THE EFFECTS OF THE COVID-19 PANDEMIC ON THE TRANSITION TOWARDS DIGITAL HEALTH SOLUTIONS

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EVIDENCE FROM TELEMEDICINE USE IN GERMANY

Daiki Baba

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Abstract

Title: The Effects of the COVID-19 Pandemic on the Transition towards Digital Health Solutions - Evidence from Telemedicine Use in Germany.

Author: Daiki Baba

Since the outbreak of the COVID-19 pandemic, the way digital health services are perceived and valued has changed. To minimize the risk of virus transmission, digital health services have come to the fore in place of traditional health services. A prominent example of digital health is telemedicine as it is convenient, time saving, and meets the needs of social distancing.

The purpose of this thesis is to examine the effects of the COVID-19 pandemic on telemedicine and the acceptance and use of this service by physicians in Germany. Country-specific characteristics of the German healthcare system are described, and physicians' perceptions of the benefits and limitations of telemedicine are elaborated. The research consists of several expert interviews and an online survey among physicians in Germany.

The results indicate that both, the acceptance and use of telemedicine among German physicians have increased in the wake of the COVID-19 pandemic. Nevertheless, it is evident that telemedicine is only used in specific cases and that the service is currently merely a complement to traditional healthcare. The main benefits of telemedicine are the savings in travel time for physicians and patients as well as improved interactions between physicians, while the main limitations are technical difficulties and the lack of physical patient examinations. Physicians from university hospitals, who are young and have strong technological know-how are the main users of telemedicine in Germany. Although telemedicine has not yet reached mass adoption, the outlook on telemedicine is promising, as the view on digital healthcare has shifted.

Keywords: Telemedicine, Digital Health, eHealth, Healthcare in Germany, COVID-19 Pandemic, Use of Telemedicine by Physicians

Resumo

Título: Os Efeitos da Pandemia da COVID-19 na Transição para Soluções de Saúde Digitais – Comprovações com base na Telemedicina na Alemanha.

Autor: Daiki Baba

Desde o surto da pandemia COVID-19, a forma como os serviços de saúde digitais são compreendidos e valorizados mudou. Para minimizar o risco de transmissão do vírus, os serviços de saúde digitais têm vindo a ocupar o lugar dos serviços de saúde tradicionais. Um exemplo proeminente de serviços de saúde digitais é a telemedicina, pois é conveniente, economiza tempo e satisfaz as necessidades de distanciamento social.

O objetivo desta tese é examinar os efeitos da pandemia COVID-19 na telemedicina e a aceitação e utilização deste serviço por médicos na Alemanha. São descritas as características específicas do sistema de saúde alemão e são elaboradas as perceções dos médicos sobre os benefícios e limitações da telemedicina. A investigação consiste em várias entrevistas feitas a especialistas e numa pesquisa quantitativa, um inquérito online, realizada entre médicos na Alemanha.

Os resultados indicam que tanto a aceitação, como a utilização da telemedicina entre os médicos alemães aumentaram como consequência da pandemia COVID-19. No entanto, é evidente que a telemedicina só é utilizada em casos específicos e este serviço é atualmente, apenas um complemento aos cuidados de saúde tradicionais. Os principais benefícios da telemedicina são a poupança de tempo de viagem para médicos e pacientes, bem como a melhoria das interações entre médicos, enquanto as principais limitações são as dificuldades técnicas e a falta de exames físicos dos pacientes. Os médicos dos hospitais universitários, que são jovens e possuem um forte know-how tecnológico, são os principais utilizadores da telemedicina na Alemanha.

Palavras-chave: Telemedicina, Saúde Digital, eHealth, Cuidados de Saúde na Alemanha, Pandemia COVID-19, Utilização da Telemedicina por Médicos

Table of Contents

Abstract III

Resumo IV

List of Abbreviations VII

List of Figures VIII

List of Tables IX

1. Introduction 1

1.1 Research Purpose and Objective 1

1.2 Research Questions and Relevance 2

1.3 Research Structure 3

2. Literature Review 4

2.1 The Concept of Digital Health 4

2.1.1 Terminology 4

2.1.2 Telemedicine and its Areas of Application 5

2.1.3 Benefits and Limitations of Telemedicine 6

2.2 Determinants of Telemedicine Implementation 8

2.2.1 Technology 9

2.2.2 Policy and Legislation 9

2.2.3 Acceptance 10

2.2.4 Financing 10

2.2.5 Organization 11

2.3 Contextualizing Digital Health in Germany 11

2.3.1 Healthcare in Germany 11

2.3.2 Historical Ban on Remote Medical Treatment 14

2.3.3 Legal Framework for Digital Health and Telemedicine 14

2.3.4 Status of Telemedicine before the COVID-19 Pandemic 16

2.3.5 Contextualizing the COVID-19 Pandemic and Telemedicine 17

3. Methodology 20

3.1 Research Design 20

3.2 Expert Interviews 20

3.2.1 Analysis of Expert Interviews 21

3.2.1.1 Benefits of Telemedicine 21

3.2.1.2 Experts' Use of Telemedicine 23

3.2.1.3 Limitations of Telemedicine 24

3.2.1.4 Points of Improvement for Telemedicine 26
3.2.1.5 Future Outlook on Telemedicine 27

3.3 Online Survey 28
3.3.1 Analysis of the Benefits of Telemedicine 28
3.3.2 Analysis of the Limitations of Telemedicine 30
3.3.3 Physicians' Opinion on Telemedicine 31
3.3.4 Use of Telemedicine before and during the COVID-19 Pandemic 32
3.3.4.1 Influence of Benefits on the Use of Telemedicine 33
3.3.4.2 Influence of Demographic Factors on the Use of Telemedicine 33
3.3.4.3 Influence of Technological Skills on the Use of Telemedicine 34
3.3.4.4 Influence of the Work Environment on the Use of Telemedicine 34

4. Discussion of Results and Managerial Implications 35

4.1 Key Attributes of Telemedicine 35

4.2 Steps to increase Acceptance and Use of Telemedicine 36

5. Conclusion 39

5.1 Main findings 39

5.2 Limitations and Future Research 39

6. References 41

7. Appendix 55

List of Abbreviations

AI	Artificial Intelligence
App	Application
BÄK	German Medical Association
BITKOM	Federal Association for Information Technology, Telco and New Media
BMG	Federal Ministry of Health
BMWi	Federal Ministry of Economics and Industry
COVID-19	Corona Virus Disease 2019
EC	European Commission
eHealth	Electronic Health
eHealth Act	Act for Secure Digital Communication and Applications in the Health Sector
eHealth Card	Electronic Health Card
ePatient	Electronic Patient
ePA	Electronic Health Record
EU	European Union
G-BA	Federal Joint Committee
GDP	Gross Domestic Product
GKV	National Association of Statutory Health Insurance Funds
IF	Innovation Fund
IT	Information Technology
KBV	National Association of Statutory Health Insurance Physicians
MBO-A	German Medical Association´s Professional Code of Conduct
mHealth	Mobile Health
OECD	Organization for Economic Co-operation and Development
PHI	Private Health Insurance
RKI	Robert-Koch-Institute
SARS-COV2	Severe Acute Respiratory Syndrome-Coronavirus 2
SHI	Statutory Health Insurance
TI	Telematics Infrastructure
WHO	World Health Organization
ZI	Central Institute for Statutory Health Care in Germany

List of Figures

Figure 1 Telemedicine and Related Terms: A Delimitation 4

Figure 2 Areas of Telemedicine Application 6

Figure 3 Determinants of Telemedicine Implementation 9

Figure 4 Levels of the German Healthcare System 13

Figure 5 Interaction among Participants of Telemedicine in Germany 14

List of Tables

Table 1 New National Laws to advance eHealth in Germany 15

Table 2 Overview of the Interviewed Experts 21

Table 3 Benefits of Telemedicine 22

Table 4 Limitations of Telemedicine 25

Table 5 Points of Improvement for Telemedicine 27

Table 6 One-sample T-test results of Telemedicine Benefits 30

Table 7 One-sample T-test results of Telemedicine Limitations 32

Table 8 Opinion on Telemedicine Use before and during the COVID-19 Pandemic 33

1. Introduction

Since the outbreak of the COVID-19 pandemic in the beginning of the year 2020 (WHO Europe, 2020, 2021), the need for new, more digitized healthcare systems has become apparent. New electronic health services that accompany and optimize traditional healthcare systems are important to improve their performance, accessibility, comfort, and efficiency (Martins et al., 2020). Developments in the areas of service delivery, artificial intelligence (AI), and data sharing have been triggered by the COVID-19 pandemic and their potential applications are vast (Peek et al., 2020). Even though the need for more digitized healthcare systems is substantial and the usefulness of digital services is obvious, many countries worldwide, including Germany, have not yet fully tapped into the era of digital healthcare. According to Nohl-Deryk et al. (2018), the digitization of the German healthcare sector is low in international comparisons and especially low when compared to other German industries. Unlike other industries, the healthcare industry is a late adopter of digital technologies (WHO Europe, 2019). In 2018, Germany occupied only the penultimate position in the Digital Health Ranking of 17 European and OECD countries (Bertelsmann Stiftung, 2021a, 2021b). The study identified causes of Germany´s poor performance. These include the lack of an effective national eHealth strategy and the absence of financial incentives and uniform regulations (Bertelsmann Stiftung, 2021a). A lack of willingness to change and an inadequate organizational structure are other major barriers for digital healthcare (Nohl-Deryk et al., 2018).

