences. It is still a question of generations. I can imagine that the next generation will no longer ask this question and will be more open in dealing with digital solutions. I am convinced that it will be about augmented AI - human + machine / hybrid AI.

- *Do you think there is a difference regarding trusting chatbots diagnoses that is dependent on the disease?*

I think it depends much more on the digital level of education and not on the severity of the clinical picture.

6. Dr Dhini Nasution, Clinical AI Researcher at Babylon Health & Medicinae Doctor (28.04.2020)

- *How long have you been working with AI related topics and in specific AI in the healthcare industry?*

I joined Babylon Health in January 2019, so it's now 1,5 years. This was the second time I worked with AI. I would say I came across AI 1 year before joining Babylon Health. Many companies say they work with AI but in fact, they don't. They just do basic telemedicine.

- *Do AI chatbots have the potential to effectively substitute any kind of medical doctors?*

I think number one would be radiologists and number two pathologists. It all depends on who owns all the data and laws in general. If you put laws away those are the most likely jobs that can be substituted.

- *What will/might be possible?*

It not at its full potential right now because there is a lot of regulation about the data is allowed to be used. AI cannot upload lactase or X-rays. It's not because the systems cannot do it but due to the regulations of the governments. If they will give the systems all the data they need it will result in less human error. I think that's really possible right now to actually minimize those human errors.

Indonesia, where I am from for example does not have many rules related to that so that allows AI to analyze the data. Doctors tell their patients to upload their lactase results and AI could then analyze that. The process of uploading is in many countries not allowed, like in the UK. I think is more or less because many people don't understand what actually AI is especially the government. A lot of people might have bad experiences with going to the doctor and that makes people's life way easier if they could just upload all of their data.

- *In which ways are AI chatbots limited?*

I see a big problem that there are too many different expressions for the same disease. In Indonesia, we have so many islands with so many dialects. We have to keep the data up to date on a regular basis so that the system can understand what the patient is talking about. For example the word "fever" has in Indonesia more than 3 different synonyms. People also have different ways of describing their pain. That's also a challenge. The chatbot needs to be able to recognize what kind of pain the patient has because everyone speaks in different ways.

- *Do you think there is a type of placebo effect when using a chatbot since the placebo effect plays a significant role when seeing a doctor?*

Even though I am a doctor myself I can see the placebo effect on myself. So sometimes I more or less know what I have but still make sure and let someone else check and I feel much better after their examination. I think the placebo effect work very objectively.
If you take a look at the chatbots that are on the market right now, I don't think that you will have a placebo effect. If people are going to trust the chatbots more and its used by more people I think this might change.

- *What are the biggest challenges of AI chatbots in the healthcare sector?*

I think that a big challenge is that you cannot generalize that a single chatbot in medicine works in every country because of the culture. For example, sex questions are a bit of a taboo and a lot of people refuse to answer questions like that even though it might relate to the symptoms. Summarizing, I think its language and culture.

- *Do you think people already trust AI chatbots?*

More and more people are getting accustomed to this. I think people are already trusting AI chatbots but since it is a long way to build a long-lasting level of trust, the trust level can still reach higher levels.

- *Do you think there is a difference regarding trusting chatbots diagnoses that is dependent on the disease?*

Well, I think it depends not only on the level of the disease but on the topicality of the disease. So, if a patient was just diagnosed with cancer she obviously wants to see a doctor as well and let her do another examination. But If the patient knows how he felt like the last time when he had the diagnosed disease, he might trust the diagnose.
It depends if it's the first diagnose, if it is maintaining or if it is a recurrent thing not only the level of the disease.

7. Johannes Schröder, Vice President of Product and former CTO at Ada Health

- *How long have you been working with AI related topics and in specific AI in the healthcare industry?*

I came into contact with AI for the first time during my studies - mid-2000s. I studied computational linguistics, and the topic is pretty strongly anchored there. However, still completely detached from healthcare. That's where I got my algorithmic background. In 2008 I worked for the first time at a company that basically used a little AI in the media area - thematic clustering.

- *Do AI chatbots have the potential to effectively substitute any kind of medical doctors?*

All in all, I would say: no. I would say they have the potential to replace certain activities of doctors and to make certain situations more efficient, especially when it comes to the patient's medical history or the standard sick leave. I find it inefficient if you have a skin infection and therefore have to go to a doctor to get an ointment. You could also take a picture of the infection and send it to your doctor - this saves time and money.

