The impact of the COVID-19 pandemic on Cloud Computing in the healthcare industry:

An analysis of cloud usage in German medical practices

Michelle Braun

Dissertation written under the supervision of Professor Fabio Caldieraro

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Abstract

Purpose

The purpose of this study is to analyse the impact of the COVID-19 pandemic on Cloud Computing (CC) usage in the healthcare industry, using German medical practices to evaluate their usage behaviour before, as in the year of 2019, and during the global pandemic in 2020.

Design/Methodology

The study employed both qualitative and quantitative research methods. Interviews with experts from the technology and healthcare industry were conducted for the qualitative part. An online customer survey for healthcare professionals from Germany was distributed for the quantitative research part and analysed with statistic tests.

Findings

It has been shown that the COVID-19 pandemic is associated with the usage frequency of cloud solutions for already existing cloud users and the willingness to consider using cloud solutions for non-cloud users amongst German medical practitioners. Additionally, it has been shown that this behaviour is dependent on several demographic factors.

Research limitations

The research is limited by the dependency on the data collection design, the subjectivity of the interviewees and the sample size of the survey. Future research can illuminate these limitations by elaborating on current results and finding root causes.

Practical Implications

To stand out from the competition, reach a new clientele of patients, and cover the patient journey, medical practices should use the COVID-19 pandemic to rethink their current usage of technological solutions.

Originality

To my knowledge, no similar analysis of the impact of the COVID-19 pandemic on CC usage in the healthcare industry, specifically German medical practices, exists.

Keywords

COVID-19 pandemic impact, Cloud Computing healthcare industry, Cloud Computing German medical practices

Sumário

Objectivo:

Analisar o impacto da pandemia de COVID-19 na utilização do Cloud Computing (CC) na indústria da saúde, utilizando práticas médicas alemãs para avaliar o seu comportamento de utilização antes, como no ano de 2019, e durante 2020.

Concepção/Metodologia

O estudo utilizou métodos de investigação tanto qualitativos como quantitativos. Foram realizadas entrevistas com especialistas da indústria da tecnologia e da saúde para a parte qualitativa. Foi distribuído um questionário em linha a profissionais de saúde para a parte de investigação quantitativa e analisado com testes estatísticos tais.

Conclusões

Foi demonstrado que a pandemia está associada à frequência de utilização de soluções para utilizadores de cloud já existentes e à vontade de considerar a utilização de soluções de cloud para utilizadores sem Cloud entre os profissionais médicos. Além disso, foi demonstrado que este comportamento está dependente de vários factores demográficos.

Limitações da investigação

A investigação é limitada pela dependência da concepção da recolha de dados, pela subjectividade dos entrevistados e pelo tamanho da amostra do inquérito. A investigação futura pode iluminar estas limitações.

Implicações práticas

Para se distinguir da concorrência, alcançar uma nova clientela de pacientes, e cobrir toda a viagem do paciente, as práticas médicas devem utilizar a pandemia para repensar a sua actual utilização de soluções tecnológicas, especificamente a CC e os benefícios associados.

Originalidade

Tanto quanto sei, não existe uma análise semelhante do impacto da pandemia na utilização da CC na indústria da saúde, especificamente nas práticas médicas alemãs.

Palavras-chave

COVID-19 Pandemia de impacto, Cloud Computing indústria dos cuidados de saúde, Cloud Computing práticas médicas alemãs

I dedicate this work to healthcare workers around the world that have been fighting the COVID-19 pandemic.

Acknowledgement

I would first like to thank my thesis advisor Fabio Caldieraro of FGV EBAPE Rio de Janeiro for his constant guidance and availability despite the remote circumstances and a distance of 8000 km.

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Finally, I must express my very profound gratitude to my roommate and best friend Julia for creating crazy experiences and being my main support system while living abroad – Merci beaucoup.

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List of Abbreviations and Acronyms

AWS	Amazon Web Services
CC	Cloud Computing
DARPA	Defence Advanced Research Projects Agency
EU	European Union
GDP	Gross Domestic Product
IaaS	Infrastructure as a Service
IAD	Institutional Analysis and Development
IT	Information Technology
MIT	Massachusetts Institute of Technology
NIST	National Institute of Standards and Technology
PaaS	Platform as a Service
SaaS	Software as a Service
SHI	Statutory Health Insurance
WHO	World Health Organization
%	Percent

1. Introduction

1.1. Background

On the 11th of March 2020, the World Health Organization (WHO) officially announced the COVID-19, namely SARS-CoV-2, outbreak as a pandemic, 71 days prior the first case of COVID-19 was reported to the WHO China Country Office. (WHO, 2021) Since the beginning of March 2020, the world has changed, and the pandemic has impacted not only humans infected with the disease but also every single country and economy. Even though governments around the world have offered fiscal and monetary support to fight against the turndown caused by the pandemic, the World Bank's forecast expected a 5.2% contraction in the global gross domestic product (GDP) in 2020 which would be the deepest recession since decades. (The World Bank Group, 2021)

Not to underestimate is the impact on the healthcare sector in Germany. Frontline workers such as nurses and doctors have been working extra hours taking care of patients, whereas doctor practices and other medical institutions have been economically impacted by a reduced number of patients. Reasons for this are cancelled or postponed surgeries that the German government demanded in order to increase capacities for intensive care beds for COVID-19 patients as well as the fear of patients of getting infected by the virus. Due to this fear and the imposed lockdown measures, the population choose to remain at home instead of going to regular doctor check-ups. (Egle, 2020)

This pandemic has led to institutions from every industry reinventing themselves and adapting to "The New Normal". (Asonye, 2020) Telemedicine, remote work and home-schooling are some examples that have been made possible owing to the technological innovations of the 21st century, foremost Cloud Computing (CC) applications that allow on-demand computing and network access via the cloud. (Alashhab et al., 2020) Hence, the relevance of Digital Health in Germany has received greater importance and increased in the past months. (Egle, 2020)

Even before the start of the pandemic and the rise of additional obstacles for the German healthcare system, major challenges such as an ageing population, lack of digital disruption and an organisation of medical practices in analogue form, increasing individualization and customer expectations, the urbanisation and the accompanying shortage of rural physicians, already existed. (Burkhart & Huesman-Koecke, 2018) Meeting these challenges during, as well as after the pandemic crisis, can be facilitated by the greater use of the potential of e-health. (Fichman et al., 2011) In this context, especially CC, can assist doctor practices in becoming more efficient and patients experiencing a more convenient and customer-centric

process. (M & K, 2016) It can be said that the COVID-19 pandemic has undeniably changed the way of living and working and is continuing to do so in 2021.

1.2. Problem Statement

This dissertation explores the proposition that the COVID-19 pandemic, as an external threat, has an impact on the cloud adoption in German medical practices. I expect that, overall, during a crisis, the adoption of CC solutions is greater than before the crisis. Reasons for this are that the pandemic enhanced the adoption and need for digital technologies by many years. Within Europe the adoption acceleration of digital technologies is 3 years ahead of the average rate of adoption from 2017 to 2019. (LaBerge et al., 2020)
To come to this conclusion, the following research questions will be answered within the scope of the study:

RQ1: "Did the COVID-19 pandemic change the need for cloud solutions in German medical practices?"
RQ2: "What are the fundamental factors influencing CC adoption decisions in German medical practices?"
*RQ3: "What are the main benefits for German medical practices to adopt cloud solution*s*?"*
RQ4: "What are the most common types of CC applications adopted in German medical practices?"

This dissertation paper focuses on the reaction of medical practices in Germany towards the COVID-19 pandemic impact on their business.
For the research, three periods will be considered, the period before the COVID-19 outbreak in Germany as the year 2019, the period during the COVID-19 pandemic as the year 2020 and lastly, the uncertain future period.
However, in terms of limitations for this research, the ending of the COVID-19 pandemic, meaning the period without any new reported cases, is still uncertain and hence only the year 2020 will be considered to measure the pandemic effect.

1.3. Research Relevance

From an academic perspective, extensive research on the socioeconomic impact of the COVID-19 pandemic exists. Yet, when it comes to the research of the COVID-19 pandemic impact on digitalization, there are only few theoretical approaches, however none that

highlights specific computing technologies. While other studies focus more on the general impact of the pandemic on the healthcare sector, especially hospitals, they fail to investigate the digital impact on medical practices in Germany. Hence, this dissertation builds upon existing literature. For medical practitioners with different backgrounds and areas of expertise, this study can assist in rethinking the effects of cloud adoption. Expert opinions combined with practitioner's judgments would yield insights for cloud providers market strategies in Germany as well as the adoption process for other stakeholder in the healthcare industry. The findings of this dissertation have several important implications for future practices, particularly the CC adoption in other crisis situations and industries.

1.4. Research Structure

The research is structured in the following way: following the introduction, relevant literature on the COVID-19 crisis and its impact on the German economy and German health system, the healthcare system in Germany including its structure, the medical practice landscape and digital challenges and the concept of CC with its service and deployment models, challenges and adoption build the theoretical foundation for this dissertation. The adherent chapter, the methodology part, includes the research design as well as the quantitative and qualitative methods used in order to collect and analyse data. The analysis and findings chapter deals with the main finding of both research approaches followed by a discussion that critically takes a closer look at the main results. The last chapter elaborates on the conclusion, limitations, and future research.

2. Literature Review and Theoretical Background

2.1. The COVID-19 pandemic in Germany

2.1.1. COVID-19 pandemic impacts on the German economy

The first case of COVID-19 in Germany was confirmed in the state of Bavaria on the 28th of January 2020. The probable source of the infection of a 33-year-old man was the professional contact with a Chinese woman eight days prior to the diagnosis. (Dr. med. Seedat, Jamela & Robert Koch-Institut, 2020) Since this day, the virus has spread across Germany and lead to 58,956 deaths within one year (data status: 3rd of February 2021). (Robert Koch-Institut, 2021) Figure 1 below, illustrates the development of the daily COVID-19 cases reported in Germany in 2020.

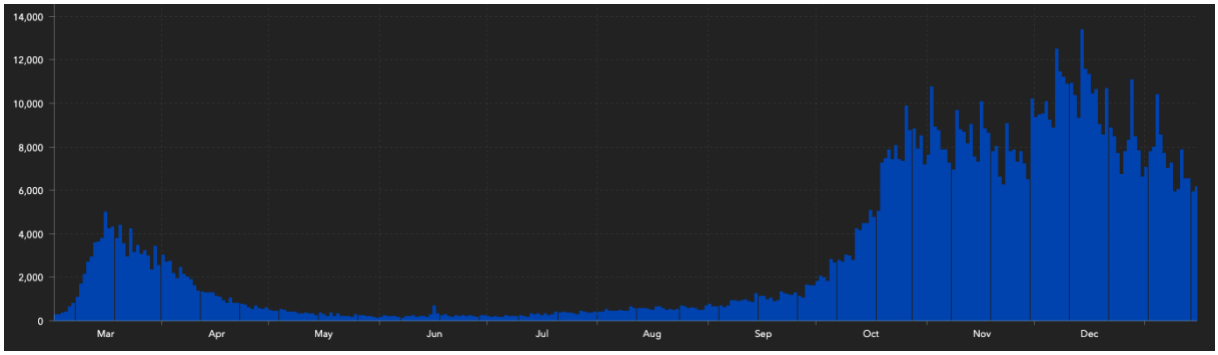

Figure 1: Daily COVID-19 cases in Germany 2020 (Robert Koch-Institut, 2020)

The German government has taken several measures to combat the spread of the pandemic and minimise its consequences. For instance, in March 2020 - as shown by the peak in figure 1 - a first lockdown period was introduced which included, amongst others the following in a chronological order: the closures of schools and day-care centres, enforcement of border controls, return campaigns for more than 160,000 travellers abroad, curfew and contact restrictions, home office regulations as well as aid packages for the economy. Due to a decreasing number of infection rates, most measures were loosened during the summer period except, for instance, the mandatory use of masks, restrictions against local coronavirus outbreaks and compulsory tests for returning travellers from specific countries with a high infection rate. However, this strategy had to be revoked in November when a second lockdown was put in place that, for example, included once again the closure of cultural and recreational facilities, restaurants, hotels and shops. (Presse- und Informationsamt der Bundesregierung, 2021)

Those measures and health policies are accompanied by strong economic impacts. After a 10-year growth phase, Germany's Gross domestic product (GDP) decreased by five percent (%)

in 2020 compared to the previous year due to the Corona crisis. Despite that, the decline is less severe than the recession during the 2009 financial crisis where the GDP dropped by 5.9%. (DESTATIS, 2021) Especially strong impacts were recorded on two major economic sectors, the manufacturing and the service sector. Whereas the first sector, which accounts for a quarter of the overall economy in Germany, noted a decline of 9.7% compared to 2019, the service sector showed contrary developments: On the one hand the online trade via platforms such as Amazon or Zalando increased significantly, while on the other hand the stationary trade was in a very critical situation due to the compulsory closure of shops. Nonetheless, the economic output of the service sector that includes trade, transport and hospitality was 6.3% lower than in the previous year. Exceptionally, the construction sector even increased by 1.4% compared to 2019. In addition to this, the export and imports of goods and services decline for the first time since the financial crisis in 2009, compared to 2019, the exports dropped by 9.9% whereas the imports decreased by 8.6%. In terms of the state budget, Germany ran up a total state budget deficit of 158.2 billion euros in 2020, which represents the second highest deficit since the German unification in 1990. (DESTATIS, 2021) Lastly, it is important to note the effects of the COVID-19 confinements and regulations on the country's labour market, whose 14-year rise came to an end. The unemployment rate rose by one percentage point to 6.3% in January 2021 which stands for an increase of 475,000 compared to January 2020. However, the regulations on short-time work are likely to have prevented layoffs in Germany. The short-time allowance reached its peak of about 6 million workers in cyclical short-time during the first lockdown in April, gradually declining during the summer period and increasing again in November with the renewed restrictions and second lockdown measures in Germany. (Bundesagentur für Arbeit, 2021)