The current pandemic is bringing other than traditional healthcare solutions to the forefront to minimize the risk of infection. One example is telemedicine, as it is convenient, meets the needs of social distancing, is cost-effective, and time-saving (Albrecht et al., 2020; Bächle & Wernick, 2019; Whitehouse & Marti, 2020). According to Ting et al. (2020), telemedicine will be another part of the post-pandemic healthcare model. It is worth exploring if the COVID-19 crisis is accelerating the transition towards digital health solutions in Germany, with a particular focus on telemedicine.

1.1 Research Purpose and Objective

The COVID-19 pandemic marks one of the most severe crises and the most serious pandemic of the century (Peek et al., 2020; OECD/European Union, 2020). According to experts, the crisis has accelerated digital transformation and released innovative power in many areas (Klös, 2020; Wissenschaftsrat, 2021), also in the healthcare industry (Giunta et al., 2020; Kichloo et al., 2020; Pieper, 2020; Ting et al., 2020).

The focus of this thesis is placed on Germany, as its level of digitization in the healthcare sector can be classified as rather low (Bertelsmann Stiftung, 2021a, 2021b; BMWi, 2017) and changes in digital health legislation as well as the effects of the COVID-19 pandemic are likely to transform the German digital healthcare sector into a more attractive market for digital products and services. Health experts expect the COVID-19 crisis to accelerate the implementation of digital health services by two years as the population has become accustomed to remote services (Roland Berger, 2020).

The purpose of this thesis is to analyze the effects of the COVID-19 pandemic on telemedicine and physicians' acceptance and use of this service to derive useful information for a widespread implementation in Germany. It is important to focus on the attitude of physicians because, unlike other digital health solutions, telemedicine is provided by physicians. Country-specific characteristics of the German healthcare system are considered and physicians' perception on the benefits and limitations of telemedicine are elaborated.

1.2 Research Questions and Relevance

Some of the driving factors for healthcare digitization may weigh more heavily in the current health crisis, which is characterized by the omnipresent risk of viral transmission, government containment measures, and high levels of general uncertainty. Consumer demand plays a major role in healthcare digitization (Jabil, 2020), however, telemedicine is also heavily driven by physicians (Broens et al., 2007; Federal Ministry of Health, 2020). Thus, the acceptance and adoption of telemedicine by physicians in Germany before and during the current health crisis, is the topic to be explored in this thesis. The primary research questions to be answered are the following:

1) How does the current COVID-19 pandemic affect the acceptance of telemedicine among physicians in Germany?

2) How does the current COVID-19 pandemic affect the use of telemedicine among physicians in Germany?

3) What aspects are potential benefits for physicians in Germany to use telemedicine?

4) What aspects are potential limitations that could inhibit physicians in Germany from adopting telemedicine?

Considering that the COVID-19 pandemic is a newly emerged threat and telemedicine is not yet widely adopted in Germany, there is limited research on the combination of these topics. This thesis aims to contribute to the scientific literature by analyzing the effects of the COVID-19 pandemic on the adoption of telemedicine by physicians in Germany as existing literature mostly relates to patients. The subject is relevant for the academic environment and for organizational practice. The perspective of physicians provides insights for managers who develop, sell, and implement telemedicine solutions as well as for decision makers who establish telemedicine in medical institutions.

1.3 Research Structure

The literature review in chapter 2 provides a detailed description of the concept of digital health in section 2.1. After that, the determinants that influence the implementation of telemedicine are described in section 2.2. Section 2.3 contextualizes digital health and telemedicine in Germany, additionally taking the impact of the COVID-19 pandemic into consideration. In the methodology chapter 3, section 3.1 introduces the research design. The expert interviews are analyzed and hypotheses are derived in section 3.2. Section 3.3 analyzes the online survey on telemedicine and COVID-19. Then, chapter 4 discusses the research results and derives managerial recommendations. Finally, the conclusion in chapter 5 reveals the main findings, highlights the limitations of the work and discusses possible future research topics.

2. Literature Review

2.1 The Concept of Digital Health

Digital health provides innovative mechanisms to deliver health services and to support health workers (WHO Europe, 2019). Globally, the rapidly growing telecommunications infrastructure and the availability of well-functioning and affordable cellphones is a driver of eHealth (Abbott & Liu, 2013). Digital health plays an important role in strengthening national health systems and in achieving equal access to health services. Furthermore, it empowers individuals, who can play a more active role in their own health and receive person-centered care (WHO Europe, 2019). Consequently, digital health will cause a major transformation in the healthcare sector and shift skills and activities in other directions (Rowlands, 2019; Choueiri et al., 2019).

2.1.1 Terminology

Many publications on digital health or eHealth emphasize the lack of a consistent and precise definition of these terms (Oh et al., 2005; Otto et al. 2020; Rowlands, 2019). To clarify the relationship between the central terms related to telemedicine, an abridged and modified classification is depicted in Figure 1.

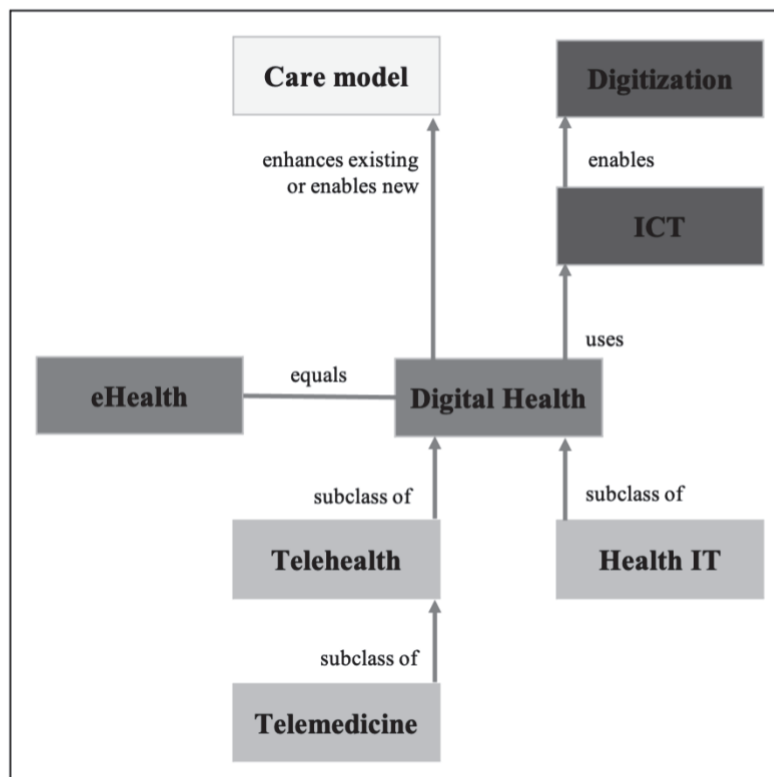

Figure 1: Telemedicine and Related Terms: A Delimitation

(Source: own illustration in reference to Otto et al., 2020)

The World Health Organization (WHO) describes digital health as "*the field of knowledge and practice associated with the development and use of digital technologies to improve health"* (WHO, 2020, p.9). The broad spectrum encompasses eHealth, which, according to the WHO is "*the cost-effective and secure use of information and communications technologies in support of health and health-related fields* (WHO, 2020, p.10). The European Commission (EC) uses the terms digital health and eHealth synonymously (European Commission, 2019).

eHealth includes wearable devices, mobile health (mHealth), electronic patient health records and interoperability of data, technologies supporting integrated care, and telemedicine (WHO Europe, 2017).

Telemedicine has its focus on the performance of medical services via health telematics (Klauber et al., 2019; Radtke, 2020). Its common principle is providing medical care to the population with physical (and temporal) distance using information and communication technologies (Bundesärztekammer, 2015; Kassenärztliche Bundesvereinigung, 2020). Means of contact are real-time video consultations, meetings or telephone calls, or asynchronous ways via SMS, Email, or messenger services (Bertelsmann Stiftung, 2015; Gogia et al., 2016). Telehealth further includes lifestyle applications without the involvement of healthcare professionals, which may be important in terms of reimbursement or jurisdiction (Abbott & Liu, 2013).

2.1.2 Telemedicine and its Areas of Application

The general objectives of telemedicine are improved access to health services, as well as more economical use of resources (Busse et al., 2017). The areas of application concern doctor-patient and doctor-doctor interactions. Telemedicine connects patients via a mobile phone or internet with clinicians for video consultations and allows home-based healthcare delivery at lower costs (Laurenza et al., 2018). The way patients interact with and visit healthcare professionals will change through telemedicine (Reddy & Sharma, 2016). Patients can benefit from an array of service offerings such as access to health assessments, diagnosis, interventions, and supervision at a distance (Kvedar et al., 2014). Wearable devices can record the health data of individuals and transmit them via an app to healthcare professionals, who can react in real time (Gogia et al., 2016). This leads to better disease management and even improves preventive care (Reddy & Sharma, 2016). Telemonitoring becomes more important in the management of chronic diseases (Grundmann, 2019). In video conferences, healthcare professionals can remotely connect with colleagues, share data, exchange diagnostic findings

or obtain a second opinion (Bundesministerium für Gesundheit, 2014). The various areas of telemedicine application are shown in Figure 2.