But I rule out a general replacement because something worse could also be behind simple conjunctivitis, for example. I could only imagine that AI can replace almost all activities that do not require interaction with the patient.

- *What will/might be possible?*

Technologically, I think there is not much more potential with algorithms. Technologically, these are not new inventions, but only classic AI research applied to the healthcare sector, which is now obviously ready to accept this change. Some of the algorithms are already 30 years old. It is only important to use them sensibly. I think what is most focused on is closer integration with other systems, such as wearables of all kinds, so that a chatbot gets a lot more information than it does now. About my sleeping behavior, my diet, my sports behavior and so on. This gives the chatbot much more background knowledge than is currently possible. On the other hand, I definitely think that integration into the health system is still lacking, but it will definitely come. In addition, there are systems that perform mental illnesses through voice analysis.

- *In which ways are AI chatbots limited?*

There are already chatbots or systems that are able to analyze images, but here the necessary integration is missing to be able to integrate these systems into a chatbot that deals with pure text analysis.

In addition, chatbots are limited in that they rely on the correct descriptions of the patient. An example of this is the description of skin irritation. Patient 1 finds that he has small red dots on his hand, while Patient 2 would call the same dot large. Therefore, it makes sense to support the entries with other data, such as wearables, pictures or the like.

I think that with very generic chatbots that want to serve the entire spectrum, there will always be certain niches that have to be researched and that each take a lot of time, which is why I think that cooperation with other manufacturers specializing in this area are quite reasonable.

- *Do you think there is a type of placebo effect when using a chatbot since the placebo effect plays a significant role when seeing a doctor?*

I definitely think so. I think the effect will be the same. I actually believe to see this effect when we analyze our user feedback. Frequently, users state that the chatbot has calmed them down, that they have used it, and it is precisely the mental component that plays a decisive role in the placebo effect.

I think it still correlates quite strongly with medical education. It's fairly common to see people with a simple cold think they have something very terrible.

- *What are the biggest challenges of AI chatbots in the healthcare sector?*

A few years ago, I would have said that integration and acceptance are the greatest challenges. We have noticed this at Ada in recent years, too, that it was difficult to talk to doctors and health insurers who were not yet prepared for this and who were not familiar with AI. I think that has changed a lot in recent years and people tend to be more open to that.

Acceptance is still a problem, but more from the regulatory side. What is not wrong per se is that the health system is heavily regulated, but increases the effort to make sensible use of integrations. If my user has to tick 28 checkmarks before actually using it, it is questionable whether he will use it at all. I also see it as a challenge that there are currently no objective quality measures. There are a lot of chatbot providers and everyone describes their approach as the best with their own numbers, own studies that prove how good you are. However, they are not all comparable. An independent quality check is therefore missing. At the moment everyone is focused on ensuring that the data is well protected, the processes are certified, but my result can still be bad in the end. There is a working group from the WHO and the ITU that deals with the area of symptom checkers. This could, for example, develop a specific test set that all manufacturers have to use to maintain a quality standard. However, I see the problem here that manufacturers could then try to pass this test set and only focus on it without pursuing their own research.

- *Do you think people already trust AI chatbots?*

I would say that trust is still developing and very strongly in a positive sense. I wouldn't speak of blind trust at the moment. I think there are huge cultural differences in trust and in the way we deal with data in general. In Asian markets, for example, basic trust in IT is much greater than in Europe. The discussion on the topic of chatbots would probably not even exist there in this way. In Germany in particular, people are generally more skeptical, more careful and have

to fight a lot of laws. The biggest concerns that we notice from our customers are mainly in terms of data protection and not general trust or mistrust towards the chatbot.
However, these concerns are, in my opinion, very strange, since I would rather worry about the quality of the diagnosis when visiting a doctor rather than worrying about whether the doctor correctly classified the medical file. In Germany in particular, it is very quickly assumed that the data can be used for unethical purposes, which slows down the development of these systems and general innovations.

- *Do you think there is a difference regarding trusting chatbots' diagnoses that is dependent on the disease?*

In general, most chatbots do not make diagnoses, but rather make an assessment. I think there is a difference, but it is the medical education I mentioned earlier. If I can imagine something that I could have, then I trust the chatbot more than if I have acute pain that I have never experienced before.

Survey

Have you ever googled your symptoms when feeling sick?