2.1.2. COVID-19 pandemic impacts on the German health system

The COVID-19 crisis poses particular challenges for the healthcare sector. In order to avoid a system overload, that could have occurred, for example, in March 2020 if the cases had continued to grow exponentially, the German government acted against this at an early stage. Thus, in mid-March, wh

2.2. The healthcare system in Germany

2.2.1. Structure and stakeholders of the German healthcare system

In an international comparison, the German healthcare system stands out with its unique structure and organisation of a self-governing healthcare system. In other words, this means

that the state defines the legal framework and tasks, the people insured and paying contributions as well as the service providers organise themselves in different associations that take over the medical care of the population. (Bundesministerium für Gesundheit, 2021b) Financing of the healthcare system is done via statutory and private health insurances. Healthcare in Germany is based on five basic principles. The first principle is *insurance obligation,* which means that all German citizens are obliged to have health insurance cover. This became compulsory for statutory health insurance (SHI) on April 1st, 2007, and for private health insurance (PKV) on January 1st, 2009. The second principle, *contribution financing,* means that both the private and SHI are financed by the contributions of their members. The amount of the contribution depends on various factors such as income (SHI), age at entry and the individual risk (PKV). However, all insured receive the same benefits. The third principle, the *solidarity principle,* states that every person with health insurance jointly covers the costs arising from the illnesses of the individual members. Each person with SHI has the same entitlement to medical care - no matter how high his or her income and contribution to the health insurance is. Additionally, the fourth principle, the *in-kind principle*, defines that those treatments are free of charge for people with statutory health insurance, no in advance payment is required. The doctors, clinics and pharmacies bill the health insurers directly for therapies and medicines. Lastly, the *self-governance principle* declares that the state provides the framework and tasks for medical care by, for instance, issuing laws. However, the way the system is organized and executed including the medical treatments, operations, therapies, and medicines is decided within the healthcare system. The self-administration is carried out jointly by representative of different areas within the system. (Bundesministerium für Gesundheit, 2020)

The German healthcare system consists of three different levels of stakeholders which are illustrated together with some examples in figure 2 below.

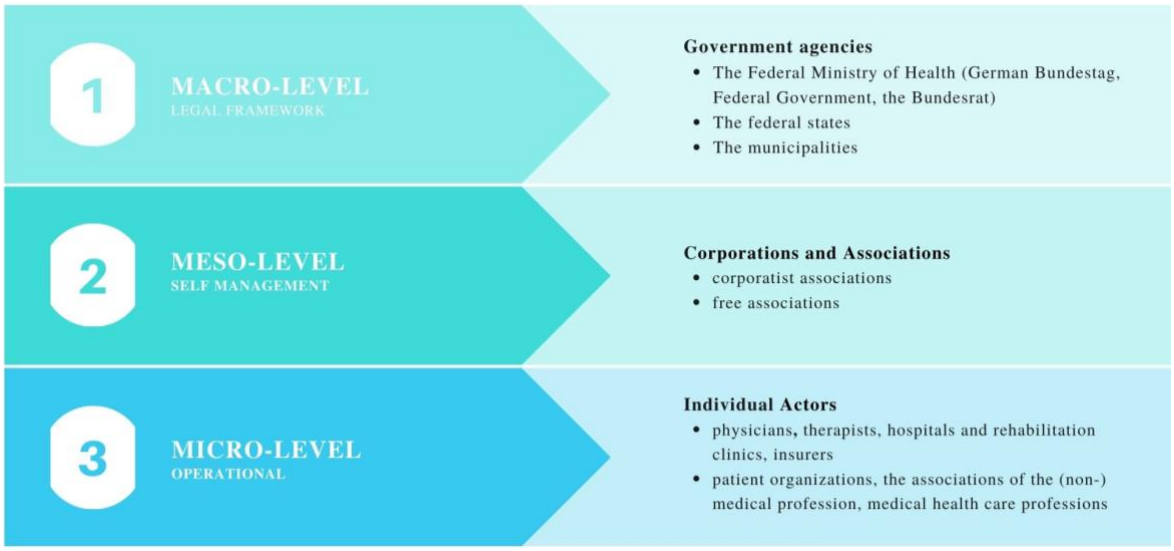

Figure 2: The three levels of the German healthcare system (Bundesministerium für Gesundheit, 2020)

The first level builds the legal framework, which contains several *government agencies* such as the Federal Ministry of Health (BMG), the states and the municipalities of Germany. In accordance with the federal structure of the Federal Republic these can be further differentiated into federal, state, and local government. This first level provides the laws and regulations that must be filled out in detail by the self-governing bodies (corporations and associations) - the second level of *self-management*. These corporations and associations are responsible for organising and ensuring health care within the framework of SHI. The final level contains the individual players and their interest groups such as physicians, therapists, hospitals, and rehabilitation clinics, which are organized in professional organizations and associations. However, self-government restricts the decisions of these individual actors through a rather dense network of regulations. (Bundesministerium für Gesundheit, 2020)

2.2.2. Medical Practices in Germany

Focusing on the micro-level of the German healthcare system, a differentiation of healthcare providers can be made between the inpatient and outpatient sector. The inpatient sector involves the service provision in hospitals. Whereas the outpatient sector concerns the contract physicians and contract psychotherapists that are located in general practices and not in the hospital itself. (Burkhardt, 2014) In order to become a licensed doctor, a doctor must be registered in the doctors' register of the Association of SHI Physicians and apply to the admissions committee. To this day, the single doctor’s practice has remained the main form of SHI-accredited medical care. Although joint practices and practice communities have certain advantages over individual practices as a result of the opportunities for collaboration among

the involved doctors. (Burkhardt, 2014) The German law distinguishes between general practitioners and specialist ones. Whereas general practitioners, paediatricians and doctors without a specialised title belong to general practitioner care. On the other hand, specialist doctors are mainly in charge of specialized tasks that, for example, relate to the treatment of a defined disease instead of general sickness. The separation into general practitioner and specialist care is reflected in special contracts with the health insurances and the different distribution of fees between the two groups of doctors. (Burkhardt, 2014) In 2019, the total number of working doctors that were registered increased by 2.5% to 402,453 doctors and the average age was around 42 years. (Bundesärztekammer, 2019) During the same year, the share of female physicians working in Germany was about 48% of the total physician workforce. (praktischArzt, 2020) The 159,846 outpatient doctors and psychotherapists that are SHI-accredited in Germany are reimbursed by the SHI funds. Those funds provide a certain amount for the outpatient care of their insured to Association of SHI Physicians that distributes the remuneration to the doctors. (Kassenärztliche Bundesvereinigung KdöR, 2021)

2.2.3. Digital challenges of Germany's healthcare system

It is proven that digitization in the healthcare sector has many advantages, for instance those benefits include personalized medicine, which facilitates the communication between the players in the healthcare system, give practitioners a more holistic view of patient health, and supports patients of being in control of their health through the usage of apps and information that is available digitally. (PricewaterhouseCoopers, 2021) In 2018, Germany was ranked second to last among 17 countries in an international comparison of digital transformation in health. (Bertelsmann Stiftung, 2018) As a reaction to this deficit of digitization in the German healthcare sector, the German government has set a legislative framework for the digitization of healthcare. In November 2019, the "Act to improve Healthcare Provision through Digitalisation and Innovation", in short, the Digital Healthcare Act was enacted and has laid the foundation for the digital transformation of the German healthcare industry - especially in electronic patient records, telemedicine, and e-prescriptions. (Bundesgesundheitsministerium, 2019) On the one hand, already more than eight in ten doctors were linked to the telematics infrastructure, which is provided by cloud systems in 2020, whereas on the other hand medical data is mainly shared in analogue form. Especially in individual practices and specialized ones such as psychotherapeutic practices, a greater amount of the patient data is not digitized. Significantly, the low provision of digital offers is most dominant in the outpatient sector where the majority offered no digital services at all and only a small number

of outpatient doctors implemented options for online booking appointments or prescription ordering via their website. (McKinsey, 2020) The greatest challenge in terms of digital transformation of the healthcare sector is the acceptance by providers – first and foremost by physicians. Reasons for this resistance is the fear of harming the physician-patient relationship. Additional obstacles are related to data protection and data security. However, on the patient side, the majority of patients are open to the use of digital healthcare solutions. (Porzsolt et al., 2009)

2.3. Cloud Computing

2.3.1. Definition and Benefits of Cloud Computing

The most widespread definition of the term CC comes from the National Institute of Standards and Technology (NIST):

> *"Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction." (Mell & Grance, 2011)*

In other words, CC describes the process of relocating storage space, computing capacity or software applications from a computer to the cloud. This is possible through providers that make these service available on their servers for a fee.

The term CC leads to 507,000,000 results on Google Search (date: 24th February 2021). (Google Search, 2021) The question remains when the term first appeared in the modern context. The Google Trends Analytic Tool dates back to 2006 and shows that the term was first searched for between the 17th and 23rd September 2006, which is shown by figure 3 below. (Google Trends, 2021) This interest over time increase is accompanied by the prior launch of Amazon Web Services (AWS) in 2006. (Amazon Web Services, Inc., 2006)

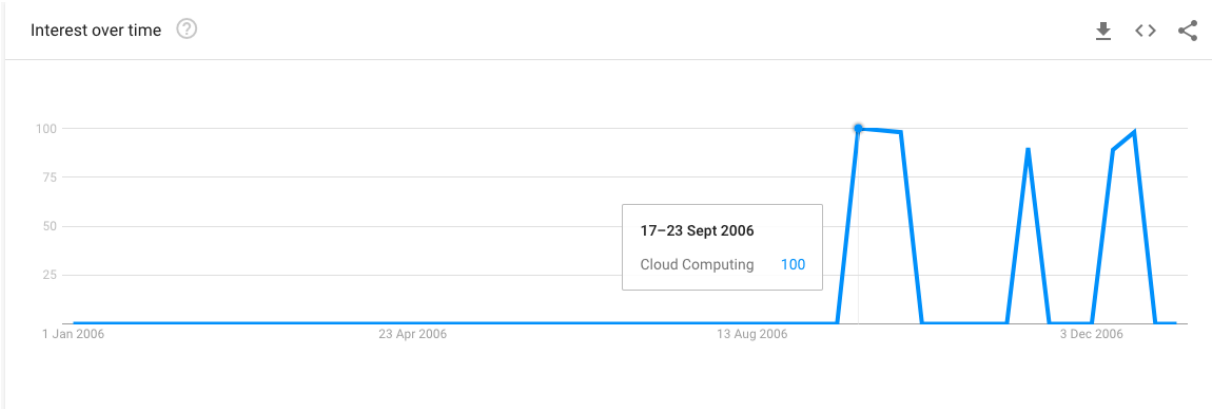

Figure 3 Google Trends, interest over time CC (Google Trends, 2021)

Nonetheless, it is important to note that the Google Trends analysis only dates back to 2004 but the concept of CC initially appeared in 1963 when the Defence Advanced Research Projects Agency (DARPA) presented their project MAC to the Massachusetts Institute of Technology (MIT) that should act as a primitive cloud version with two or three people that could assess it. (DARPA, n.d.)

Several benefits of CC are present, for example, instead of buying, owning, or maintaining physical data centres, technology services (such as computing power, storage and databases) can be accessed on-demand basis via a cloud provider. Additionally, its pay-as-you-go pricing model includes both subscription-based and consumption-based options, there are no upfront commitments and clients only pay what they use. This financial benefit also includes that customers do not need to buy any hardware, software, or pay the maintenance costs for datacentres (Mell & Grance, 2011)

Further advantages include the following five essential characteristics:

1. On-demand self service

No human interaction is required for cloud users, they can automatically use sever time and network storage as a self-service. (Mell & Grance, 2011)

2. Broad network access

CC capabilities are accessible over the network and accessed through standard mechanisms that encourage heterogeneous thin or thick customer platforms to use (for instance, mobile phones, tablets, laptops, and workstations). (Mell & Grance, 2011)

3. Resource pooling

The computer resources of the supplier are bundled to serve several customers. A multi-tenant model, serving multiple customers, is used with various dynamically allocated and reassigned

physical and virtual resources based on consumer demand. Examples of those resources are storage, processing, memory and network bandwidth which are pooled among multiple users and applications. (Mell & Grance, 2011)

4. Rapid elasticity

In dynamic environments, businesses need to be able to adapt quickly to ever changing consumer needs. With CC the supplied capabilities can be elastically fitted to scale demand and can be adapted in any quantity at any time. (Mell & Grance, 2011)

5. Measured service

Cloud systems automatically adapt to the usage of resources by measuring depending on the type of service (for example: storage, processing, bandwidth, and active user accounts). In order to provide transparency for the supplier and user alike, it is possible to monitor, control and report the usage in the cloud. (Mell & Grance, 2011)

2.3.2. Service Models of Cloud Computing

The NIST identified three different service models of CC that can be sold by a cloud provider. (Mell & Grance, 2011)