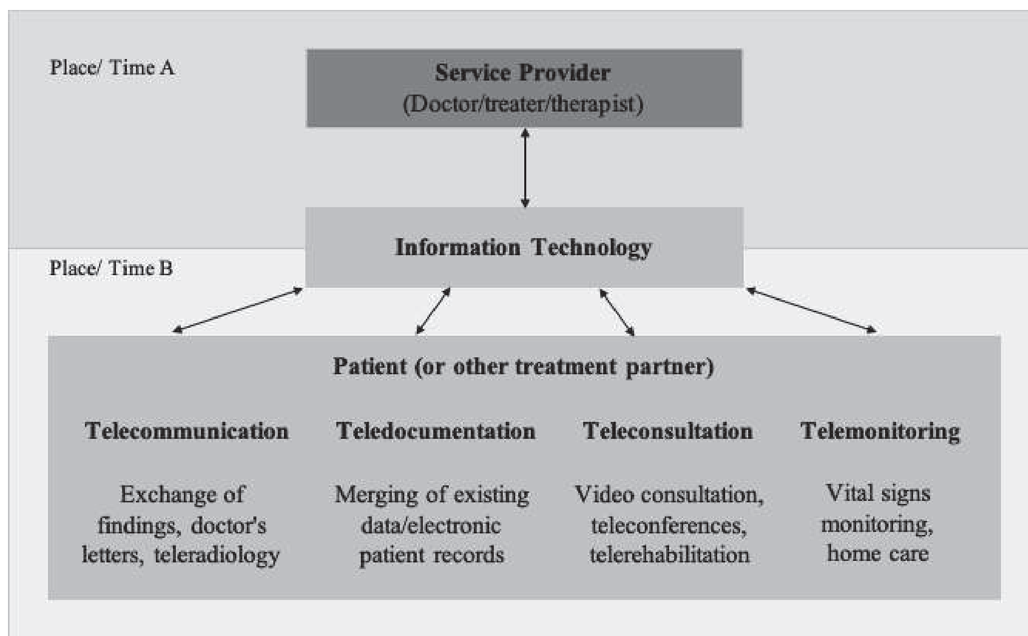

Figure 2: Areas of Telemedicine Application

(Source: own illustration in reference to Grundmann, 2019)

2.1.3 Benefits and Limitations of Telemedicine

Benefits

Telemedicine has many advantages for patients, service providers and cost bearers. In rural or remote areas with physician shortages, telemedicine enables access to quality healthcare (Wootton, 1996; Bächle & Wernick, 2019; Hagge et al., 2020). When health workers are not evenly distributed in a country, telemedicine can be used to cover large distances in a consultative manner (WHO Europe, 2019), and medical care can be maintained in economically underdeveloped regions (Bundesministerium für Gesundheit, 2020a). In Germany, the demographic change with an aging population and an increase in chronic diseases as well as a shortage of physicians are problems that can be minimized by telemedicine and other digital technologies (Bundesministerium für Gesundheit, 2020a; Klauber et al., 2019; Bächle & Wernick, 2019). Telemedicine provides a mechanism for exporting expertise (Wootton, 1996; Hagge et al., 2020), even across national borders (Bächle & Wernick, 2019). Moreover, medical test results can be stored digitally for discussions with colleagues and the anonymized data can be used for educational purposes (Hagge et al., 2020).

In addition, telemedicine reduces the need for travel, which is especially beneficial for patients with limited mobility and in times of a global pandemic (Bertelsmann Stiftung, 2015). In urban settings, telemedicine can accelerate medical referrals or prevent redundant ones and improve healthcare quality (Wootton, 1996; Hagge et al., 2020). Access to specialists can be attained and waiting times can be avoided (Hagge et al., 2020; Bertelsmann Stiftung, 2015).

Moreover, telemedicine is expected to facilitate healthcare delivery and improve patient outcomes (Bächle & Wernick, 2019), to reduce morbidity and mortality (Goldenberg & Wenig, 2002) and to decrease healthcare costs (Albrecht et al., 2020, Whitehouse & Marti, 2020) by early detection of severe diseases (Goldenberg & Wenig, 2002).

In the current pandemic, telemedicine helps to save costs, relieve the workload of physicians and ensures protection against infection (Albrecht et al., 2020). Further, telemedicine offers potential savings for limited resources of medical equipment, such as protective clothing and antiseptics (Hagge et al., 2020), that are unavailable due to supply chain disruptions (Bofinger et al., 2020). Patients experiencing symptoms similar to those of COVID-19, can seek immediate and convenient medical advice via telemedicine (Hagge et al., 2020).

Limitations

The implementation of telemedicine also has certain limitations. The lack of available technological resources and infrastructure (BMWi, 2021; Brauns & Loos, 2015) in certain parts of the country may be a problem for the widespread implementation in Germany. In comparison with other OECD countries Germany shows a backlog in broadband roll-out and a clear urban-rural difference in broadband deployment (BMWi, 2021). In addition, Germany has a very strict legislation regarding the use of telemedicine (Osborne Clarke, 2017), its regulation and reimbursement (Brauns & Loos, 2015; Bertelsmann Stiftung, 2015). Other important issues include ensuring the security of digital networks, data protection (Sury, 2020; BMWi, 2021), and privacy issues (Reddy & Sharma, 2016; Bächle & Wernick, 2019). In addition, safety standards and fear of cybercrime are aspects of concern for potential users (Sury, 2020).

Furthermore, the health workforce may fear a loss of jobs (WHO Europe, 2019), and the benefits of telemedicine may not be obvious to them (Bertelsmann Stiftung, 2015). In general, it may be observed that the introduction of innovative digital processes may be delayed in times of economic success, as the need for change is not seen (BMWi, 2021). Physicians may further miss performing the traditional patient examination (Hagge et al., 2020; Kichloo et al., 2020; Krusche et al., 2020). Some physicians are of the opinion that video consultations offer limited diagnostic options and only a few indications are suitable for telemedicine (Albrecht et al.,

2020), whereas others expect a negative impact on the doctor-patient relationship (Haserück, 2020; Bertelsmann Stiftung, 2015). A successful implementation of telemedicine depends on the willingness of healthcare providers to offer this service as well as on the acceptance of the purchasers to make use of it (Reddy & Sharma, 2016; WHO Europe, 2019, Wootton, 1996). According to the Bertelsmann Stiftung (2015), the main limiting factor for a wide usage of video consultations in Germany is a lack of acceptance among doctors. Moreover, elderly and socially disadvantaged citizens do not always have the necessary technical equipment for telemedicine (Krusche et al. 2020) and only patients with a high degree of media literacy will benefit from telemedicine (Bertelsmann Stiftung, 2015). The rigid structures in statutory health insurances (Behringer, 2018; Reddy & Sharma, 2016) are another major problem in digitized healthcare.

2.2 Determinants of Telemedicine Implementation

The successful implementation of telemedicine may be challenging and depends on many determinants that are relevant to different stakeholders in the healthcare system. It affects aspects of governance, technology, regulation, workforce, training and support (WHO Europe, 2019). Broens et al. (2007) classified the determinants into five major categories: 1. technology, 2. policy and legislation, 3. acceptance, 4. financing and 5. organization, which are shown in Figure 3. In addition, national specifics as well as cultural and social characteristics may have an influence (Broens et al. 2007; Bächle & Wernick, 2019).

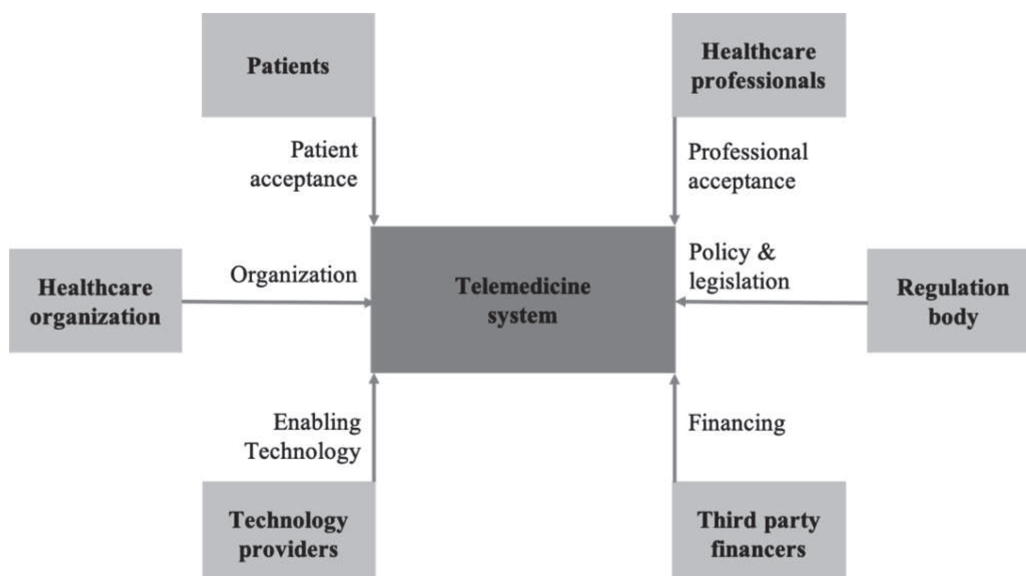

Figure 3: Determinants of Telemedicine Implementation

(Source: own illustration in reference to Broens et al., 2007)

2.2.1 Technology

Solid deployment of technology in healthcare processes is needed to make use of digital solutions to improve health (Martins et al., 2020). There is a need for sound systems and their supporting infrastructure (Broens et al., 2007). Good technical feasibility and quality is also an important factor (Federal Ministry of Health, 2020; Nolting & Zich, 2017). Furthermore, technical support in the deployment as well as in the operational phase is necessary (Bertelsmann Stiftung, 2015) and helps to deal with problems and avoids demotivation (Broens et al., 2007). Another important point is training of medical staff, doctors, and patients to strengthen their digital healthcare competence (Broens et al., 2007; Bächle & Wernick, 2019; Federal Ministry of Health, 2020; Van den Berg et al., 2009; Krusche et al., 2020) and to achieve user acceptance (Gogia et al., 2016).