#	Answer	%	Count
1	Yes	83.24%	144
2	No	16.76%	29
	Total	100%	173

When was the last time you went to see a doctor?

#	Answer	%	Count
1	< 1 week ago	4.05%	7
2	1 week ago	2.31%	4
3	2-3 weeks ago	13.29%	23
4	1 months ago	21.39%	37
5	3 months ago	21.97%	38
6	> 3 months ago	36.99%	64

	Total	100%	173

How satisfying was the Google-result?

(0 - Not satisfying at all - 10 Really satisfying)

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Level of satisfaction	0.00	10.00	4.53	2.20	4.85	144

Did you still go and see a doctor?

#	Answer	%	Count
1	Yes, in every case	27.78%	40
2	Sometimes	70.83%	102
3	Never	1.39%	2
	Total	100%	144

Was the doctor's diagnosis the same as your google research?

#	Answer	%	Count
1	Yes	7.64%	11
2	No	50.00%	72
3	Almost the same	39.58%	57
	Total	100%	144

How satisfying was the doctor's diagnosis?

(0 - Not satisfying at all - 10 Really satisfying)

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Level of satisfaction	2.00	10.00	7.73	1.59	2.54	144

Have you ever used an AI chatbot to self-diagnose your symptoms?

#	Answer	%	Count
1	Yes	2.31%	4
2	No	97.69%	169
	Total	100%	173

Imagine you have been feeling a little bit sick for 2 days and you want to know what to do. Ada, the healthcare chatbot, tells you that you have a common cold. It suggests that you just need to drink a lot of water and need to rest. Would you still go and see a doctor?

#	Answer	%	Count
1	No	26.01%	45
2	Probably not	46.24%	80
3	Not sure	16.18%	28
4	Probably yes	8.09%	14
5	Yes	3.45%	6
	Total	100%	173

Now imagine have you been feeling really sick for 2 days and you are curious what to do. Ada, the healthcare chatbot, tells you that you have a common cold. It suggests that you just need to drink a lot of water and need to rest. Would you still go and see a doctor?

#	Answer	%	Count
1	No	6.36%	11

2	Probably not	10.98%	19
3	Not sure	15.61%	27
4	Probably Yes	45.09%	78
5	Yes	21.97%	38
	Total	100%	173

How much do you trust in your doctor's diagnosis?

(0= No trust at all, 10 = I completely trust my doctor)

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Level of trust	3.00	10.00	8.05	1.32	1.73	173

How much do you trust in a chatbot's diagnosis?

(0= No trust at all, 10 = I completely trust the chatbot)

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Level of trust	0.00	9.00	4.51	1.83	3.34	173

Do you agree with the following statement?

"AI chatbots are going to replace doctors in most areas."

#	Answer	%	Count
1	Strongly disagree	15.03%	26
3	Somewhat disagree	46.82%	81
4	Neither agree nor disagree	15.61%	27
5	Somewhat agree	19.65%	34
6	Strongly agree	2.89%	5
	Total	100%	173

Do you agree with the following statement?

"I can imagine to be diagnosed by a chatbot instead of seeing a doctor."

#	Answer	%	Count
1	Strongly disagree	12.14%	21

2	Somewhat disagree	28.32%	49
3	Neither agree nor disagree	10.40%	18
4	Somewhat agree	43.93%	76
5	Strongly agree	5.20%	9
	Total	100%	173

Age

#	Answer	%	Count
1	< 18	0.00%	0
2	18 - 22	6.36%	11
3	23 - 27	61.27%	106
4	28 - 32	8.67%	15
5	33 - 40	4.05%	7
6	> 40	19.65%	34
	Total	100%	173

Gender

#	Answer	%	Count
1	Male	46.82%	81
2	Female	53.18%	92
	Total	100%	173

List of Countries

#	Answer	%	Count
1	Australia	0.58%	1
2	Austria	4.05%	7
3	Brazil	0.58%	1
4	Canada	1.73%	3
5	Denmark	2.89%	5
6	Finland	0.58%	1
7	France	0.58%	1

8	Germany	67.63%	117
9	Italy	4.62%	8
10	Luxembourg	0.58%	1
11	Netherlands	1.16%	2
12	New Zealand	0.58%	1
13	Norway	0.58%	1
14	Portugal	10.98%	19
15	Serbia	0.58%	1
16	United Kingdom of Great Britain and Northern Ireland	1.16%	2
17	United States of America	1.16%	2
	Total	100%	173