1. Software as a Service (SaaS)

SaaS offers ready-to-use software applications via cloud infrastructure and is the most prevalent service model of the three of them. The cloud provider, a third-party, gives the consumers the opportunity to use their applications that are running on a cloud infrastructure, they provide customers with services such as email, collaboration tools, design tools via their software. Cloud infrastructure incorporates the collection of hardware and software that allow the five essential characteristics that were described in the previous paragraph. The service provider's applications are accessible by various clients via various devices. Consumers have limited possibilities to configure application settings and are not able to manage or control the underlying cloud infrastructure. (Mell & Grance, 2011) Examples of SaaS providers are Google with the collaboration cloud G-Suite, Microsoft with the productivity cloud Microsoft 365 and Salesforce with its Customer Relationship Management cloud. (Evans Strategic Communications, 2019)

2. Platform as a Service (PaaS)

Compared to SaaS where customers can only change configuration settings, the PaaS allows them to control over the deployed applications as well as configuration settings of the application-hosting environment. Instead of only the software, PaaS also provides consumers with the hardware tools over the Internet. Developers can use different frameworks from PaaS providers and build their own customized applications upon. Nonetheless, consumers are not able to control the underlying cloud infrastructure such as networks, servers, operating systems, or data storages. Furthermore, no in-house hardware or software needs to be installed for the development of a new application, since this is all deployed via the cloud. The three main PaaS vendors ranked by revenues are Microsoft Azure, Amazon Web Services and Google Cloud. (Evans Strategic Communications, 2019)

3. Infrastructure as a Service (IaaS)

Consumers are provided with the processing, data storage, networks, and additional fundamental computing resources such as operating systems and applications in order to deploy and run software. The infrastructure is used by customers to build their own system on top. As with SaaS and PaaS the consumer does not manage the underlying cloud infrastructure, however with IaaS the consumer can control the operating system, middleware, storage and deployed applications and has some access to networking components such as host firewalls. (Mell & Grance, 2011) The three main PaaS vendors Microsoft Azure, Amazon Web Services and Google Cloud dominate the IaaS market.(Evans Strategic Communications, 2019)

2.3.3. Deployment Models of Cloud Computing

The following four different deployment models that indicate how the cloud services are provided have been identified by the NIST:

1. Private cloud

The cloud infrastructure is not available on the public internet and is exclusive to the usage of one individual organization with different business units. The private cloud is especially recommended for sensitive or valuable data. The private cloud can either be located on or off premises or third-party service providers are paid to host the private cloud. (Mell & Grance, 2011)

2. Community cloud

A community cloud is a private cloud model that is used by several organizations from a specific community of consumers with shared concerns (for example: mission, security requirements, policy, compliance considerations). The community cloud is either managed internally or by a third-party or a combination of both of them and is hosted on or off premises. (Mell & Grance, 2011) For instance, Católica Lisbon School of Business and Economics and FGV EBAPE could use a community cloud to cooperate in specific areas of research.

3. Public cloud

The public cloud is open for use by the general public and can be owned, managed and operated by a third-party cloud provider. (Mell & Grance, 2011) The same cloud resources such as hardware, storage and network devices are shared with other cloud users. Use cases include web-based email, online office applications, storage and development environments. (Microsoft, 2021)

4. Hybrid cloud

The hybrid cloud is a combination of public and private cloud. Programs and data can be shared easily from one deployment system to another. This leads to greater flexibility, more deployment options and the possibility to work with private cloud for sensitive information at the same time while working running a second version with public data. (Mell & Grance, 2011)

2.3.4. Challenges of Cloud Computing

The benefits of CC do not come without challenges and risks. Major concerns are related to consumer protection and data security. When using cloud solution, reliance on third-party providers and their ability to make decisions about company's data and platforms is crucial. (Sadoughi et al., 2020) In order to counter this trust issue, main cloud providers have made commitments by developing policies to securely handle customer data. (Kuo, 2011) The privacy and data challenges come along with a fear of loss of control faced by organizations. The three different service models counteract to this by providing different sharing levels and hence different security, privacy, and trust requirements.

Another considerable challenge to cloud adoption is technical reliability. The more cloud-based solutions are used, the higher becomes the overall dependency on the technology. Resource exhaustion due to the increasing number of providers, unpredictability of

performance, data lock-in where customers are dependent on a single cloud provider, data transfer bottleneck and bugs in cloud systems are just some of the technical challenges that might occur. (Kuo, 2011)

When aiming to increase the adoption of CC, it is essential to insure interoperability. The latter can be described as the ability to integrate existing systems with cloud-based ones which is of utmost significance in the healthcare sector. An increased availability of interoperability and the efficient data exchange between different systems in real-time would lead to a reduction of the challenges associated with vendor lock-ins. (Sadoughi et al., 2020)

The challenge of sufficient internet connectivity and speed is particularly prevalent in Germany and its rural areas. With regard to broadband coverage, Germany only ranks 21st and consequently below the European average. (Bethke, 2020) A powerful and accessible internet connection is the cornerstone for CC and the usage of its services. (Sadoughi et al., 2020)

2.3.5. Adoption of Cloud Computing in Healthcare

There is a substantial growth in demand for healthcare services because of demographic changes, an aging population and increased occurrences of chronic diseases and viruses. This has led to an increasing need for higher quality healthcare offers with fewer and more costly resources and has ultimately left many healthcare providers searching for more innovative and cost-effective solutions. Research shows that in the past trade-offs had to be made between the improvement of the quality of medical care and the reduction of costs for the public. Those conflicts can be resolved with the help of digitization that allows high-quality, affordable care and ensures that rural areas are increasingly connected via, for example, telemedicine solutions. (PricewaterhouseCoopers, 2021) Especially CC systems have a potential of providing solutions that address the problems related to the growing numbers of patients' data and the need for personalized services as well as productivity. (Sultan, 2014)

Literature review has shown that key motivational factors associated with the adoption of CC in healthcare are the direct improvement of health-related services and finances. (Gao & Sunyaev, 2019) Healthcare organizations tend to have limited Information Technology (IT)-specific resources such as IT capabilities, staff, or infrastructure as well as limited monetary resources in terms of budgets for IT adoption projects. However, previous research has shown that CC adoption is not related to a high need for financial and IT input. (Gao & Sunyaev, 2019) The associated costs of installing and maintain applications locally is effectively controlled and reduced by using cloud solutions that offer on-demand self-service and pay-as-you-go models with major cost advantages. Furthermore, labour related costs and workload

are reduced as less in-house technicians are required for the implementation and the maintenance of cloud service in healthcare. (Sultan, 2014)

Another factor influencing the adoption decisions of CC solutions is the compliance with industry standards. The healthcare system in Germany is highly regulated and involves many different stakeholders and institutions that regulate, for example, patient-related critical data and information. (OECD & European Observatory on Health Systems and Policies, 2019) Although with the introduction of an electronic patient file via health insurers in January 2021 a slight progress has been made, physicians only have limited access to this file via an interface in their practice management systems. (Bundesministerium für Gesundheit, 2021a) Hence, it is extremely important to work with cloud providers that offer cloud service level agreements tailored to the healthcare sector. The COVID-19 pandemic has significantly disrupted the healthcare industry and left providers with the burdens to adapt to a dynamic and fast-changing environment, as a solution CC offers the benefit of rapid elasticity which makes adaptation to different circumstances possible. (Mell & Grance, 2011)

Lastly, employing cloud technology leads to more flexibility for health organizations, offsite access of medical data and IT resources can be gained via broad network access. (Gao & Sunyaev, 2019)

3. Research Methodology

3.1. Research Design

For the research of this study, data from primary and secondary sources was used. A theoretical foundation was constructed through the analysis of existing literature such as academic articles, journals, books, and specialist online articles. This secondary data was gathered to get an overview of the COVID-19 pandemic, the structure of the German healthcare system and a basic understanding of the CC concept so a connection between CC and the healthcare industry could be drawn. Subsequently, this secondary data was validated with the primary data.

For the primary data collection, both qualitative and quantitative data collection methods were applied. This mix-method approach gives a better understanding of the research subjects than one approach alone. Qualitative methods provide a depth of comprehension and identify strategies for enabling implementation, whereas quantitative methods test and confirm the hypotheses. In this way, results can be equally confirmed and lead to more profound conclusions. (Palinkas et al., 2015)

Interviews with experts from the technology and healthcare industry were conducted for the qualitative research. The experts from the technology industry are working for cloud providers and the other group of experts were part of official associations such as the German Medical Association (Bundesärztekammer), the coordinating body of physicians' self-regulation in Germany or the Rhineland-Palatinate Association of Statutory Health Insurance Physicians. (Bundesärztekammer, 2021)

The insights of the in-depth interviews with experts from the industry, combined with those of the literature review, supported the construction of the quantitative research, an online customer survey for healthcare professionals from Germany. This mix-method approach was used to answer the four research questions mentioned in the problem statement of this study.

3.2. In-depth interviews

A total of six expert interviews were conducted based on a semi-structured interview approach. This approach was chosen in order to be able to ask open-ended questions without following a binding sequence and leaving room for discussions and adaptations with the interviewees. They were able to freely comment, explain and elaborate more on aspects that were considered important to them. From those six experts, two were part of the official healthcare associations in Germany. The other four experts were specialists working for cloud providers, whereas two worked for the main cloud providers such as Google, Salesforce and

AWS and the other two experts worked for smaller cloud providers located in Germany and specialised on providing solutions only to companies in the healthcare industry. The main questions relating to the impact of the COVID-19 pandemic on technologies in general were the same for all experts, however, both types of interviewees were asked additional industry-specific questions.

The major objective of the in-depth interviews was to understand the impact of the COVID-19 pandemic on the healthcare industry, specifically cloud solution usage and medical practices. Table 1 includes an overview of the interviewees, their position, type of company and industry. For comprehensiveness reasons, letters from A to F were assigned to each expert and used consistently in this dissertation paper. It is also important to note that the transcript of each interview in the Appendix represents the individual expert's opinion and not the one of the respective companies the experts are working for.

Interview	Position	Type of Company	Reason for expert to be chosen
A	CEO of a cloud company and Orthodontist	Cloud provider	Technology expert and healthcare professional
B	Referent Telemedicine and Telematics	Medical Association in Germany	Official association of the German government and technology expert
C	Head of Tech Operations	Radiology company offering cloud solutions	Healthcare company that offers cloud solutions for the industry
D	Sales Manager	Cloud provider	Industry leader
E	Employee	State Association in Germany	Official association of the German government and technology expert
F	Manager, Enterprise Business Development	Cloud provider	Industry leader

Table 1: Interview partners

3.3. Online Survey

To gather insights from the point of view of physicians based in Germany, an online survey using the platform "Qualtrics" was generated and distributed. The goal of this survey was to evaluate German medical practitioners' attitude towards CC before and during the pandemic. The first part of the survey assessed physicians' general knowledge and usage behaviour towards CC. In this section, the term CC was explained in order to ensure a common understanding for every participant of the survey. Depending on the frequency of usage, participants were redirected to different second blocks of the survey. The section for regular cloud users was aimed at their usage behaviour, meaning how often they used cloud solutions before and during the pandemic, what kind of cloud applications they have used, their cloud strategy and their perceived benefits and challenges of CC. The section for non-cloud users was aimed at questions regarding the consideration of cloud services before and during the pandemic as well as important features of technological solutions and assumed challenges of CC. The benefits and challenges in both sections were assessed using a five-point Likert scale. The survey concluded with a final block about the participants' demographics including whether the participant was a general or specialized practitioner.

The survey was distributed among the author's medical doctors that she is a patient of, via associations' members and online panels such as the "Deutsche Medizin Forum", the author's current employer's customers that are medical practices within Germany. A pre-test of the survey was conducted with five participants that lead to adjustment of several questions in terms of clarity and understanding. Due to the difficulty of reaching a network of medical practitioners, the initial aim of the distribution phase was to receive at least 110 survey responses from medical professionals in Germany. The data collected was anonymous and only demographic data in the past section gave clarity about the residence, gender, age and specialization of the survey participants. Results were analysed using standard multivariate statistic methods.

4. Analysis and Findings

4.1. Analysis of Expert Interviews

The expert interviews analysis was structured based on the answers to the questions that were asked in the interviews. In addition to the content retrieved from the answers, the interviewees' different points of views were incorporated as well. References are made by using the letters assigned to each interviewee in the appendix part of this dissertation.

4.1.1. Challenges for medical practices and demand for Cloud Computing

The question that was included in the interview guideline of the interviewees working in the healthcare industry, either for the official associations or medical focused cloud providers, referred to the challenges for medical practices that arose due to the COVID-19 pandemic. Four of the interviewees stated that there are two kinds of challenges that appeared during the pandemic (A, B, D, E). On the one hand, there are challenges on the communication level, that include a change in the patients' needs, for example, staying in touch with patients through the implementation of remote consultation. On the other hand, challenges directly affecting the operational part of the medical practice. For instance, those included adapting to the new hygienic measures or treating patients that were infected with the virus.

All interviewees were asked about their opinion in terms of a perceived change in the demand for CC due to the pandemic. Out of the six interviewees, five stated that the COVID-19 crisis led to an increase in the use of digital applications, in particular CC. One interviewee mentioned that the change had already been there prior to 2020, however, the pandemic accelerated this process (B). Only the State Association in Germany concluded no increase in the demand had been noticed and hence a change is not associated with the pandemic situation but rather with changing legal requirements (E).

4.1.2. Types and benefits of Cloud services

In terms of type of cloud solutions, new products have emerged such as COVID-19 tracking applications that are based on CC (F) and existing solutions such as telemedicine have recorded a boost (C). This is proved by the number of permit holders before the pandemic (40 permit holders) compared to the number of permit holders during the pandemic (1,722 permit holders) and due to the authorisation to perform and bill in this area that has increased rapidly (E).