2.2.2 Policy and Legislation

Suitable policies and legislation are necessary preconditions for the successful implementation of telemedicine (Broens et al., 2007). As the Federal Republic of Germany has a federal system with 16 states, the policy framework is defined by the federal legislature, but the individual states decide how regulations are implemented in their territories (Federal Ministry of Health, 2020). Therefore, the decision-making and legislation concerning telemedicine may differ on state level. This may lead to different standards of telemedicine within the country and may hamper the nationwide adoption of telemedicine services (Bächle & Wernick, 2019). Due to the principle of self-governance of the German healthcare system, the Federal Joint Committee of the healthcare system (G-BA) decides on its organization. This makes health law a very complex field.

In the European Union (EU), the diversity of healthcare systems with complex legislation complicates the international use of telemedicine. Therefore, it is substantial to create harmonization of laws, otherwise it would be difficult to introduce telemedicine services and products to an international market (Bächle & Wernick, 2019). Martins et al. (2020) emphasize that digital health requires international cooperation and that the COVID-19 pandemic has demonstrated that responses should be global.

Other important factors are security mechanisms as well as standards for interoperability of telemedicine applications (Martins et al., 2020; WHO Europe, 2019). Governments must ensure the security and privacy of health data and the implementation of interoperability standards through policy regulations to gain public trust (WHO Europe, 2019). For a seamless interaction

of ambulatory and hospital care better legal regulations and support of interoperability for telemedicine systems are required (Klar & Pelikan, 2009).

2.2.3 Acceptance

Acceptance is a precondition for the advancement of digital health (Federal Ministry of Health, 2020). This applies to all medical service providers as well as to patients (Federal Ministry of Health, 2020; Broens et al., 2007). Health professionals need to be prepared for digital transformation (WHO Europe, 2019) and innovators should take user feedback and suggestions from pilot projects into account (Nolting & Zich, 2017, MUT, 2021).

Usefulness and ease of use are factors that contribute to user acceptance (Venkatesh & Bala, 2008). High attractiveness for patients results from the personal benefits (Nolting & Zich, 2017). Openness to telemedicine solutions is increasing among patients and service providers, who recognize it as a reliable alternative to overcome deficiencies in the traditional healthcare system (Nolting & Zich, 2017).

Digital health literacy is a requirement for a patient-oriented digitization (Bundesministerium für Gesundheit, 2020a; Samerski & Müller, 2019). According to recent surveys, patients who use telemedicine tend to be younger than 40, have an academic background, live in economically advantaged regions (EPatient Analytics, 2020) and are more likely to reside in cities (KMA, 2020).

Among physicians, digitization is only accepted, if clear added value is created in daily operations (Haserück, 2021). Resistance to new tools and a refusal to change routines can hinder the implementation of telemedicine (Gogia et al., 2016). On the other hand, the creation of clinical guidelines and financing mechanisms could increase the use of telemedicine, as the example of Portugal has shown (Martins et al., 2020).

2.2.4 Financing

The costs of telemedicine relate to investment, maintenance, and operation (Broens et al. 2007). While pilot projects are often funded, implementation of new products or technologies depends significantly on decisions concerning financing and reimbursement (Häckl, 2010). However, reimbursement for telehealth services through third party insurance mechanisms can be difficult (Gogia et al., 2016). Häckl (2010) noted that the lack of reimbursement was the central obstacle to the implementation of telemedicine in Germany. Therefore, a billing code that covers the investments of the doctor must be established (Bertelsmann Stiftung, 2015). Bächle & Wernick

(2019) concluded that an expansion of the range of reimbursable telemedicine services would contribute to a better adoption.
Since the technical requirements for digital health services cost administrative effort and money, physicians will only accept and promote digital services, if they create added value (Haserück, 2021). Recently, medical practices in Germany have criticized high investments and a poor cost-benefit ratio of digitization (Haserück, 2020).

2.2.5 Organization

The implementation of telemedicine affects the healthcare organization in a country in general and in detail. The introduction of telemedicine in an institution affects not only a single practice, but also its collaborating partners (Broens et al., 2007). As a result, responsibilities, rights, and traditional roles may change. In addition, a well-functioning collaboration between healthcare professionals and non-medical stakeholders, such as technology partners or governmental actors, is essential for the service to work seamlessly (Broens et al., 2007). Therefore, national standards and cross-border formats are required (WHO Europe, 2019).

2.3 Contextualizing Digital Health in Germany

This chapter provides information on healthcare in Germany, the historical ban on remote treatment, the legal framework for eHealth and telemedicine, and the status of telemedicine in Germany before and in the context of the COVID-19 pandemic.

2.3.1 Healthcare in Germany

Healthcare Market

The traditional German healthcare sector has been growing continuously since 2013 and has a market volume of 89.9 billion euros in 2020, measured in revenue. It is forecasted that the healthcare sector will continue to grow in the following years (Radtke, 2020).
According to a recent study, the market spending on digital health in Germany will amount to 57 billion euros by 2025 (Roland Berger, 2020), which means an increase of 19 billion euros from previous estimates by the same company before the COVID-19 outbreak. (Choueiri et al., 2019). In 2021, revenue in the eHealth market in Germany will amount to 1.68 billion euros and is expected to grow to 2.20 billion euros in 2025 (Statista, 2021a). For online video consultations, the market volume in revenue will amount to 0.53 billion euros in 2021 and is forecasted to increase to 0.724 billion euros by 2025 (Statista, 2021b). According to a study from Demirci et al. (2021), the market potential in revenue for telemedicine in Germany in 2030

will range from 1.42 billion euros (conservative scenario) to 2.10 billion euros (realistic scenario) or 3.61 billion euros (optimistic scenario).

Basic Principles

The German healthcare system is based on five main principles: mandatory health insurance, contribution financing, solidarity principle, benefits-in-kind principle, and self-administration principle (Federal Ministry of Health, 2020). In 2020, 88% of the public was covered by statutory health insurance (SHI), 10% by private health insurance (PHI), and 2% by other insurances (VdEK, 2021). SHI and PHI are funded by the contributions of their members and differ in the scope of covered services, which also applies to telemedicine (Krankenversicherung, 2021).

Although the German state defines the legal framework, the German healthcare system has a decentralized and self-governing structure with many stakeholders. The most important body in the self-administration is the Federal Joint Committee (G-BA) (Latal et al., 2017). Its actors decide, which medical treatments are delivered by service providers and financed by the statutory health insurance funds, guided by the aspects of cost-effectiveness and appropriate care (Bundesministerium für Gesundheit, 2020a).

Levels of the Healthcare System

The German healthcare system is complex with shared responsibilities between its hierarchically organized three levels (Federal Ministry of Health, 2020) (see Figure 4). The state actors define the framework for healthcare at the federal and state level with the Federal Ministry of Health (BMG) primarily responsible for national health policies (macro-level). The meso-level consists of the bodies of self-administration. The providers of healthcare build the micro-level with individual actors.

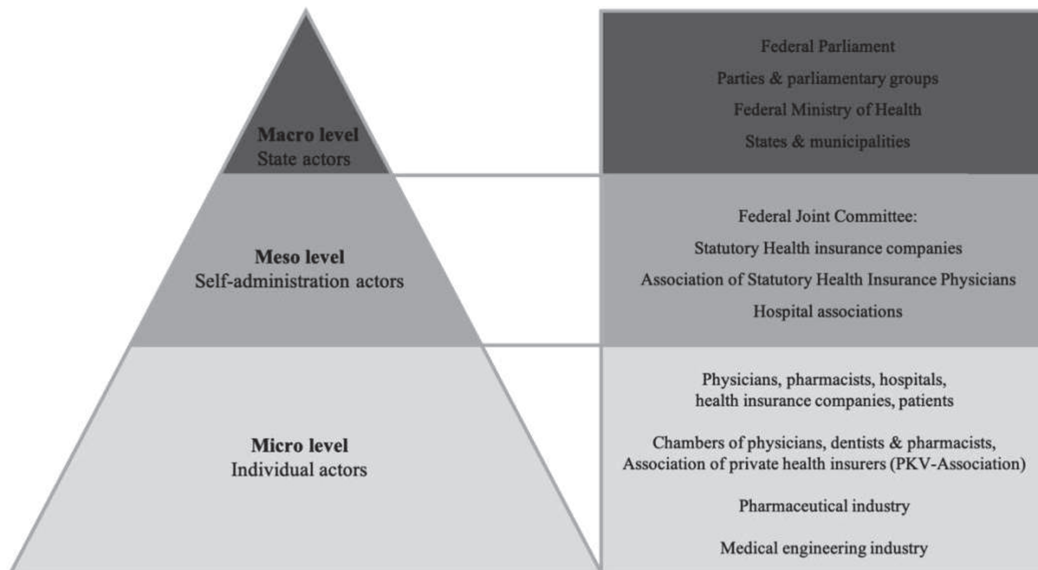

Figure 4: Levels of the German Healthcare System

(Source: Own Illustration)

Interaction among the Stakeholders of the German Healthcare System

The interactions among participants of telemedicine in Germany are depicted in Figure 5.

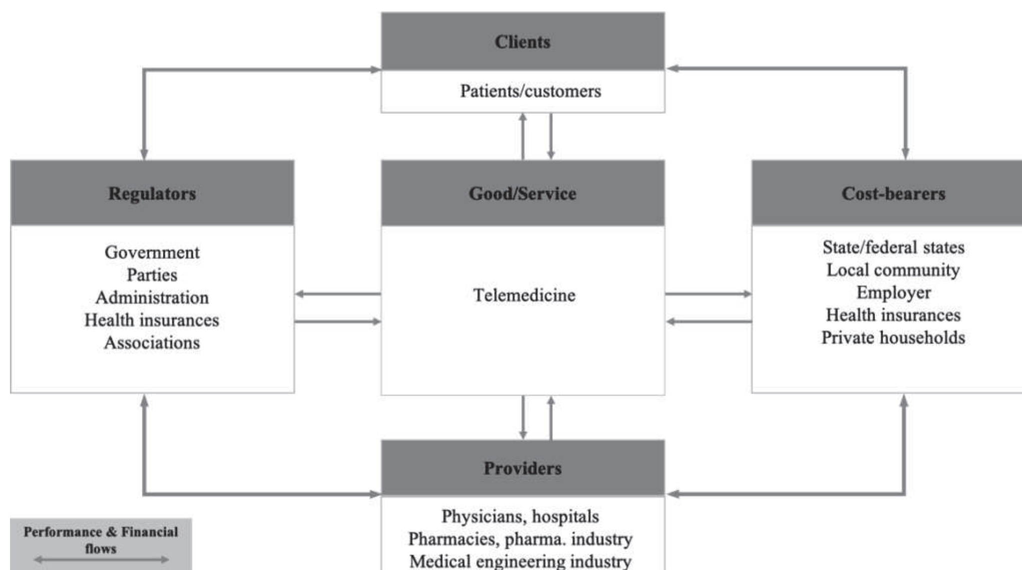

Figure 5: Interactions among Participants of Telemedicine in Germany

(Source: Own Illustration in reference to Penter & Augurzky, 2014)

Different sales channels are open to providers of digital health products such as telemedicine. The first channel is the primary health market, in which services are reimbursed by health insurers and which is highly regulated. The secondary health market, where services are paid for by the customers themselves, has lower entry barriers. However, due to the comprehensive SHI coverage, many insured persons are not willing to pay for additional services themselves (Demirci et al., 2021).

2.3.2 Historical Ban on Remote Medical Treatment

Historically, there has been a ban on remote treatment in the Medical Associations´ Model Professional Codes (MBO-Ä) of the German Federal States, dating back to the 19th century (Bächle & Wernick, 2019). It was based on the concern that medical advice provided remotely is of lower quality and may harm the reputation of doctors and the health of patients (Siglmüller, 2020; Bayrisches Ärzteblatt, 2017). According to Section 7 (4) of the MBO-Ä, until 2018, physicians were prohibited from treating or advising patients solely on the basis of print or communication media (Bundesärztekammer, 2015, 2018; Deutsches Ärzteblatt, 2018; Krüger-Brand, 2018). Video consultations were allowed and billable, but only for follow-up appointments (Bundesärztekammer, 2015, 2017; Datenschutz, 2021).
Since October 2019, telemedicine has been permitted in Germany without prior personal doctor-patient contact in special cases, if it is medically justifiable. (Bundesärztekammer, 2019; Krüger-Brand, 2018; Gesetzliche Krankenkassen, 2020). Additionally, advertising for remote treatments was forbidden according to Section 9 (1) of the German Drug Advertising Act until 2019.

2.3.3 Legal Framework for Digital Health and Telemedicine

For a successful digital transformation of the healthcare system, the development of a legal framework is an essential factor. The first digital health law in Germany's history, the eHealth Act, came into force in January 2016 (Bundesgesetzblatt, 2015). Its objective was to introduce the electronic health card, which enables digital storage and retrieval of patient data. It also set the timeline for the rollout of the telematics infrastructure (TI) as a central instrument for secure communication between insured persons, therapists, hospitals and health insurance companies. Other goals included improving the interoperability of healthcare information technology (IT) systems and promoting telemedicine services.

Since March 2018, the BMG has been very active with the new Minister of Health, Jens Spahn, in drafting new laws to foster the digital transformation of the German healthcare system. The key legal measures are summarized in Table 1.

Legal Measure	**Date of Effect**	**Objective**	**Source**
eHealth Act	01/2016	Introduction of eHealth card, establishment of telematics infrastructure, interoperability of healthcare IT systems, promotion of telemedicine	(Bundesgesetzblatt, 2015)
Nursing Staff Strengthening Act (PpSG)	01/2019	Psychotherapists entitled to offer video consultations	(Bundesministerium für Gesundheit, 2018)
Appointment Service and Supply Act (TSVG)	05/2019	Foundation for digitization: physician appointment services, telemedicine, eHealth records	(Bundesministerium für Gesundheit, 2019c)
Drug Safety and Supply Act (GSAV)	06/2019	Regulation of the introduction of electronic prescriptions	(Bundesministerium für Gesundheit, 2019b)
Digital Supply Act (DVG)	12/2019	Support of eHealth: apps on prescription, easy use of online consultations & physician reimbursement for e-services, access to secure healthcare data networks	(Federal Ministry of Health, 2019)
Patient Data Protection Act (PDSG)	10/2020	Introduction of ePrescriptions and ePatient records and security of patient data	(Bundesministerium für Gesundheit, 2020c)
Hospital Future Act (KHZG)	10/2020	State-support of 4,3 billion euros for digitization in medical centers & hospitals	(Bundesministerium für Gesundheit, 2020b)
Digital Supply and Care Modernisation Act (DVPMG)	Exp. Q3/2021	Foster digital devices in care, extension of telemedicine & modern networking in healthcare system	(Bundesregierung, 2021)

Table 1: New National Laws to advance eHealth in Germany (Source: Own Illustration)

With the *TSVG*, the BMG has become the majority shareholder of the *Gematik (company for telematic applications)* and can thus accelerate decisions on digitization such as the high-speed TI rollout (Bundesministerium für Gesundheit, 2020a). Physicians who do not connect to the TI are sanctioned with a reduction in their fees of 2.5% by March 2020 *(DVG)* (Deutsches Ärzteblatt, 2020). Physicians are now allowed to provide information on their websites about the availability of video consultations (Federal Ministry of Health, 2019). As of January 2021, all members of the statutory health insurances are eligible for the ePA.

In light of the COVID-19 pandemic, Spahn emphasizes the importance of digital health solutions in hospitals (Bundesministerium für Gesundheit, 2020a). With the *Hospital Future Act (KHZG),* the state is providing financial subsidies of 4,3 billion euros for digitization in hospitals (Bundesministerium für Gesundheit, 2020b). Of these funds, 15% are earmarked for IT security measures and funds can also be invested in the introduction or improvement of telemedicine.

The *DVPMG*, which is scheduled for the summer of 2021, will promote digital devices in care, more telemedicine, and modern networking in the healthcare system (Bundesregierung, 2021). Spahn emphasized that "*the pandemic has shown how much digital solutions improve medical care"* (Bundesministerium für Gesundheit, 2021a, p. 1). With the *DVPMG*, the telematics infrastructure will be modernized in a user-friendly way. By 2023, insured persons and healthcare providers will have a digital identity that can be used for authentication during video consultations (Bundesministerium für Gesundheit, 2021b). Moreover, telemedicine will be expanded to midwives, other healthcare professionals and emergency medical services.

Another government measure to foster eHealth is an innovation fund to promote telemedicine projects and eHealth solutions with an annual grant of 200 million euros for the years 2020 to 2024, financed by the SHI (Bundesministerium für Gesundheit, 2019a; Gemeinsamer Bundesausschuss Innovationsausschuss, 2021; Gemeinsamer Bundesausschuss, 2021). Moreover, the introduction of the Health Innovation Hub serves as a contact point and bridge builder to the digital ecosystem and between all key stakeholders in the German healthcare system (Health Innovation Hub, 2021a, 2021b).

2.3.4 Status of Telemedicine before the COVID-19 Pandemic

Although telemedicine services have existed in Germany for many years, they have not been integrated into everyday care on a larger scale (Nolting & Zich, 2017; Agenon, 2018) and have mostly remained isolated applications (Bundesärztekammer, 2010). Often, only small patient populations benefit from model projects, for instance, members of a particular health insurance company or residents of a certain region (Nolting & Zich, 2017).

In 2010, the German Medical Assembly formulated the requirements for appropriate telemedicine as follows: Telemedicine should only be used to complement personal doctor-patient contact or when conventional methods are not available (Bundesärztekammer, 2010). It decided that care scenarios for telemedicine should be developed by healthcare professionals on the basis of medical needs of the patient rather than to develop new sales markets for the healthcare industry (Bundesärztekammer, 2010). The need for financing and reimbursement

concepts, interoperability standards, and a clear legal framework was identified (Bundesärztekammer, 2010). Areas of potential benefit were identified as teleconsultations, teledocumentation, telecommunication and telemonitoring (Bundesärztekammer 2018).
In 2017, a directory for IT standards in the German health system called *vesta* was launched (Ärzteblatt, 2017; Klauber et al., 2019; Vesta, 2021a). The *vesta* information portal provides information on nationwide telemedicine projects and eHealth applications (Vesta, 2021b). New digital health applications are only covered by statutory health insurances if they meet the listed interoperability criteria.
In 2019, an incentive for physicians who offer video consultations was provided by the SHI. This is an additional 10 euros per patient for up to 50 video consultations per quarter, provided that at least 15 video consultations per quarter are performed (Kassenärztliche Bundesvereinigung, 2019). However, the number of video-only consultations in a practice has been limited to 20% of all treatment cases per quarter and to 20% of all billed services (Kassenärztliche Bundesvereinigung, 2021).