Interviewee A and D also mentioned online appointment booking solutions as well as cloud-based practice management systems as common cloud solutions that were used during the

pandemic. However, interviewee E stated that there are no numbers of how many medical practices outsource their data to external service providers and that they as an association do not recommend external data storage to their members (E).

All interviewees except C and E were asked about the benefits of cloud solutions. Several ones were brought to attention which are summarised in table 2 below. Already in the literature review, the benefit of scalability and the pay-per-use model were mentioned. It is easier to switch services once all data is stored in the cloud and this facilitates scalability for medical practices (D, F). Scalability eventually leads to increased efficiency and a streamlined administration that facilitates the management within medical practices (A, B, D). Another factor that concurrently represents a benefit that influences cloud adoption in medical practices is conformity with regulations (B, D). Using local cloud providers presumes that conformity with regulations is given and medical practices do not need an internal legal specialist to guarantee this. Whereas in the literature review, CC was partly seen as a threat to the doctor-patient relationship, interviewee A and D confirm that using those solutions results in greater trust and improved communication. Additionally, by enhancing this relationship, patients' needs are met, and the reputation of the respective doctor practice is increased (A, D, F). Ultimately, with this enhanced reputation, medical practices are seen as a progressive digital patient service and hence attract a new clientele with more educated patients that are also willing to spend more in favour of cloud solutions (A).

Benefits	**A**	**B**	**C**	**D**	**E**	**F**	**Lit. Review**	**#**
Scalability				x		x	x	3
Increased Efficiency	x						x	2
Streamlined administration		x		x				2
Conformity with regulations		x		x			x	3
Improved communication	x			x				2
Better meeting patient demand	x			x		x		3

Increased reputation	x			x				2

Table 2: Key findings of benefits of cloud solutions

4.1.3. Privacy and other limitations of Cloud Computing

As already discovered in the literature review part of this dissertation one major limitation is the perceived privacy issue associated with CC. However, data exchange is regulated by medical confidentiality, which means that medical doctors have to make contracts with cloud providers as a basis for data processing. The medical practitioner is responsible, while cloud providers must ensure that the data is processed in accordance with the European Union's (EU) data protection regulations (A, D, E). It is important to note that the regulations from the EU and their member countries require cloud providers to have their servers within the EU (C). Since the healthcare sector is still very conservative and not informed about security and privacy standards of big cloud providers, the providers have made significant investments in the past years in order to address those concerns and to match different expectations (F).
Five of the interviewees were asked a question regarding further limitations and challenges of CC, see table 3 below. As an additional challenge, switching barriers were mentioned (A, C, D). This means that existing traditional systems are based on certain standards which make it difficult for medical practitioners to get out of them without losing any data. On top of that the current market is dominated by those big practice management system players which make it a challenge to switch to cloud providers. This lack of interoperability between those software systems is also a business model of some of the big players and led to constant re-collection of medical data for some medical practices (B). Confirmed by all interviewees and the literature review is the challenge of mentality and the initiation of a change process by implementing cloud solutions or any other medical solution. A discrepancy in mentality can be seen among generations of medical practitioners, especially younger doctors are more likely to adopt cloud solutions and when taking over an existing medical practice launching a change process within the team (B). Part of the conservative mentality is that medical doctors believe that their focus should be on the patient treatment and do not take the whole patient journey into account that can be enhanced with CC. Hence, cloud solutions are rather seen as an expensive investment that no sufficient budget is allocated towards (F).

Challenges	A	B	C	D	E	F	Lit. Review	#
Switching barriers	x	x	x	x	N/A		x	4
Mentality / Change process	x	x		x	N/A	x	x	5
Costs of cloud solutions					N/A	x		1

Table 3: Key findings of challenges of cloud solutions

4.1.4. Future outlook of Cloud Computing

Most of the experts agree that there will be a strong growth of CC and that cloud solutions will have the potential to replace traditional IT systems in the future (A, B, C, D, F). Expert A notes that in order to keep up this strong growth, data migration to the cloud needs to be facilitated and especially by the existing dominating practice management vendors in the market. Another challenge that needs to be continuously tackled and reassured is the one of security and privacy compliance (B, C). Expert F enhances that our society is only at the beginning of the digitization process and that like any other company, medical practices need to quickly be able to adapt to changes of any kind and can do so efficiently with cloud solutions. Additionally, governments and technology providers also have to react to legal, data and privacy obstacles in order to accelerate the strong growth of CC in the upcoming years. However, expert E is unsure about the future of CC and mentions that availability plays a significant role in medical practices. This means secure and functioning IT systems, which can be a challenge with external processing and lead to more dependency compared to internal solutions.

4.2. Survey Analysis

As a result of the theoretical background and literature review as well as the qualitative interviews, the following hypotheses can be derived:

H1: The general consideration of CC increased in 2020 compared to 2019.
H2: The general usage of CC increased in 2020 compared to 2019.

Five of the interviewees confirmed that there is a reason to hypothesize that the general usage of CC increased in 2020 compared to 2019. For a more detailed analysis, a differentiation between cloud users that are already using cloud solutions and non-cloud users that haven't used any cloud solutions yet, has been made.

H3: Demographic factors influence the likelihood of using cloud solutions.
H3a: A younger age of medical practitioners is associated with a higher likelihood of using cloud solutions.
H3b: The gender of medical practitioners influences the likelihood of using cloud solutions.
H3c: The type of medical practitioner is linked with the likelihood of using cloud solutions.
The literature review stated that the average age of medical practitioners in Germany is around 42 years old. However, the interviewees B and D implied that the adoption of cloud solutions is linked to a mentality change within a medical practice and consequently a replacement of older practitioners with younger ones. Thus, hypothesis 3a was deduced.
As stated in the theoretical background, the majority of medical practitioners in Germany are male. Furthermore, a digital gender divide between men and woman exists where woman are not benefiting from the digital revolution in the same way that men do which leads to the assumption of hypothesis H3b. (Shaun Crawford, 2019)
Since the literature review and interviews brought to light that general and specialized practitioners are facing different challenges based on their field of practice, they are in need of different kinds of solutions to fulfil these requirements. Hence, there is a reason to hypothesize that the type of medical practitioners plays a role in the likelihood of using cloud solutions.
In the next section, a survey and a statistical analysis will be used to test these hypotheses.

4.2.1. Sample description

During the data collection phase, 125 surveys have been accessed. Partially completed responses were eliminated from the dataset. Additionally, data obtained from participants that were not residing in Germany or younger than 25 years old were also cleared out since they are not part of the targeted statistical sample. The age minimum of 25 years was based on the average age of graduate medical students in Germany. Furthermore, respondents that failed to follow the statement in one of the 18 questions that asked participants to "Click slightly important" were also eliminated from the dataset. Leaving a total sample of 115 valid answers for further analysis. The questions of the second section were randomized in order to avoid

biases and unconscious predictions and additionally all questions of the survey were backed up by “forced response” and hence there were no missing data in the dataset.

Table 4 below describes the respondents’ distributions around the sampling variables. Analysing the descriptive statistics of the sample, the average age of the sample is approximately 45 years, 63% of medical doctors are general practitioners compared to 37% of specialized practitioners. With 57% the majority of the 115 respondents is female and more than half of the respondents (57%) have you used cloud solutions for their profession as a medical doctor before. The cloud users mainly use cloud solutions such as: online appointment booking tools (24.15%), video consultation of patients (23.77%) or practice management systems (18.87%). Their adoption strategy is mainly based on hybrid cloud (46.15%), followed by public cloud (36.92%).

Variable	Frequency	%
Age		
Average age: 45.18 years		
Min age: 28 years		
Max age: 66 years		
<=35	27	23.48%
>= 36 & <=55	59	51.3%
=> 56	29	25.22%
Gender		
Male	50	43.48%
Female	65	56.52%
Type of medical doctor		
General practitioner	73	63.48%
Specialized practitioner	42	36.52%
Usage of cloud solutions for medical practice		
Yes	65	56.52%
No	50	43.48%
Types of cloud solutions		
Online appointment booking	64	24.15%
Video consultation	63	23.77%
Practice management system	50	18.87%

Patient data management	24	9.10%
Electronic data exchange	24	9.10%
File hosting service	40	15.09%
Cloud adoption strategy		
Private cloud	1	1.54%
Public cloud	24	36.92%
Hybrid cloud	30	46.15%
Community cloud	1	1.54%
Not sure	9	1.38%

Table 4: Descriptive statistics of the sample (N=115)

4.2.2. Cloud adoption before and during the pandemic

At the beginning of the survey, a few introductory questions were asked. Their goal was to determine the use of cloud solutions as well as consideration of implementing cloud solutions in the respondents' respective medical practice.

Most of the respondents indicated that they have used cloud solutions before. From those 57%, the majority has used cloud solutions only once prior the pandemic (31%), whereas this behaviour changed during the pandemic with 54% of respondents using cloud solutions daily. Of the non-users of cloud solutions (43%), only 12% have considered cloud solutions prior the pandemic, whereas this number increased to 74% during the pandemic. (Appendix 8).

While looking at hypothesis H1 that refers to an increase of the general consideration of CC in 2020 compared to 2019, it can be said that prior the pandemic 6 respondents (12%) of the people who had never used cloud solutions considered cloud services for their professional use in their medical practice. Whereas 44 respondents (88%) did not consider cloud solutions prior the pandemic. This consideration changed in 2020, where 37 (74%) of the people who had never used cloud solutions, considered using cloud services and 13 respondents (26%) continued to not consider cloud services for the usage in their medical practice (Appendix 8). In order to see the difference in consideration in 2019 and 2020, a 2-sample test for equality of proportions with continuity correction was run. The results show that there was an increase in the consideration from 2019 to 2020 and the proportion of people considering cloud solutions is significantly higher with a p-value lower than 0.05 (Appendix 10).

In order to test the hypothesis H2, a Welch two sample t-test was run to compare the usage frequency of cloud solutions in 2019 with the usage frequency of cloud solutions in 2020 for already existent cloud users (Appendix 9). The results show that there was an increase from 2019, where cloud services for professional use were on average used once or every two months (2.6) to 2020, where cloud services were used every week or daily (5.35). This increase is statistically significant with a p-value lower than 0.05. The null hypothesis that the two-population means are the same at that confidence level can be rejected, giving support to the increase in usage frequency.

4.2.3. Differences in the usage of cloud solutions

Concluding the survey, the respondents were asked several demographic questions such as age, gender, profession.

In order to test hypothesis H3a that younger age is associated with a higher likelihood of using cloud solutions, a linear probability model was created, where the binary variable of Q4 cloud usage (1=Yes, 0=No) was used as a dependent variable and the continuous variable of Q18 age was used as an independent variable (Appendix 11). The results of the regression show that with every year of age, there is a decrease in the probability of being a cloud user by 1.1%. The variable age is statistically significant at the 1% ($p<0.01$) significance level and hence we can say that age does influence the likelihood of using cloud solutions.

To test the other two hypotheses H3b and H3c, z-tests were computed.
While looking at hypothesis H3b that gender influences the likelihood of using cloud solutions, it can be said that 61.54% of the female participants were cloud users whereas 50% of the male participants were cloud users. A 2-sample test for equality of proportions with continuity correction was run to test the null hypothesis that the gender of cloud users is equal to the gender of non-cloud users. The result shows that the p-value is lower than 0.05 and hence the null hypothesis can be rejected. Additionally, it can be concluded that the proportion of cloud users is significantly different in the two groups and hypothesis H3b can be accepted. (Appendix 10).
Looking at hypothesis H3c that assumes that the type of medical practitioner is linked to the likelihood of using cloud solutions, it can be said that 51% of general practitioners were cloud users and 67% of specialized practitioners were cloud users. Another 2-sample test of equality of proportions with continuity correction was used to test H3c. The p-value of the test is less

than the significance level alpha = 0.05. To conclude, the proportion of cloud users is significantly different in the two groups (Appendix 10).

4.2.4. Most important factors of technological solutions

To find out what the most important factors of technological solutions for non-users of cloud-solutions and for already existent cloud users are, the respondents were asked to rate several factors based on their importance.

Table 5 below shows that the three most important factors of cloud solutions for existent cloud users are regulation conformity (1.08), reliability (1.2) and efficiency (1.55). For cloud users sustainability (3), cost savings (2.75) and scalability (2.55) are least important.

Features	**Importance**					**Mean**
	Extremely important	Very important	Moderately important	Slightly Important	Not important at all	1-5
Scalability	5	22	35	3	0	2.55
Cost savings	1	20	38	6	0	2.75
Reliability	52	13	0	0	0	1.2
Sustainability	1	22	22	16	4	3
Regulation conformity	60	5	0	0	0	1.08
Efficiency	29	36	0	0	0	1.55
Streamlined Administration	7	47	11	0	0	2.06
Enabling to meet better patients' needs	46	18	1	0	0	1.31
Increased performance	26	38	1	0	0	1.62

Table 5: Importance of factors cloud user

Note: 5-point Likert scale: 1 = extremely important; 5 = not important at all

Table 6 below shows the importance of factors of technological solutions for non-cloud users. As with cloud users, regulation conformity (1.28) and reliability (1.52) are two of the most important factors. However, enabling to better meet patients' needs (1.6) is on the third rank of importance for non-cloud users. As with cloud users, sustainability (3.4) and cost savings (2.62) are least important for non-cloud users. Additionally, scalability (2.54) plays a less significant role while choosing technological solutions).