2.3.5 Contextualizing the COVID-19 Pandemic and Telemedicine

Since the official outbreak of COVID-19 in China in December 2019, SARS-COV2 has rapidly spread around the globe (WHO Europe, 2020, 2021). When the outbreak was declared a pandemic, the WHO had considered that social distancing and quarantine measures had to be implemented to prevent the COVID-19 transmission (WHO Europe, 2020). Finally, the ongoing global pandemic and the drastic containment measures have resulted in a health, financial and economic crisis, as well as social disruption in many countries (Leopoldina, 2020; Gopinath, 2020).
The COVID-19 pandemic triggers a demand shock resulting in decreasing demand, as consumption is massively restricted due to national and global governmental restrictions, social distancing measures and general uncertainty (Maria del Rio-Chanona et al., 2020). On the other hand, the pandemic generates an unexpected supply shock with disruption of global supply chains and production downtimes due to disease or quarantine measures (Bofinger et al., 2020). Changes on the demand side can also be observed in the healthcare sector. Lower demand has been reported for screening or prevention services in medical practices (Bublak, 2021; Mangiapane et al., 2021; Ärzte Zeitung, 2020) and for in-person medical services (Zentralinstitut für Kassenärztliche Versorgung, 2020). Patients cancel their appointments or even refuse to visit a clinic in emergency cases, because they are afraid of being infected with SARS-COV2 (Dormann et al., 2020; Deutsches Ärzteblatt, 2020). Consequently, the demand

for traditional medical consultations in Germany declined massively in the health crisis compared to previous years (Mangiapane et al., 2021; Zentralinstitut für Kassenärztliche Versorgung, 2020). Therefore, the COVID-19 pandemic has shown the need for the integration of digital solutions into the health care system (Bundesministerium für Gesundheit, 2020d, 2021a; Whitehouse & Marti, 2020). In this context, telemedicine offers many advantages (Whitehouse & Marti, 2020). In Germany, routine procedures have been changed and telemedicine services were increasingly used (Krusche et al., 2020). Physicians had to choose alternative options to maintain the provision of healthcare services and to ensure their economic survival.

According to a global survey of April 2020 on the positive effects of the COVID-19 pandemic on the digital health industry, 65% of the industry experts cited telemedicine as the most impacted segment (Radtke, 2020). The majority of experts anticipate an increased acceptance of digital health services among patients. Specifically, tech-startups in the field of telemedicine are winners of the COVID-19 crisis and telemedicine is gaining momentum (European Startups, 2020).

During the pandemic, doctors and patients have partially overcome their inhibitions and prejudices towards telemedicine (McKinsey & Company, 2020) and their willingness to adopt digital solutions has increased (BMWi, 2021; Stiftung Münch, 2020). Many physicians will likely implement telemedicine into practice after the pandemic (Perniola et al., 2020) or expand its use (Backhaus et al., 2020; BPtK, 2020).

Patients' reasons for using telemedicine included: fear of infection with SARS-COV2 (85%), time-effectiveness (52%), a general fear of infection (45%), avoidance of waiting times (38%), convenience (35%) and curiosity (26%) (Bitkom, 2020). The main reason for offering telemedicine in German practices during the COVID-19 pandemic is to protect patients and medical staff from infection (Albrecht et al., 2020).

Moreover, telemedicine helps to improve communication between clinics and thereby facilitates high-quality medicine during the pandemic. For example, experts from the Charité, University Hospital Berlin, offer daily tele-visits of intensive care patients in other hospitals (Haserück, 2021; Charité, 2021). In February 2021, the G-BA decided to pay additional financial charges to certified special hospitals offering telemedical cooperations to general hospitals for the treatment of COVID-19 patients. This billing option is only limited to the budget year of 2021 (Gemeinsamer Bundesausschuss Innovationsausschuss, 2021).

The legal restrictions on video consultations have been temporarily invalidated since the second quarter of 2020 (Gesetzliche Krankenkassen, 2020; BÄK, 2020) and the recommendations for

reimbursement of telemedicine services related to the COVID-19 pandemic have been extended in favor of physicians until September 2021 (Bundesärztekammer, 2021). Physicians are now allowed to offer unlimited video consultations with an unlimited number of cases. The permission for video consultations applies to all indications and to first-time visits (Kassenärztliche Bundesvereinigung, 2021). Since October 2020, digital consultations among physicians are also reimbursable (Heinemann & Matusiewicz, 2021). In the COVID-19 pandemic, the increased use of telemedicine in Germany can be mainly attributed to these special arrangements and openings by the KBV and GKV (Albrecht et al., 2020; Bitkom, 2021; Haserück, 2021). It is to be expected that telemedicine will be integrated in daily practice in the long term after the pandemic and will meaningfully supplement traditional doctor-patient communication (Stiftung Gesundheit, 2020).

All in all, the pandemic contributes to the development of an innovation-friendly climate and seems to drive the digital healthcare market. However, only solutions that contribute to high-quality healthcare will likely survive after the pandemic (Healthcare Marketing, 2020; Heinemann & Matusiewicz, 2021).

3. Methodology

3.1 Research Design

First, a comprehensive literature review on digital health was conducted to lay the theoretical foundation. Therefore, extant scientific literature on digital health in the form of journals, reports, books, newspaper articles and online sources was accessed. In addition, proprietary data were collected using a mixed-methods approach, combining qualitative and quantitative data. Steckler et al. (1992) argue that the joint use of qualitative and quantitative paradigms leads to a good understanding of the given research subject. A qualitative method can produce vast, detailed and sound process data, while a quantitative method provides factual and reliable outcome data (Steckler et al., 1992). By combining the different methods, the results can be mutually confirmed and possible methodological weaknesses can be balanced, leading to more valid conclusions (Molina-Azorin et al., 2017).

The qualitative research involved interviews with healthcare experts, namely physicians, who are a key factor for the implementation of telemedicine. Quantitative research consisted of an online survey in which data were collected on a larger scale. Physicians from different medical specialties and socio-demographic backgrounds from various regions in Germany were surveyed.

3.2 Expert Interviews

For this thesis, a total of six expert interviews was conducted using the semi-structured interview approach. A semi-structured approach was adopted to provide flexibility in the interviews. The interviews followed a general set of questions, but the order of questions or specific questions themselves were adjusted based on the respondents' answers. The aim of the expert interviews was to shed light on telemedicine from different angles to evaluate the potential progress, perception, and use of telemedicine in Germany during the COVID-19 pandemic.

Table 2 provides an overview of the experts, their medical specialty, type of institution and their telemedicine use. To facilitate quoting of experts in the analysis and findings part, each expert was assigned a numerical code (#1, 2, etc.).

Interview #	Profession	Type of Institution	Telemedicine use
1	Physician – Human Geneticist	University Hospital (Small/Urban)	Use
2	Physician – General Practitioner	Medical Practice (Small/Rural)	Minimal use

3	Physician – Internist/General Practitioner	Medical Practice (Small/Rural)	No use
4	Physician – Surgeon	University Hospital (Large/Urban)	Use
5	Physician - Internist & Gastroenterologist	General Hospital (Small/Rural)	Use
6	Physician - Ophthalmologist	University Hospital (Large/Urban)	Use

Table 2: Overview of the Interviewed Experts (Source: Own Illustration)

3.2.1 Analysis of Expert Interviews

The interview structure can be broadly divided into the following five segments: benefits, personal opinion and use, limitations, points of improvement, and future outlook of telemedicine. The experts' responses were clustered and subsequently analyzed per segment. Together with the information from the literature review, the expert interviews helped to generate hypotheses that will later be tested in the quantitative research through the survey.

3.2.1.1 Benefits of Telemedicine

After a brief introduction to the topic, the interviews began with questions about the benefits of telemedicine for the experts. Table 3 gives an overview of all benefits specifically mentioned by the experts (experts indicated with #).

Benefits	#1	#2	#3	#4	#5	#6	Sum	Lit. Rev.
Easy access to healthcare	✓	✓	✓	✓	✓	✓	6	✓
Improve coordination & interaction of care	✓			✓	✓		3	✓
Convenient care	✓			✓	✓		3	✓
Improve healthcare quality	✓					✓	2	✓
Save travel time for patients	✓	✓		✓	✓	✓	5	✓
Save travel time for physicians	✓			✓	✓		3	✓
Protection from infectious diseases	✓			✓	✓		3	✓

Cost savings					✓*	✓*	2	✓
Effective scheduling			✓		✓*	✓	3	

* *For patients only*

Table 3: Benefits of Telemedicine (Source: Own Illustration)

Most frequently mentioned was that telemedicine provides easier access to quality healthcare for a broader range of people in Germany (#1,2,3,4,5,6). The experts argue that particularly patients living in rural areas can benefit from the digital service and patients with limited physical mobility or limited means of transportation (#1,6), especially in the pandemic (#1,4).
Many experts said that telemedicine saves travel time for both, patients (#1,2,4,5,6) and physicians (#1,4,5). Telemedicine is also attractive from a financial standpoint, as users save on travel costs (#4,5).
Another benefit noted was that telemedicine enables comfortable and convenient care as patients do not have to leave their homes and can comfortably attend a medical appointment in their personal environment (#1,4,5). This is especially helpful for patients with chronic diseases or those who solely need follow-up appointments (#1,6). Physicians can easily schedule online appointments, provide strict times for appointments (#3,5,6) and reduce waiting times for patients (#5,6).
The medical experts also emphasized that telemedicine in form of videoconferencing facilitates and improves communication with colleagues and other medical professionals, especially in the pandemic (#1,4,5). The service allows meetings to be held virtually and eliminate unnecessary travel. This form of communication makes healthcare more time-effective and structured (#5,6).
Other advantages such as protection from infectious diseases like COVID-19 (#1,4,5) and improved quality of healthcare (#1,6) were mentioned by some experts. Since many benefits were identified in the interviews and since they are often particularly emphasized in the context of the ongoing pandemic, it would be interesting to analyze physicians' general attitude towards telemedicine before and during the pandemic on a larger scale.
Thus, the first hypothesis derived from the experts' interviews is:

H1: The acceptance of telemedicine among German physicians is higher during the COVID-19 pandemic than before.