Features	**Importance**					**Mean**
	Extremely important	Very important	Moderately important	Slightly Important	Not important at all	1-5
Scalability	2	20	27	1	0	2.54
Cost savings	3	19	22	6	0	2.62
Reliability	29	17	3	1	0	1.52
Sustainability	0	9	18	17	6	3.4
Regulation conformity	42	5	1	1	1	1.28
Efficiency	17	30	2	1	0	1.74
Streamlined Administration	13	32	5	0	0	1.84
Enabling to meet better patients' needs	21	28	1	0	0	1.6
Increased performance	17	24	7	2	0	1.88

Table 6: Importance of factors non-cloud users

Note: 5-point Likert scale: 1 = extremely important; 5 = not important at all

4.2.5. Perceived challenges of cloud solutions

In an effort to find out what the most perceived challenges of cloud solutions for non-users and for already existent cloud users are, the respondents were asked to rate several factors based on their likelihood to be a challenge.

Table 7 below shows that for cloud users especially existing infrastructure investments (1.82) and legacy system and integration (1.57) are challenges likely to appear with the implementation of cloud solutions. Unlikely to appear are challenges associated with providing performance (3.78) and time investment (3.7).

Challenges	**Importance**					**Mean**
	Extremely likely	Somewhat likely	Neither likely nor unlikely	Somewhat unlikely	Extremely unlikely	1-5
Existing infrastructure investment	17	44	3	1	0	1.82
Legacy system and integration	29	35	1	0	0	1.57
Costs of cloud solutions	0	8	36	16	5	3.28
Maintaining control	0	7	39	18	1	3.2
Preserving security	2	45	9	7	2	2.42
Providing performance	0	3	19	32	11	3.78
Time investment	0	4	16	34	11	3.7

Table 7: Perceived challenges of cloud users

Note: 5-point Likert scale: 1 = extremely likely; 5 = extremely unlikely

The perceived challenges by non-cloud users can be found in table 8 below. As with the cloud users, the most common challenges that are likely to appear are associated with legacy systems and integration (1.88) as well as existing infrastructure investments (1.9). Unlikely to appear are challenges associated with providing performance (3.86) or time investment (3.72). It is important to note that compared to cloud users, non-cloud users are more likely to

perceive costs of cloud solutions (3.5 vs. 3.28) and maintaining control (3.46 vs. 3.2) as challenges associated with cloud solutions.

Challenges	**Importance**					**Mean**
	Extremely likely	Somewhat likely	Neither likely nor unlikely	Somewhat unlikely	Extremely unlikely	1-5
Existing infrastructure investment	17	26	4	2	0	1.9
Legacy system and integration	18	25	4	2	0	1.88
Costs of cloud solutions	3	10	16	10	2	3.5
Maintaining control	2	14	13	10	2	3.46
Preserving security	4	36	6	0	0	2.36
Providing performance	0	10	6	21	7	3.86
Time investment	1	8	12	18	5	3.72

Table 8: Perceived challenges of non-cloud users

Note: 5-point Likert scale: 1 = extremely likely; 5 = extremely unlikely

4.3. Discussion

In order to evaluate if the COVID-19 pandemic has had an impact on the usage of cloud solutions, the findings derived from the in-depth interviews and online survey analysis are critically examined. Some findings leave room for further analysis and observation.

Did the COVID-19 pandemic change the need for cloud solutions in German medical practices? This dissertation found that there has been in increase in both the cloud usage and

the cloud solution consideration during the pandemic compared to the year 2019 before the pandemic. Five experts as well as the survey gave support which led to accepting both hypotheses H1 and H2. However, it is possible that the change process had already been existent prior to 2020 but has been accelerated by the pandemic itself (B). Only interviewee E noted no increase and reported no linkage to the pandemic situation.
However, it can be said that the cloud usage also depends on demographic factors such as age, gender and kind of medical practitioner, which resulted in accepting hypothesis H3. Whereas the average age of respondents was 45 years, it was statistically proven that the probability of using cloud solutions decreases with every year of age and hence younger medical practitioners are more likely to use cloud solutions, which is in line with the hypothesis H3a. This goes hand in hand with the mentality within a medical practice. While looking at the gender, more female practitioners used cloud solutions than male practitioners which led to accepting hypothesis H3b. Also, more female respondents (57%) answered the survey compared to male respondents (43%) and it can be argued that female practitioners are in general more open to trying new technologies, which would need to be verified with future studies. Additionally, the survey gave support to the hypothesis H3c which states that the type of medical practitioner is linked to the likelihood of using cloud solutions. The results shows that specialized practitioners were more likely to use cloud solutions compared to general practitioners. In order to identify the root cause behind those findings, further research is required.

What are the fundamental factors influencing CC adoption decisions in German medical practices? The factors influencing the CC adoption decisions in Germany in a negative way are associated with the perceived challenges connected to CC. First and foremost, as already mentioned in the literature review, it was confirmed by both the expert interviews (A, D, E) and survey analysis that the main perceived challenges are the ones of privacy and data security. It has been revealed, that in order to comply with the regulations within Germany and the EU, cloud providers are obliged to have their servers within the EU (C). Even though the main cloud providers such as Google Cloud, Microsoft Azure or AWS, follow these regulations and laws, the awareness is still very low, and they have to practice a lot of educational work about their policy standards for the rather conservative healthcare sector (E). The majority of the interviewees also confirmed that another factor influencing the CC adoption decision are existing switching barriers. Current healthcare practice management vendors don’t facilitate switching to cloud solutions and once the decision is made, data

migration is unlikely to happen, and medical practitioners have additional work and costs in order to transfer the data from current systems (A). Additionally, another important factor that plays a role is the mentality and openness to new solutions within a medical practice, especially to initiate a change process. Most of the time, this mentality is influenced by the change of the leader, the medical practitioner, which often occurs when a medical practitioner retires and a younger generation takes over the practice. (Harmon & Safari, 2019) However, there is a difference between the most commonly perceived challenges of cloud users and non-cloud users. The analysis of the survey responses revealed that non-cloud users are more likely to perceive costs of cloud solutions and maintaining control as a major challenge associated with CC. It can be discussed that non-cloud users are not aware of the pay-per-use models and different cost structures of cloud solutions that change and can be individually tailored to the needs of medical practices. It has also been confirmed by the expert interviews that some organizations don't allocate a lot of budgets to IT in general and hence believe that cloud services are too costly. Instead of focusing on the big picture and the whole experience, some medical practitioners put the centre of attention on the patients themselves and hence see no need in improving the overall patient journey (F).

What are the main benefits for German medical practices to adopt cloud solutions?

In order to tackle some of the challenges that occurred with the COVID-19 pandemic, CC has been used (A, B, C, D, F). For instance, challenges were based on either a communication level and change in patients' needs or an operational level such as new hygienic measures (A, B, D, E). The most common benefits mentioned in the interviews are scalability (D, F), conformity with regulations (B, D) and better meeting patients' needs (A, D). Additional important factors of cloud solutions that were confirmed by the survey respondents are regulations conformity, reliability, and efficiency. In addition to that, for non-cloud users, enabling to better meet patients' needs plays a more important role, whereas scalability is ranked less important. It can be argued that the awareness for CC benefits is lower amongst non-cloud users and that their focus is strictly on the patient themselves instead of improving the overall environment with cloud solutions. Hence, non-cloud users might not be aware of the importance of scalability. Also, since they might not have experienced the benefits of the cloud yet and that they are more traditional and older in general and have a reduced openness to new solutions. Because ultimately, medical practices are also businesses that need to compete, stand out from other medical practices to not lag behind (F). Furthermore, with CC, medical practices can attract a new kind of patients, the younger, digital and health-conscious

ones, that are willing to pay more for prevention methods (A). Future research should be done in this case in order to identify the true causes.

What are the most common types of CC applications adopted in German medical practices? The most common types of CC solutions include online appointment booking systems (24.15%), video consultation platforms (23.77%) and practice management systems (18.87%). While looking at these solutions, it is reasonable that that the majority of respondents of the survey use hybrid cloud adoption strategies (46.15%) because in order to exchange sensitive data a private adoption strategy is needed, whereas for video consultation, public cloud is sufficient. The increase in telemedicine and video consultation can also be justified by the number of permit holders before in comparison to during the pandemic (40 vs. 1,722 permit holders) (E). In addition to these solutions, new products such as COVID-19 tracking applications of several countries and governments have emerged that are based on CC (F).

5. Concluding Remarks

5.1. Main Findings and Conclusion

Technology is playing an increasingly important role in the German healthcare industry. (PricewaterhouseCoopers, 2021) At the same time, the COVID-19 pandemic has accelerated the need and openness for innovative solutions such as CC. A future strong growth and potential to replace traditional IT systems is excepted if current challenges continued to be tackled by the respective institutions (A, B, C, D, F). Given these rapidly changing circumstances, new solutions in the healthcare industry are introduced in order to help medical practices to tackle the obstacles associated with the COVID-19 pandemic. Furthermore, there are still controversial point of views, even from official associations within Germany, existent in the highly regulated and conservative healthcare landscape that need to be addressed (E).

This research aimed to find out how the COVID-19 pandemic has affected the CC usage in German medical practices and associated therewith, the challenges and benefits of cloud solutions for the healthcare industry. The online survey findings show that the pandemic has increased the frequency of usage of cloud solution in German medical practices for respondents that were already using cloud solutions prior the pandemic. Additionally, the willingness to potentially use cloud solutions amongst respondents that were not using CC prior the pandemic, has also increased. The survey was, however, also aiming to find dependencies between demographic factors and cloud usage behaviour. These dependencies show that female medical professionals are more likely to use or consider using cloud solutions, same counts for younger and specialized practitioners. As the expert interviews and survey results revealed, headwinds come from older generations and conservative associations that are mentally not there yet.

In terms of the benefits of cloud solutions for medical practices, it can be concluded that obvious advantages include the pay-per-use model with flexible billing options, no investments in servers or hardware specialist, and hence no regular IT maintenance and possibilities to scale and grow the medical practice. Additional advantages evolve around the whole patient journey and experience that is facilitated and enhanced through technological solutions.

There is still room for improvement in terms of obstacles associated with cloud solutions. Apart from the challenges intrinsic to the medical practice such as an open mindset and mentality, especially privacy and data security concerns need to be addressed and medical practitioners reassured. Associated with this, data exchangeability and transfer of medical

information needs to be facilitated by technology providers and governments in order to enhance the adoption process of CC in the German healthcare industry. Furthermore, the switching barriers due to main IT healthcare system providers that do not facilitate the data transfer to cloud systems need to be addressed.

However, these are factors that can be improved and have already been improved in the past months due to the COVID-19 pandemic. Ultimately, the key to the adoption process of cloud solutions will depend on future regulations and the mindset of the medical practitioners and associations. If the medical practitioners are ready to deal with switching IT systems and the initial investments of time and budget, the benefits of cloud solutions will be predominant. Even though, the COVID-19 pandemic has facilitated and accelerated this process, some practitioners are still sceptical about the investment costs, privacy and benefits of CC. Major changes and development of cloud solutions are expected within the next few years and essentially a disruption of the rigid structures of the German healthcare system, this will make cloud solutions a more normal and common technology for medical practitioners.

5.2.Limitations and Future Research

The survey of this research was distributed among the author's professional circle, via medical associations and online platforms and further distributed by each. This led to an under-representation and over-representation of specific groups in the sample. Female practitioners and general practitioners are dominant. A more diverse sample could have affected to CC usage frequency or consideration amount. Furthermore, a larger sample size might have had a similar impact as some underrepresented groups had appropriate variables. As a result of the limited survey scope and tight time limit, a more general categorization was chosen and led to no distinct preferences in terms of benefits and challenges associated with cloud solutions. In terms of the expert interviews, only one healthcare specific cloud provider was represented, and conclusions could have been different if another viewpoint from this specific industry would have been present. In order to avoid biased and industry-specific conclusions and gain more detailed insights, more experts from healthcare specific cloud providers and existing healthcare IT manufacturers could have been added.

There are many other factors than the demographic ones mentioned in this research, that could have played a role and occurred in 2020 compared to 2019 that led medical practitioners to rather consider or more regularly use cloud solutions for their medical practice. It is suggested that future research investigates this in more detail. Further, it can be elaborated, if the general openness and willingness to adopt other technological solutions also depend on the gender

and age itself. Another area that could be further researched is to include the place of residence and not only the country of residence in the demographic questions part of the survey. This way it can be identified if CC usage or consideration depend on disparities between the medical practitioner's density of cities and the country. (Hofmarcher et al., n.d.) Additionally, the perceived challenges and benefits of cloud solutions could be researched in more detail in order to identify the root causes for the differences between cloud users and respondents that are not using cloud solutions.

References

Alashhab, Z. R., Anbar, M., Singh, M. M., Leau, Y.-B., Al-Sai, Z. A., & Abu Alhayja'a, S. (2020). Impact of coronavirus pandemic crisis on technologies and cloud computing applications. *Journal of Electronic Science and Technology*, 100059. https://doi.org/10.1016/j.jnlest.2020.100059

Amazon Web Services, Inc. (2006). *Announcing the Amazon Web Services Solutions Catalog*. About AWS. https://aws.amazon.com/about-aws/whats-new/2006/06/19/announcing-the-amazon-web-services-solutions-catalog/

Asonye, C. (2020). *There's nothing new about the 'new normal'—And here's why*. World Economic Forum. https://www.weforum.org/agenda/2020/06/theres-nothing-new-about-this-new-normal-heres-why/

Bertelsmann Stiftung. (2018). *Deutschland—Deutschland hinkt hinterher*. Bertelsmann Stiftung SmartHealthSystems. https://www.bertelsmann-stiftung.de/de/unsere-projekte/der-digitale-patient/projektthemen/smarthealthsystems/deutschland

Bethke, L. (2020, June 11). *Deutschland im digitalen Vergleich in der EU an Platz zwölf* [Text]. Deutschland - European Commission. https://ec.europa.eu/germany/news/20200611-digitalisierung_de

Bundesagentur für Arbeit. (2021). *Berichte: Arbeitsmarkt kompakt – Auswirkungen der Corona-Krise*.

Bundesärztekammer. (2019). *Ergebnisse der Ärztestatistik zum 31.12.2019*. Bundesärztekammer. https://www.bundesaerztekammer.de/ueber-uns/aerztestatistik/aerztestatistik-2019/

Bundesärztekammer. (2021). *About the German Medical Association*. https://www.bundesaerztekammer.de/weitere-sprachen/english/german-medical-association/

Bundesgesundheitsministerium. (2019). *Driving the digital transformation of Germany's healthcare system for the good of patients—Bundesgesundheitsministerium*. Digital Healthcare Act DVG. https://www.bundesgesundheitsministerium.de/digital-healthcare-act.html

Bundesministerium für Gesundheit. (2020). *Das deutsche Gesundheitssystem: Leistungsstark. Sicher. Bewährt.* 61.

Bundesministerium für Gesundheit. (2021a). *Die elektronische Patientenakte (ePA)*. Bundesgesundheitsministerium. https://www.bundesgesundheitsministerium.de/elektronische-patientenakte.html

Bundesministerium für Gesundheit. (2021b). *Selbstverwaltung*. Bundesgesundheitsministerium. https://www.bundesgesundheitsministerium.de/themen/gesundheitswesen/selbstverwaltung.html

Burkhardt, T. G., Wolfram. (2014). *Strukturen und Versorgungsformen*. Bundeszentrale für politische Bildung. https://www.bpb.de/politik/innenpolitik/gesundheitspolitik/72594/strukturen-und-versorgungsformen

Burkhart, M., & Huesman-Koecke, S. (2018). Das deutsche Gesundheitswesen auf dem Prüfstand. *PWC*, 55.

DARPA. (n.d.). *Project MAC*. Defense Advanced Research Projects Agency. Retrieved 8 December 2020, from https://www.darpa.mil/about-us/timeline/project-mac

Das deutsche Gesundheitssystem: Leistungsstark. Sicher. Bewährt. (n.d.). 61.

DESTATIS. (2021). *Bruttoinlandsprodukt im Jahr 2020 um 5,0 % gesunken*. Statistisches Bundesamt. https://www.destatis.de/DE/Presse/Pressemitteilungen/2021/01/PD21_020_811.html

Dr. med. Seedat, Jamela & Robert Koch-Institut. (2020). *Beschreibung des bisherigen Ausbruchsgeschehens mit dem neuartigen Coronavirus SARS-CoV-2 in Deutschland (Stand: 12. Februar 2020)*. https://doi.org/10.25646/6476

Egle, C. (2020). *Corona-Krise und die deutsche Wirtschaft*. EY. https://www.ey.com/de_de/covid-19/corona-krise-und-die-deutsche-wirtschaft

Evans Strategic Communications. (2019, January 25). Cloud Wars Top 10—Most Influential Cloud Vendors in the World. *The World's Top Cloud Vendors*. https://cloudwars.co/cloud-wars-top-10-vendors-world/

Fichman, R. G., Kohli, R., & Krishnan, R. (Eds.). (2011). The Role of Information Systems in Healthcare: Current Research and Future Trends. *Information Systems Research*, *22*(3), 419–428. https://doi.org/10.1287/isre.1110.0382

Gao, F., & Sunyaev, A. (2019). Context matters: A review of the determinant factors in the decision to adopt cloud computing in healthcare. *International Journal of Information Management*, *48*, 120–138. https://doi.org/10.1016/j.ijinfomgt.2019.02.002

Google Search. (2021, February 24). *'cloud computing'—Google Search*. https://www.google.im/search?q=%22cloud+computing%22&hl=en&num=10&lr=&ft=i&cr=&safe=images&tbs=&gws_rd=ssl

Google Trends. (2021, February 24). *Google Trends*. Google Trends. https://trends.google.com/trends/explore?date=all&geo=US&q=Cloud%20Computing

Harmon, P., & Safari, an O. M. C. (2019). *Business Process Change, 4th Edition*. https://learning.oreilly.com/library/view/-/9780128158487/?ar

Hofmarcher, M. M., Lietz, C., & Riedel, M. (n.d.). *Resource consumption in the EU: Allocation is more than financing – payment mechanisms in Social Health Insurance Countries Focus: Physicians and cities: A close link*. 22.

Kassenärztliche Bundesvereinigung KdöR. (2021). *Honorarverteilung und -berechnung: Wie kommt das Geld zum Arzt?* Kassenärztliche Bundesvereinigung; Kassenärztliche Bundesvereinigung (KBV). https://www.kbv.de/html/1019.php

Kuo, M.-H. (2011). Opportunities and Challenges of Cloud Computing to Improve Health Care Services. *Journal of Medical Internet Research*, *13*(3), e67. https://doi.org/10.2196/jmir.1867

LaBerge, L., O'Toole, C., Schneider, J., & Smaje, K. (2020). *How COVID-19 has pushed companies over the technology tipping point—And transformed business forever | McKinsey*. McKinsey & Company. https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/how-covid-19-has-pushed-companies-over-the-technology-tipping-point-and-transformed-business-forever

M, B., Chintan, & K, P., S. (2016). *Cloud Computing Systems and Applications in Healthcare*. IGI Global.

Mangiapane, D. S., Zhu, L., & Czihal, T. (n.d.). *Veränderung der vertragsärztlichen Leistungsinanspruchnahme während der COVID-Krise*. 58.

McKinsey. (2020). *Germany's ehealth infrastructure strengthens, but uptake lags in pharmaceutical and medical products | McKinsey*. https://www.mckinsey.com/industries/pharmaceuticals-and-medical-products/our-insights/germanys-e-health-infrastructure-strengthens-but-digital-uptake-is-lagging

Mell, P., & Grance, T. (2011). *The NIST Definition of Cloud Computing*. 7.

Microsoft. (2021). *Public Cloud vs Private Cloud vs Hybrid Cloud | Microsoft Azure*. https://azure.microsoft.com/en-us/overview/what-are-private-public-hybrid-clouds/

OECD & European Observatory on Health Systems and Policies. (2019). *Germany: Country Health Profile 2019*. https://doi.org/10.1787/36e21650-en

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research. *Administration and Policy in Mental Health and*

Mental Health Services Research, *42*(5), 533–544. https://doi.org/10.1007/s10488-013-0528-y

Porzsolt, F., Ghosh, A. K., & Kaplan, R. M. (2009). Qualitative assessment of innovations in healthcare provision. *BMC Health Services Research*, *9*(1), 50. https://doi.org/10.1186/1472-6963-9-50

praktischArzt. (2020, July 15). *Frauen im Arztberuf: Gleichstellung bei Ärztinnen?* praktischArzt. https://www.praktischarzt.de/magazin/immer-noch-eine-aufgabe-gleichstellung-bei-aerztinnen/

Presse- und Informationsamt der Bundesregierung. (2020a, March 12). *Besprechung der Bundeskanzlerin mit den Länderchefs*. Bundesregierung. https://www.bundesregierung.de/breg-de/themen/coronavirus/beschluss-zu-corona-1730292

Presse- und Informationsamt der Bundesregierung. (2020b, March 25). *Das Gesundheitssystem wird gestärkt*. Bundesregierung. https://www.bundesregierung.de/breg-de/themen/coronavirus/covid19-krankenhaus-gesetz-1735060

Presse- und Informationsamt der Bundesregierung. (2021). *Corona: Das sind die geltenden Regeln und Einschränkungen*. Bundesregierung. https://www.bundesregierung.de/breg-de/themen/coronavirus/corona-massnahmen-1734724

PricewaterhouseCoopers. (2021). *Digitalisierung im Gesundheitswesen*. PwC. https://www.pwc.de/de/gesundheitswesen-und-pharma/digitalisierung-im-gesundheitswesen.html

Prof. Dr. med. Dr. rer. pol. Obermann, K., Brendt, I., & Dr. phil. Müller, P. (2020). *Ärzte im Zukunftsmarkt Gesundheit 2020/2: Digitale Gesundheitsanwendungen (DiGa) und innovative Startups im Gesundheitswesen*. Stiftung Gesundheit.

Robert Koch-Institut. (2020). *RKI COVID-19 Germany*. Robert Koch-Institut: COVID-19 Dashboard. https://experience.arcgis.com/experience/478220a4c454480e823b17327b2bf1d4

Robert Koch-Institut. (2021). *RKI - Coronavirus SARS-CoV-2—COVID-19: Fallzahlen in Deutschland und weltweit*. Robert Koch-Institut. https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/Fallzahlen.html

Sadoughi, F., Ali, O., & Erfannia, L. (2020). Evaluating the factors that influence cloud technology adoption—comparative case analysis of health and non-health sectors: A

systematic review. *Health Informatics Journal*, *26*(2), 1363–1391. https://doi.org/10.1177/1460458219879340

Schreyögg, J. (2020). *Inhaber des Lehrstuhls für Management im Gesund- heitswesen und wis- senschaftlicher Direktor am Hamburg Center for Health Economics sowie Mitglied des Sachverstän- digenrats Gesundheit.* 2.

Shaun Crawford. (2019, March 6). *Three ways to make innovation more inclusive for women*. EY. https://www.ey.com/en_gl/women-fast-forward/three-ways-to-make-innovation-more-inclusive-for-women

Sultan, N. (2014). Making use of cloud computing for healthcare provision: Opportunities and challenges. *International Journal of Information Management*, *34*(2), 177–184. https://doi.org/10.1016/j.ijinfomgt.2013.12.011

The World Bank Group. (2021, January 5). *World Bank expects global economy to expand by 4% in 2021*. UN News. https://news.un.org/en/story/2021/01/1081392

WHO. (2021). *About the virus*. WHO. https://www.euro.who.int/en/health-topics/health-emergencies/coronavirus-covid-19/novel-coronavirus-2019-ncov

Appendix

Appendix 1 – Interview A

Date: 2.03.2021, Duration: 30 minutes
Expert: Dr. Michael Visse, Position: Orthodontist and developer of iee systems
Company: iie-systems GmbH & Co.)
Type of Company: Cloud-computing provider, German healthcare sector

Note: This interview has been translated from German to English.

What challenges did German medical practices face during the pandemic?
Major challenges have appeared on the medical level and the communication level with doctors being challenged to stay in contact with their patient and keeping the communication up. Also, hygienic measures had to be put in place such as keeping distances, informing patients not to come to practice if patient has fever. Depending on the doctor's specialty the pandemic brought additional work.

Have you noticed a change in CC demand in the health sector due to the COVID 19 pandemic?
Yes, I have noticed an increase. The demand was already there before, but due to the pandemic it catalysed. Patients are now more likely to want to book appointments online with doctors. Doctors were not aware of this, now the COVID-19 pandemic has increased their awareness towards it and doctors have started offering digital consultation hours.

How did you notice this increase and what positive benefits did it have?
There has been a 10-20% increase in demand for online solutions.
What types of CC applications do you think have the most potential to be value-adding for medical practices?
When doctors had a Corona case in their practice, all patients who were in practice had to be informed, this process could be done quickly via cloud technology. Every practice management software has an appointment calendar that includes all patients, informs these

patients selectively via cloud technology. Via groups, you can search for all patients who were in treatment from then to then and inform them via a specific text.
Also, medical practices had to close due to the COVID-19 pandemic and could easily inform all future appointments via their cloud system. Another function is that two days before their treatment, patients receive a reminder for their appointment, it is possible to implement a note in this message informing patients about the procedure if they have COVID-19 symptoms. Additionally, all patients were informed about hygiene measures and social distancing by e-mail. It is possible that doctors use their traditional practice management software and integrate an API that docks onto web-based interface of our cloud system. However, before data is transferred, patients have to give a consent in order to allow patient data such as name, date, birthday to be synchronized.

What are the underlying factors influencing decisions to implement CC in medical practices before and during the pandemic?

One major factor is increased efficiency, CC is easy and fast to educate and communicate with customers quickly. Another factor is connectivity, meaning quick exchanges between practice and patient and reaching your patients during the pandemic. Practice reputation also plays a role, which means being seen as progressive digital patient service is a game changer for patients, they feel good when doctors are modern. Patients use this cue to assume that the medical practice and the processes itself are advanced as well. Since the patient is not a professional, he/she can only judge the service and not so much the actual treatment of the doctor, hence efficiency and reliability as well as trust and competence are very important. Especially for the younger patient, everything has to be mobile optimised, because there is such an increasing amount of end devices users. However, the older patient follow suit and use more and more smartphones and thus have an increasing expectation towards medical practices as well.
Lastly, it is important to state that as a doctor with CC I select my clientele, meaning people with a good education are more willing to pay for health services and to spend money on them. With CC as a doctor, I can get a different clientele than just those patients who are ill. I can also reach the ones interested in the idea of health maintenance and preventions which is much more pronounced among digital natives. I believe that medical practices that do not rely on digitalisation do so at their own risk.

To what extent is privacy and data protection an issue?

It does not play a big role if patient is reasonably educated about benefits of service and is convinced of giving their data and receiving value in exchange. Data protection in the medical field is extremely regulated by medical confidentiality. Doctors have to make a contract with the provider as a basis for data processing, the doctor is always responsible for the patient's data, not the cloud provider. The cloud provider is only responsible for ensuring that the data is processed in accordance with EU data protection regulations. Since it is such a regulated area, medical doctors have to ensure data integrity, do not modify data and practice reasonable data protection and only give access to authorised persons.