Additionally, it would be interesting to investigate whether the most frequently mentioned benefits in the interviews are also the most important ones for a larger group of physicians. Thus, the following hypotheses are generated:

H2: Some benefits of telemedicine have an importance rating that is significantly different from the average importance rating of all benefits.
H2a: The benefit easy access to healthcare shows a significantly positive difference from the average importance rating.
H2b: The benefit saving travel time for physicians/patients shows a significantly positive difference from the average importance rating.

3.2.1.2 Experts' Use of Telemedicine

Of the six interviewed physicians, five use telemedicine for their work (#1,2,4,5,6). The application can be divided into two areas: Communication among doctors (doctor-to-doctor) and treatment of patients (doctor-to-patient). It becomes apparent that doctor-to-doctor meetings frequently take place in a remote setting via videoconferences. All four hospital physicians (#1,4,5,6) mention that video conferences are used on a weekly basis (#1) up to a daily basis (#4,5,6). These conferences comprise discussions with their departments, special conferences with other departments and medical consultations. The meetings are effective as findings such as laboratory results or X-ray and histological findings can be easily shared on the screen and do not need to be printed (#4,5). All four hospital physicians (#1,4,5,6) indicated that such meetings took place in person prior to the COVID-19 pandemic.
A general practitioner further mentioned that videoconferences (long conversations) or E-mails (short conversations) with other specialists have become common during the pandemic (#2).
In a doctor-to-patient context, the adoption of telemedicine is not as high among the interviewed physicians. Three doctors mentioned that remote patient consultations via video conferences only happen in rare cases (#1,2,6). Two of them noted that the consultations were only adopted due to the current pandemic and were almost not present before its outbreak (#2,6). Expert #4 revealed that due to the pandemic, nearly all results of the aftercare are now delivered to patients via telephone, which was previously done in-person. Only one expert frequently uses videoconferences with patients (#5) for follow-up appointments, when a change of therapy is necessary, or for chronically ill patients (#5).
In order to analyze the impact of COVID-19 on the telemedicine use on a larger scale, the following hypothesis is generated:

H3: The use of telemedicine by German physicians is higher during the COVID-19 pandemic than before.

3.2.1.3 Limitations of Telemedicine

The experts highlighted a variety of limitations of telemedicine. The complete list is shown in Table 4.

Limitations	#1	#2	#3	#4	#5	#6	Sum	Lit. Rev.
Technical difficulties	✓	✓		✓	✓	✓	5	✓
Lack of technological Know-how	✓			✓	✓		3	✓
Lower healthcare quality	✓		✓				2	✓
Insufficient technol. infrastructure				✓	✓	✓	3	✓
IT costs		✓			✓		2	✓
No physical contact			✓	✓	✓	✓	4	✓
Others	Bureaucratic burden (#5)						1	

Table 4: Limitations of Telemedicine (Source: Own Illustration)

The probably most obvious telemedicine limitation is the lack of physical contact with patients. Expert #3 argues that it is very difficult or even impossible to provide a good diagnosis via telemedicine. Furthermore, it was mentioned that a personal and psychological component is important for a trust-based doctor-patient relationship and for high-quality patient care (#3). In addition, experts #4 and #5 remark that in some medical specialties, specifically technical ones, a physical examination is the essential element for a correct diagnosis. Therefore, telemedicine would only be applicable in rare cases, such as follow up examinations to discuss alternative treatment options, adjust drug dose, modify therapy, review the healing process (#4) and reinforce compliance (#5).

Other limitations concern the technological components of telemedicine services. Three experts are of the opinion that there is an insufficient technological infrastructure in their medical institution and that the services pose technical difficulties. The technical difficulties range from

software problems (#1,2,5), connection issues (#2,5,6), difficulty of use (#4) to complete service crashes (#2).
In addition, expert #4 alludes that the technical infrastructure in his hospital is not optimal and that there is a general lack of good internet connections in Germany. While using videoconferences, the picture or sound is often not synchronous. Expert #5 adds that different software systems, with different user interfaces, schedules and passwords are used. System harmonization would make the service much more efficient and easier to use. Expert #6 adds that devices from different suppliers vary in their suitability for telemedicine. He advocates for universal software systems to ensure ease of use and equal benefits for all users.
Further limitations are the lack of technological know-how of either doctors (#4, 5) or patients (#1). All three experts believe that mainly older users might have technical or mental difficulties with telemedicine services resulting in a reluctance to try new digital health solutions. Therefore, it is interesting to investigate how technical expertise affects the use of telemedicine. This leads to the following hypothesis:

H4: A physician's technological know-how influences the use of telemedicine.

Lastly, three experts (#1,3,4) argued that telemedicine services can lead to lower healthcare quality. It was mentioned that some patients have a certain inhibition to speak freely in a remote treatment setting, which could lower the quality of treatment (#1). Experts #3 and #4 are convinced that treatment via video consultation carries a high risk of misdiagnosis and quality healthcare cannot be achieved. Finally, it would be interesting to measure whether the limitations most frequently listed by the experts are the most important for a broader group of physicians.
This leads to the following hypotheses:

H5: Some limitations of telemedicine have an importance rating that is significantly different from the average importance rating of all limitations.
H6a: The limitation technical difficulties shows a significantly negative difference from the average importance rating.
H6b: The limitation no physical contact shows a significantly negative difference from the average importance rating.

3.2.1.4 Points of Improvement for Telemedicine

The experts' points of improvement for telemedicine are discussed and Table 5 gives an overview of all improvement suggestions mentioned by the physicians.

Points of Improvement	#1	#2	#3	#4	#5	#6	Sum	Lit. Rev.
Technology training	✓	✓		✓			3	✓
System standardization	✓				✓	✓	3	
Improve telematics infrastructure	✓	✓	✓	✓			4	✓
Financial support		✓		✓		✓	3	✓
Increase service awareness				✓		✓	2	
Others	Careful patient selection (#1), Better reimbursement (#2), Lower bureaucracy (#5)						1	

Table 5: Points of Improvement for Telemedicine (Source: Own Illustration)

The most common improvement point is the optimization of the telematics infrastructure (#1,2,3,4). It is argued that high-quality equipment is needed such as card readers and laptops with good microphones and cameras. In addition, reliable software services and internet connections are demanded. Closely related to this point is the call for standardized telemedicine systems (#1,5,6). Telemedicine services should be embedded into existing hospital systems in order to have appointment schedules and videoconferences in one system (#5,6) and the charging of telemedicine services should be implemented into the existing service offering (#1). Another frequently mentioned aspect is technological training. Patients should have the opportunity to receive training to benefit from telemedical services (#1,2). Expert #2 even mentions that patients should potentially be financially supported to buy the necessary equipment. Furthermore, training and new trends (such as telemedicine, AI, or Big Data) in medicine should be addressed in medical school so that physicians are better prepared when they start their jobs (#4).

A further proposal is the financial support of healthcare professionals. It was mentioned that the government should support physician offices with financial contributions to alleviate the ever-increasing IT-related costs (#2). Other experts argue that the government and the Federal Ministry of Health should provide more funding to the limited budgets of hospitals to exploit the full potential of telemedicine (#4,6).

Finally, two experts think that telemedicine needs more awareness in society and especially with patients (#4,6). Digital healthcare applications should be a more discussed topic in politics to increase its awareness and societal acceptance (#4). Moreover, campaigns and promotions about telemedicine, as some health insurances have already started, should be launched to increase public acceptance (#6).

3.2.1.5 Future Outlook on Telemedicine

Lastly, the experts were asked about the future outlook for the general use of telemedicine in Germany. Five of six experts expect (a lot) more use in the post-pandemic years. Only one expert takes a critical view and sees no further potential for telemedicine in the future (#3). Three experts are of the opinion that telemedicine is still in its infancy and that there is a lot of space for improvement and growth (#1,2,5). It is argued that only a small number of hospitals use telemedicine for patient care (#1, 5), but that there are many medical disciplines that could benefit from digital service offerings (#5). Expert #5 believes that telemedicine will only gain momentum in the next decade when the technological issues have been solved. Expert #3 argues that telemedicine is merely helpful for certain situations and is better suited for larger, urban hospitals with good infrastructure. To test whether the type of medical facility and its location has an impact on telemedicine use, the following hypotheses are developed:

H6: The type and location of a medical facility affect the use of telemedicine.
H6a: The type of medical institution is correlated with the use of telemedicine.
H6b: The location of the medical institution is correlated with the use of telemedicine.

Expert #5 believes that the increasing global digitization will favor a greater future use of telemedicine and that the convenience aspects play a major role for patients. Experts #5 and #6 appeal to the increased efficiency of digital solutions and are convinced that telemedicine will even be more efficient in the future. It is noted that in areas of medicine where a complete physical examination is not required, telemedicine could completely predominate (#6).
Finally, it is important to examine socio-demographic factors that might influence the use of telemedicine by physicians. Therefore, the following hypotheses are formulated:

H7: Socio-demographic factors of physicians influence the use of telemedicine.
H7a: Age of physicians is correlated with the use of telemedicine.
H7b: Gender of physicians is correlated with the use of telemedicine.