To what extent is CC limited?
In terms of obstacles, reasonable internet is a prerequisite. Bigger obstacles are the change of routine and the change that has to happen within the company. Employees are mirror image of their bosses, hence if the change fails this is mostly associated to a leadership problem. However, if the doctor himself is convinced, then he also convinces his employees. This means that first and foremost the advantages of CC must be clearly understandable for doctor. The pandemic has pushed digitalisation and made doctors aware of the CC benefits and lead to more willingness and openness.

How will CC change the doctor-patient relationship?
People who assume a negative impact are the ones that are reluctant to change. There is this concept called “Halo effect” which basically means that for the first impression you have no second chance, thus the doctor-patient relationship and initial first contact will be improved by digitalisation. CC leads to a positive factor for patients and extremely improves their relationship to the medical practice because patients receive e.g., appointment confirmation with anamnesis form to be filled out at home and no longer have to quickly fill them out on-site quickly with clipboard which ultimately leads to a better experience and service.
Another example are blood value examinations, where the blood results are sent directly by e-mail

How widespread will CC be in the future? Does CC have the potential to replace traditional IT systems in medical practices at some point?
CC will be like the internet, it will be unstoppable, as the advantages are too great. No more servers are needed in practice, hardware will be replaced, and no more data management will be necessary. Additionally, data backups are centralized in the cloud which you can access

anywhere in the world without needing a VPN. CC has a great potential to replace traditional IT systems in medical practices because CC is much more flexible than current software solutions. The future will take place in CC and a strong growth is already happening and will continue to happen. Banks and other industries already have CC everywhere.
However, so-called practice management vendors have programs written on Windows applications and cannot be easily transferred to cloud-based programs, data migration is unlikely to happen, those vendors need to evolve but this is currently not a very serious concern in Germany. Reasons for this is that the current vendors only charge monthly fees of 150€-200€, but cloud providers could never do it for so little money, they start with 300-400€ and as they don't have the reach, would need to offer services that go beyond that.
Another potential obstacle is that doctors are attached to that traditional administrative software because it includes all the billing and staff is already well trained on it.

Appendix 2 – Interview B

Date: 17.03.2021, Duration: 30 minutes
Expert: Dr. med. Amin-Farid Aly Position: Referent Telemedicine and Telematics
Company: anonymous
Type of Company: Association in Germany

Note: This interview has been translated from German to English.

What kind of challenges were German medical practices facing during the pandemic?
There have been several challenges, on the one hand with patients who wanted to come to practices and continue to be treated and with patients who have chronic diseases and needed to be monitored and come at certain intervals to practices.
Also, completely new challenges have appeared, luckily, the ban on pure remote treatment was lifted in 2018, which means that the treatment of patients who have not been seen before is possible if medical due diligence is observed. This ban was lifted even before the pandemic. Doctors were very afraid to treat patients via video consultation, experienced doctors say that they have fewer senses at their disposal. First impressions like smell, posture etc. of patients are missing. These make up an unconscious part of the treatment and diagnosis, if this is omitted, it means certain danger, therefore it has been very difficult to lift this pure ban.

Have German medical practices adapted/ rethought their IT infrastructure as a response to the COVID-19 challenges?

A change in the health care system towards a rethinking of the IT infrastructure already started in 2005. Back then, there was consideration of how to prepare practice information systems and hospital information systems much better for the exchange of data. The software industry had to be broken up, exchange from practice to practice was not possible. However, it took a long to facilitate data exchange and existing business models had to change. There are several providers that operate largely in the cloud, you can see there is a change that was already there before and the pandemic has strengthened it again, accelerated.

There are practice information systems that are purely about CC. The need has changed again due to the pandemic, it has become much clearer that there is an urgency there.

In terms of the basic attitude among physicians, I can say that there has been a slow change. In 2008/2009 there were still very strong fights against all possible innovations. However, in 2017/2018 a generational change has been noticed, younger doctors came in and the older, who did not think anything of technologies, slowly became the minority. The objections of the older ones were mainly related to data protection and doctor's confidentiality. However, the mentality changed in 2017/2018 and even the older ones realized that it is almost too late now. The difference is not seen between urban and rural regions, but it depends on the practice owner himself or herself

What are the main drivers for German medical practices to adopt/not adopt cloud solutions?

The biggest problem doctors have is when they are locked into practice information systems, meaning that they have systems that are based on certain standards and where they can't get out of. The reason why they can't get out is because as soon as they get out, they lose all the data. With CC doctors have the possibility to switch services much faster since SaaS system distribute data via the cloud. With the pay-per-use model, doctors can easily switch to other providers while keeping all data secure. With CC the whole effort such as data protection, security aspects, which a doctor has to solve in his practice, may not be in his scope with the usage of CC. Doctors used to operate the software administration themselves, however the requirements have become increasingly stringent. In the past years, it became clear that practices are quite vulnerable and that self-made solutions are no longer useful. One option would be working with software companies. However, if a doctor decides to work with one, they become dependent on that company. An alternative would be cloud solutions, which lets

the doctor focus on his profession as a medical practitioner and not worry about security issues. This solution works well, as long as it is safe. If news report that it is not available 24/7 or if the doctor has made them liable in any form in the past years, then the reputation of cloud providers and the whole construct of cloud solutions start to collapse.
To sum up, security is the biggest issue followed by the ability to migrate data to the cloud. Additionally, current software systems rarely move to cloud. Practices are most likely to change the system once a new practice owner from another generation arrives. The market is very heterogeneous fragmented and there are no real competitors. The main players are big companies such as CompuGroup, that have bought several individual systems. In my opinion the development of CC in German medical practices is happening very slowly.

What kind of cloud services are German medical practices using?
Instead of the big players, there are mainly specific medical cloud providers. German doctors are more cautious in working with the big companies such as Google, due to trust issues in terms of data security. It is important that the medical providers have servers in the EU since the privacy shield has now been overturned, there is no legal certainty that they can outsource data abroad.

How far will CC be taken in the future?
If it is done securely, then it is a solution of the future. The danger with CC is always that I store data on other people's computers. I have the possibility to encrypt the data so that no one can access it, but the problem is the metadata, which I have to leave open. From this metadata I can get a lot of information. The temptation to get hold of health data is very great, as this data is very valuable. Trust is super important and has to be there. I never know to for sure what I buy I need effort and will of the provider that he does not misuse data. Scepticism amongst health care providers is great because we know as doctors that data are worth a lot and were entrusted to us. We need a lot of time without any security incidents so that doctors have the confidence that nothing has happened all these years and it is a secure solution. Security technologies have become so complex that a normal person can no longer see through them.

Appendix 3 – Interview C

Date: 15.03.2021, Duration: 30 minutes
Expert: Avner Shahal Position: Head of Tech Operations
Company: medneo
Type of Company: healthcare, Radiology as a Service

Note: This interview has been translated from German to English.

To what extent does cloud computing play a role at medneo?
Our partner physician practices don't have CC issues because IaaS is taken over by medneo Hence, the topic does not resonate with physicians in practices. At medneo we run the CC environments with different data centres.

What role does it play with medneo's customers, the medical practices?
Our customers are mostly technology, meaning they are not very involved with IT and solutions such as CC. The new KBV measures as of 1. April 2021 state that cloud will be significantly restricted due to data protection and hosting of patient-related data that could possibly reach outside the EU will be prohibited. For us this is no threat since we are compliant and taking measures with this and medneo has data centres in Germany. Large cloud providers such as Microsoft don't play a big role as a competition because they mostly have their data centre outside the EU.

Has the need changed as a result of the COVID-19 pandemic?
Telemedicine has received a boost. However, this should not be considered without restrictions because of patient data. There are different guidelines on which certified solutions can be used. Most common solutions such as teams, zoom, etc. are not commonly used in the healthcare industry since you have to rely on German solutions with data centers in the country. An example of an online appointment scheduling solution is e.g. Doctena .

To what extent is CC limited?
From a business point of view, you can't access biggest providers as a medical practice, but rather have to use small companies, and don't do telemedicine via teams etc. This is all due to

regulations from European Parliament as well as country-specific data protection measures that go along with COVID-19.

How widespread will CC be in the future? Does CC have the potential to replace traditional IT systems in medical practices at some point?
CC has already replaced many IT systems and can no longer be brought back. Nowadays, we do everything on the cloud. We also no longer rely on what has to take place on site. It can also work privacy compliant, medneo does that and cloud together. Another great benefit of CC is that it manages everything, updating is much more difficult if you put everything on local servers.

Appendix 4 – Interview D

Date: 16.04.2021, Duration: 25 minutes
Expert: anonymous Position: Sales Manager
Company: anonymous
Type of Company: International cloud-computing provider

Note: This interview has been translated from German to English.

Have you noticed a change in CC demand in the health sector due to the COVID 19 pandemic?
Yes, the pandemic had an impact on the CC usage in all industries, however one of the highest impacts was noticed in the healthcare sector. Especially in Germany there were many non-digital medical practices that had to drastically change their way of working and scale their practices while providing for their patients in uncertain environments. We can see a higher amount of request for CC solutions in the healthcare industry.

What types of CC applications do you think have the most potential to be value-adding for medical practices?
Due to social distancing, many doctors had to quickly find online solutions such as online appointment bookings, online consultation and telemedicine in general. Those are general solutions that are easier to implement. However, there are also some doctors that changed their whole infrastructure, meaning that they started using patient management.

What are the underlying factors influencing decisions to implement CC in medical practices before and during the pandemic?

In Germany, conformity is a very important factor, meaning that medical practices need to protect their patient data and hence need solutions that are conform with the legal requirements. They want to efficiently meet their patient needs, since patients are becoming more and more digitally connected as well and they want to increase internal efficiency and scale their medical practices in order to succeed in this competitive landscape. Before the pandemic, CC adoption was not considered as much, hence back then the focus was more on improving internal processes since the external pressure that came along with the COVID-19 pandemic simply wasn't there yet

To what extent is privacy and data protection an issue?

As mentioned earlier, the healthcare industry in Germany is highly regulated. Hence, we need to make sure that we are always up to date with the latest European and German guidelines and also communicate this benefit to our customers. There is this overall negative image of data and security issues in other areas such as with social media platforms like Facebook, however, this can't be generalized and hence we need to work hard to really show our added value and reassure German medical practices.

To what extent is CC limited?

In terms of limitations, I would say the biggest challenge is the mentality of some practitioners that are not willing to adopt cloud solutions but also the current infrastructure which is dominated by some big practice management system players and doesn't let you easily switch to the cloud. As cloud-providers we need to reassure our clients and provide them with easy onboarding solutions that make switching to the cloud simple, time and cost-efficient.

How will CC change the doctor-patient relationship?

We have heard this objection from some of our leads in the past, but it is important to say that the doctor-patient relationship will in no way be negatively impacted. Doctors will rather meet their patient needs, inefficient administrative tasks can be streamlined, made easier and more accessible via the cloud. Also, patients are more likely to switch to medical practices that are modern and hence show quality and expertise, which is generalized by the patient and

makes them trust this practice more and more. Additionally, with the COVID-19 pandemic, thanks to CC, patients are able to stay in touch with their doctors which is a great benefit for the relationship.

How widespread will CC be in the future? Does CC have the potential to replace traditional IT systems in medical practices at some point?
In my opinion, CC is the future, you can see this by having a look at the immense growth rates especially during the past year. Almost every industry is adopting cloud-solutions and now it is more important than ever that highly regulated industries such as healthcare and finance are following. It will for sure at some point replace the traditional IT systems and on a positive note, the pandemic has accelerated this process.

Appendix 5 – Interview E

Date: 20.04.2021, Duration: 20 minutes
Expert: anonymous Position: anonymous
Company: Rhineland-Palatinate Association of Statutory Health Insurance Physicians
Type of Company: State Association

Note: This interview has been translated from German to English.

What challenges did German medical practices face during the pandemic?
The main challenge at the beginning was to ensure the outpatient treatment of patients suffering from COVID-19 despite the lack of protective equipment. To this end, we set up our own Corona outpatient clinics, so that patients only had to go to hospital if they had a severe course of the disease. In the further course, the difficulty was to take away the fear of going to the doctor's office, especially for chronically ill patients. One solution was to offer video consultations.

What solutions have German medical practices found to meet these challenges?
Part of this solution is the use of video consultation. The authorisation to perform and bill in this area has increased rapidly. Before the COVID-19 pandemic, there were 40 permit holders

and now this figure stands at 1,722 members. Due to a general decree issued by our Board of Directors, our members can currently offer and bill for video consultations until 30 June 2021 even without authorisation from the KV RLP.

Have German medical practices adapted/rethought their IT infrastructure in response to the COVID 19 challenges?
Not as a result of the pandemic. Rather by the legal requirement to connect to the telematics infrastructure (TI) from 2019 in order to check the validity and up-to-dateness of the insured's master data and to guarantee access to the legally prescribed applications according to § 334 SGB V.

What kind of technology do the medical practices use?
In addition to the telematics infrastructure (VPN access), video consultation is very often used, which is end-to-end encrypted and can only be carried out with certified video service providers.

Are you familiar with the term Cloud Computing (CC)? What is your understanding of the term in the context of the German healthcare system?
Many panel doctors associate the term cloud computing with the telematics infrastructure (TI).

From your point of view, what is the current status quo regarding CC in German medical practices?
We do not know whether and how many practices outsource their data to external service providers. The KV RLP does not recommend external data storage to its members.

Has the need changed due to the COVID 19 pandemic?
From our point of view, no.

What are the main drivers for German medical practices to adopt/not to adopt cloud solutions?
Referring to question 5, the TI. Panel doctors are subject to medical confidentiality. They are responsible both for compliance with data protection and for the proper processing and

storage of their patient documentation. Here, too, there are still very many sceptics regarding data protection and information security.

What kind of cloud services and providers do they use?
Video consultation of KBV-certified providers.

How widespread will CC be in the future? Does CC have the potential to replace traditional IT systems in medical practices at some point?
Besides the confidentiality of data, availability plays a major role in medical practices. Secure and functioning IT is enormously important for medical practices. Many practices already complain about the poor availability of their service providers and realise how dependent they are on them. External processing would make medical practices even more dependent.

Appendix 6 – Interview F

Date: 22.04.2021, Duration: 40 minutes
Expert: Rayane Radjabaly Position: Manager, Enterprise Business Development
Company: Salesforce
Type of Company: cloud-based software company

How does Salesforce collaborate with companies from the healthcare industry?
Salesforce is historically focused on CRM. However, in the past years, the company has been successful to understand the different healthcare dynamics and life science industry through developing solutions that are close to healthcare business and offering solutions that are iterative and scalable.

Have you noticed a change in CC demand in the healthcare industry due to the COVID-19 pandemic?
Yes, with the pandemic, new products have appeared. For example, the “vaccine cloud” that helps public institutions, companies and medical practices to manage the roll out and monitor the vaccine process. This product developed from the expertise that Salesforce has gotten from partnering with different companies.

Historically hospitals, doctor practices and laboratories were always considered as the conservative ones, since the first lockdown, they have been using technologies and CC to be able to meet challenges and respond to the crisis in speed and scale. The emphasis here lies on scalability in order to help citizens and countries. Also, most governments developed their own COVID-19 tracking application and relied on CC and API technologies to do so.

What are the fundamental factors influencing CC adoption decisions in medical practices before and during the pandemic?

There is a mix of factors. First of all, navigating through changes that are as big as a pandemic lead to a need for transformation. Even before the pandemic, there had been a shift in the need for patients, the demand to book appointments conveniently online, have quick digital consultations with all patient data in one place are just some of the examples. The expectations and needs have changed, the patients are at the centre of the investment, marketing, research and development. Another factor is the competition, companies and organizations try to replicate success that they have seen elsewhere. This social pressure effect leads to medical practices not wanting to lag behind and use technologies to scale their businesses.

To what extent is privacy and data protection an important factor?

Privacy and data protection are for everyone an important factor. Especially in Europe with different legislations and the GDPR, medical practices have become very demanding in terms of security guidelines. Technology providers have invested a lot to address those concerns and match the different expectations. There have been a lot of investment in developing white books, articles in order to educate people and teams of security experts have been built to address those concerns. Additionally, regulators in most countries have addressed those issues, because medical practices are one of first frontline services they offer to citizen, so they adapted regulations and constraints that, for example, relate to data sharing. This has functioned as an acceleration because ultimately providers will also invest more in order to educate.

The healthcare sector is still very conservative and not up to date with security and privacy standards of big providers. There have been confrontations between European and American providers. Medical practices confront big cloud providers with privacy and data protection concerns but don’t go beyond this point and have meaningful conversations. However, once they are educated and understand that there is no risk, they are more open to cloud solutions.

There is a discrepancy between what happens because of lack of awareness, what the law is requesting and the perception by medical practices that see CC as a threat or risk.

What types of CC applications do you think have the most potential to be value adding for medical practices?

You have to think in terms of different layers. For example, SaaS solutions store patient data in one platform, that medical doctors can access from anywhere in the world, no matter where they are located in that specific moment. The second and third layer are scalable infrastructures with PaaS and IaaS. Those layers depend on what underlying IT infrastructure the medical practice relies on. In the best-case scenario, archives are stored and managed on a local drive that they use as a server. This drive is very local, which means that difficulties arise once they have to share data with for example consultants or patients that are temporarily located outside their home country.

What are other objections from medical practices?

There are organizations that don't allocate a lot of budget and money to IT in general. As an objection they believe that cloud services are too pricey, and they have no budget for CC. Doctors believe that only expertise is on treating patients and hence would locate most budget on. However, they wouldn't allocate it on the whole experience and patient journey that can be enhanced with technologies and CC. It is important that they take a step back, look at the ROI, and realize that for example, the time to booking needs to be improved, a platform for self-service with common questions needs to be developed and rescheduling fees if a patient doesn't show up should be implemented. For a lot of medical doctors this deems secondary but if this is made a priority, it will enhance the whole patient experience significantly.
Often from German medical practices, an objection is that big cloud providers such as Google or Salesforce are too generic in their eyes and not customizable to the medical practices business. This is not the case, since the whole benefit of any cloud is that it is customizable and scalable.

How far will CC be taken? Does CC have the ability to replace traditional/In-house IT systems in medical practices at some point?

We are just at the beginning of the digitization of the society and communities. Medical practices are no different than other companies, they need to adapt to changes in demand and behaviour of their patients. Current obstacles are stronger requirements in terms of legal, data

and privacy. However, technology providers or governments will have to react to those and evolve. It will be very interesting to see how that translates to multiple changes in the next 10 to 15 years and even medical doctors will understand that they will have to leverage those opportunities

Appendix 7 – Online survey

Start of Block: General attitude towards the perception of Cloud Computing

Q2 Are you familiar with the term Cloud Computing?

- ○ Yes (1)
- ○ No (2)

Q4 Have you used any cloud solutions for your profession as a medical doctor/practice before?

- ○ Yes (1)
- ○ No (2)

Q3 Cloud computing is the on-demand delivery of IT resources over the Internet with pay-as-you-go pricing. Instead of buying, owning, and maintaining physical data centers and servers, you can access technology services, such as computing power, storage, and databases, on an as-needed basis from a cloud provider like Amazon Web Services (AWS), Google Cloud, Microsoft Azure or many smaller specialised companies.

End of Block: General attitude towards the perception of Cloud Computing

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Start of Block: Cloud users

Display These Question:

If Have you used any cloud solutions for your profession as a medical doctor/practice before? = Yes

Q5 Which of the following cloud solutions do you regularly use as a medical doctor/practice? (multiple answers possible)

- ☐ Online appointment booking (1)
- ☐ Video consultation of patients (2)
- ☐ Practice management system (3)
- ☐ Patient data management (4)
- ☐ Electronic data exchange (5)
- ☐ File hosting servie (e.g. OneDrive by Microsoft (6)

Q6 How often have you, on average, used cloud services for your professional use in the past 12 months(during the pandemic)?

- ○ Never (1)
- ○ Once (2)
- ○ Every 2 months (3)
- ○ Once per month (4)
- ○ Every week (6)
- ○ Daily (7)

Q7 Which of the following aspects is important to you while using Cloud Computing?

	Extremely important (1)	Very important (2)	Moderately important (3)	Slightly important (4)	Not at all important (5)
Scalability (1)	○	○	○	○	○
Cost savings (2)	○	○	○	○	○
Reliability (3)	○	○	○	○	○
Sustainability (4)	○	○	○	○	○
Regulation conformity (5)	○	○	○	○	○
Efficiency (6)	○	○	○	○	○
Click slightly important (7)	○	○	○	○	○
Streamlined administration (8)	○	○	○	○	○
Enabling to better meet patients' demand (9)	○	○	○	○	○
Increased performance (10)	○	○	○	○	○

Q8 How often have you, on average, used cloud services for your professional use in 2019 (prior to the pandemic)?

- ○ Never (1)
- ○ Once (2)
- ○ Every 2 months (3)
- ○ Once per month (4)
- ○ Every week (5)
- ○ Daily (6)

Q9 In your perception, which one of the following elements could be a challenge associated with cloud-solutions?

	Extremely likely (1)	Somewhat likely (2)	Neither likely nor unlikely (3)	Somewhat unlikely (4)	Extremely unlikely (5)
Existing infrastructure investment (1)	○	○	○	○	○
Legacy system and integration (2)	○	○	○	○	○
Costs of cloud-solutions (3)	○	○	○	○	○
Maintaining control (4)	○	○	○	○	○
Preserving security (5)	○	○	○	○	○
Providing performance (6)	○	○	○	○	○
Time investment (7)	○	○	○	○	○

Q20 What statement best describes your cloud adoption strategy?

- ○ Private cloud (1)
- ○ Public cloud (2)
- ○ Hybrid cloud (3)
- ○ Community cloud (4)
- ○ Not sure (5)

End of Block: Cloud users

Start of Block: Non cloud users

Display These Question:

If Have you used any cloud solutions for your profession as a medical doctor/practice before? = No

Q10 Have you considered cloud-based solutions in 2019 (before the pandemic)?

- ○ Yes (1)
- ○ No (2)

Q11 In your perception, which one of the following elements could be a challenge associated with cloud-solutions?

	Extremly likely (1)	Somewhat likely (2)	Neither likely nor unlikely (3)	Somewhat unlikely (4)	Extremely unlikely (5)	I don't know enough about Cloud Computing to answer this question (6)
Existing infrastructure investment (1)	○	○	○	○	○	○
Legacy system and integration (2)	○	○	○	○	○	○
Costs of cloud-solutions (3)	○	○	○	○	○	○
Maintaining control (4)	○	○	○	○	○	○
Preserving security (5)	○	○	○	○	○	○
Click Somewhat unlikely (6)	○	○	○	○	○	○

Providing performance (7)	○	○	○	○	○	○
Time investment (8)	○	○	○	○	○	○

Q12 Have you considered cloud-based solutions in the past 12 months (during the pandemic)?

○ Yes (1)

○ No (2)

Q13 What factors are important to you while working with technological solutions?

	Extremely important (1)	Very important (2)	Moderately important (3)	Slightly important (4)	Not at all important (5)
Scalability (1)	○	○	○	○	○
Cost savings (2)	○	○	○	○	○
Reliability (3)	○	○	○	○	○
Sustainability (4)	○	○	○	○	○
Regulation conformity (5)	○	○	○	○	○
Efficiency (6)	○	○	○	○	○
Streamlined administration (7)	○	○	○	○	○
Enabling to better meet patients' demand (8)	○	○	○	○	○
Increased performance (9)	○	○	○	○	○

End of Block: Non cloud users

Start of Block: Demographics

Q14 What is your gender?

- Male (1)
- Female (2)
- Prefer not to say (3)

Q18 What is your current age?

_____

Q25 In which country do you currently reside?

▼ Afghanistan (1) ... Zimbabwe (1357)

Q19 I am a ...

- ... general practioner (1)
- ... specialised practitioner (2)

End of Block: Demographics

Appendix 8 – Cloud adoption prior and during the pandemic

Variable	Frequency	%
Cloud usage prior the pandemic		
Never	16	24.62%

Once	20	30.77%
Every 2 months	14	21.54%
Once per month	8	12.31%
Every week	3	4.62%
Daily	4	6.15%
Cloud usage during the pandemic		
Never	0	0%
Once	1	1.54%
Every 2 months	2	3.08%
Once per month	6	9.23%
Every week	20	30.77%
Daily	35	53.85%
Cloud consideration prior the pandemic		
Yes	6	12%
No	44	88%
Cloud consideration during the pandemic		
Yes	37	74%
No	13	26%

Appendix 9 – Welch Two Sample t-test

```
        Welch Two Sample t-test

data:  dt[, Q6] and dt[, Q8]
t = 13.222, df = 107.53, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 2.340980 3.166712
sample estimates:
mean of x mean of y
 5.353846  2.600000
```

Q6 = cloud solutions usage frequency in 2020

Q8 = cloud solutions usage frequency in 2019

Appendix 10 – 2-sample test for equality of proportions with continuity correction

Cloud considerer before and during the pandemic:

```
        2-sample test for equality of proportions with continuity correction

data:  c(6, 37) out of c(50, 50)
X-squared = 36.72, df = 1, p-value = 1.364e-09
alternative hypothesis: two.sided
95 percent confidence interval:
 -0.7913113 -0.4486887
sample estimates:
prop 1 prop 2
  0.12   0.74
```

44 non cloud considerers in 2019

6 cloud considerers in 2019

13 non cloud considerers in 2020

37 cloud considerers in 2020

50 total cloud and non-cloud considerers

Gender of cloud users and non-cloud users:

```
        2-sample test for equality of proportions with continuity correction

data:  c(25, 40) out of c(50, 65)
X-squared = 1.0975, df = 1, p-value = 0.2948
alternative hypothesis: two.sided
95 percent confidence interval:
 -0.31527272  0.08450349
sample estimates:
   prop 1    prop 2
0.5000000 0.6153846
```

25 male and cloud users

50 male

40 female and cloud users

65 female

Profession of cloud users and non-cloud users:

```
        2-sample test for equality of proportions with continuity correction

data:  c(37, 28) out of c(73, 42)
X-squared = 2.1588, df = 1, p-value = 0.1418
alternative hypothesis: two.sided
95 percent confidence interval:
 -0.36154244  0.04190774
sample estimates:
   prop 1    prop 2
0.5068493 0.6666667
```

37 general practitioners and users

73 general practitioners

28 specialized practitioners and users

42 specialized practitioners

Appendix 11 – Linear Regression

```
================================================
                        Dependent variable:
                    ---------------------------
                                Q4
------------------------------------------------
Q18                          -0.011***
                              (0.004)
Constant                     1.062***
                              (0.189)
------------------------------------------------
Observations                    115
R2                             0.061
Adjusted R2                    0.053
Residual Std. Error      0.485 (df = 113)
F Statistic          7.347*** (df = 1; 113)
================================================
Note:                *p<0.1; **p<0.05; ***p<0.01
```

Q4 = Have you used any cloud solutions for your profession as a medical doctor/practice before?

Q18 = What is your current age?