3.3 Online Survey

Based on the findings of the expert interviews, the survey was designed to explore results and hypotheses with a larger sample of physicians. The survey aims to shed light on the attitudes of physicians towards telemedicine and its use before and during the COVID-19 pandemic. In addition, the survey examines physicians' perceptions of the benefits and limitations of telemedicine.

The survey can be divided into six sections: benefits of telemedicine, limitations of telemedicine, physicians' opinion on telemedicine, physicians' use of telemedicine, impact of the COVID-19 pandemic on telemedicine use, and socio-demographic data. Multiple one-sample t-tests were conducted to measure the importance and significance of the benefits and limitations of telemedicine as well as physicians' opinion towards this service. With regard to the use of telemedicine and the influence of COVID-19 and socio-demographic factors on it, t-tests as well as linear and multiple linear regressions were performed to determine correlations between the variables.

The online survey was developed via the online survey platform *Qualtrics* and is based on standardized question types. Prior to publication, the quality, clarity, and comprehensibility of the questions was evaluated and adjusted in a pre-test with five participants. Then, the survey was distributed in the author's social environment and shared with colleagues, family, friends, and over social media platforms such as *LinkedIn, WhatsApp, Instagram,* and *Facebook* from August 9th until August 21st, 2021. The data collection was anonymous, and the results were analyzed using the statistical computing program *RStudio* and the spreadsheet program *Excel.*

In total, 86 responses were collected. From the total number of responses, five had to be excluded as the participants did not fill out the questionnaire completely. One had to be excluded because the respondent was not a physician. After cleaning and editing the data, 80 questionnaires were analyzed. The sample provides a good overview about the medical landscape in Germany, as physicians of all ages, genders, types of medical facilities and geographical regions were surveyed. An overview of the socio-demographic data is shown in Appendix VIIIa and Appendix VIIIb.

3.3.1 Analysis of the Benefits of Telemedicine

To test the most important benefits from the expert interviews on a larger scale, the survey respondents were asked to rate the stated benefits on a five-point Likert scale (from 1 = strongly agree to 5 = strongly disagree). The larger sample size of the survey leads to more robust results and is important to determine the characteristics that physicians value in telemedicine. The

distribution of the responses regarding the benefits of telemedicine is shown in Appendix IX and the reliability of the benefit variables can be seen in Appendix X.

The most important benefit is *Travel* (*saved travel time for patients/physicians)*, as the mean value of this feature is the lowest with 1.64 (1 = strongly agree to 5 = strongly disagree). In verbal terms, this means that, on average, respondents either partially or strongly agree with this benefit. Other important benefits of telemedicine services are *Protection* (*protection against infectious diseases)* (mean = 1.75), *Access* (*easy access to healthcare)* (mean = 1.93) and *Interaction* (*improved interaction between physicians)* (mean = 1.96) (see Appendix XI).

To test whether the mean of an individual benefit has a statistically significant difference from the mean of all benefits, several one-sample t-tests were performed (Appendix XII). The mean of all benefits is 1.96 and serves as the benchmark value for the individual benefits in t-tests. The perceived importance of the individual benefits by physicians can be seen in Table 6.

Benefits	**Access**	**Interaction**	**Convenience**	**Travel**	**Protection**	**Scheduling**
Mean of all benefits	1.96	1.96	1.96	1.96	1.96	1.96
Mean of individual benefit	**1.93**	**1.96**	**2.18**	**1.64**	**1.75**	**2.33**
n	80	80	80	80	80	80
DF	79	79	79	79	79	79
Std deviation	0.84	1.01	1.10	0.94	1.10	1.03
T	-0.399	0	1.728	-3.077	-1.733	3.153
p-value	0.690	1	0.088	0.003	0.087	0.002
Significance	Not significantly better	Not significantly better/worse	Not significantly worse	Significantly better	Not significantly better	Significantly worse

Table 6: One-sample T-test results of Telemedicine Benefits

(Source: Own Illustration)

It can be observed that the benefit *Travel* is rated significantly better than the mean of all benefits (mean = 1.96) with a mean value of 1.64 at a 1% level of significance (p-value < 0.01). Thus, on average, physicians regard *Travel* as a major advantage of telemedicine.

In addition, the benefits *Access* (mean = 1.93) and *Protection (protection against infection)* (mean = 1.75) are also rated better than the mean of all benefits (mean = 1.96), however, the difference is not statistically significant (p > 0.01). The benefits *Interaction* and *Convenience (convenient care)*, show no statistically significant deviation from the mean of all benefits. In contrast, the benefit *Scheduling (effective scheduling)* (mean = 2.33) has a significantly lower mean compared to the mean of all benefits with a p-value of < 0.01 (1% level of significance). This indicates that physicians do not regard effective scheduling as an important benefit in comparison to the other benefits.

Thus, hypothesis H2a can be rejected as the benefit *easy access to healthcare* shows no statistically significant difference to the mean of all benefits. Hypothesis H2b can be accepted as the benefit *saving travel time for physicians/patients* shows a statistically significant positive difference to the mean of all benefits.

Finally, the physicians were asked to name additional benefits. More than ten additional benefits were listed and some were mentioned more than once. These include: *"the provision of better care for immobile/old patients"*, *"a lower barrier for patients to see a doctor"* and *"more economic efficiency/cost savings"*.

3.3.2 Analysis of the Limitations of Telemedicine

In this section, the limitations of telemedicine are analyzed. The mean values for each limitation can be found in Appendix XIII and the conducted one-sample t-tests for the limitations are shown in Appendix XIV.

Limitations	**Technical**	**Physical Contact**	**Infra-structure**	**Know-how**	**Quality**	**Costs**
Mean of all limitations	2.06	2.06	2.06	2.06	2.06	2.06
Mean of individual limitation	**1.83**	**1.38**	**1.89**	**2.09**	**2.34**	**2.84**
n	80	80	80	80	80	80
DF	79	79	79	79	79	79
Std deviation	0.85	0.46	1.06	1.02	1.21	1.26
T	-2.463	-8.983	-1.496	0.244	2.428	6.280

p-value	0.016	1.1e-13	0.139	0.808	0.017	1.7e-08
Significance	Significantly better	Significantly better	Not significantly better	Not significantly worse	Significantly worse	Significantly worse

Table 7: One-sample T-test results of Telemedicine Limitations (Source: Own Illustration)

The mean of all limitations is 2.06 and is the benchmark value for the t-tests. The results in Table 7 show that the mean values of the limitations *Technical (technical difficulties)* (mean = 1.83) and *Physical Contact (no physical contact with patients)* (mean = 1.38) are statistically better than the mean of all limitations (mean = 2.06) at a 5%, respectively 1% level of significance. Thus, physicians believe that those two limitations are severe obstacles to the use of telemedicine. On the other hand, *Quality (lower healthcare quality)* (mean = 2.34) and *Costs (high IT costs)* (mean = 2.84) show a statistically significant difference, that is significantly worse than the mean of all limitations. This implies that physicians consider those limitations as less serious barriers.

Therefore, hypotheses H5a and H5b can both be accepted as the limitations *technical difficulties* and *no physical contact* show a statistically significant negative difference to the mean of all limitations.

Finally, physicians additionally described *"more distant and less trust-based relationships with patients"* and *"privacy issues"* as further limitations of telemedicine.

3.3.3 Physicians' Opinion on Telemedicine

This section evaluates the physicians' opinion on the usefulness of telemedicine and whether the COVID-19 pandemic has changed their opinion. For this purpose, the survey participants were asked on their opinions on telemedicine before the outbreak and during the pandemic. Before the COVID-19 pandemic, the majority of physicians thought that telemedicine was either partially useful (56.25%) or even very useful (10.00%) (Appendix XVa). The mean value of 2.59 points indicates that, on average, the physicians viewed telemedicine before the pandemic as between *"partly useful"* and *"neutral"* in verbal terms (see Table 8).

#	Opinion on telemedicine:	Minimum	Maximum	Mean	Std Deviation	Count
1	**before** the COVID-19 pandemic	1.00	5.00	**2.59**	1.09	80
2	**during** the COVID-19 pandemic	1.00	5.00	**1.88**	0.92	80

Scale: 1 = Very useful; 5 = Not useful at all

Table 8: Opinion on Telemedicine Use before and during the COVID-19 pandemic (Source: Own Illustration)

In the current COVID-19 pandemic, physicians' opinions about the usefulness of telemedicine have changed. Today, 48.75% of all surveyed physicians consider telemedicine as *"partly useful"* and 37.50% as *"very useful"* (Appendix XVb). Table 8 shows that the mean value decreased to 1.88, indicating that physicians now consider telemedicine more useful than in the past. Verbally, physicians now rate telemedicine as between *"partly useful"* and *"very useful"*. This difference is statistically significant at a 1% level of significance ($p<0.01$) (see Appendix XVI). Thus, on average, physicians have a significantly more positive opinion (acceptance) about telemedicine in the current pandemic than before.
Consequently, hypothesis H1 can be accepted as the acceptance of physicians towards telemedicine is higher during the pandemic than before.

3.3.4 Use of Telemedicine before and during the COVID-19 Pandemic

The use of telemedicine by physicians before and during the COVID-19 pandemic is shown in Appendix XVIIa and Appendix XVIIb. Prior to the pandemic, 13 of the surveyed physicians (or 16.25%) used telemedicine compared to 38 physicians (or 47.50%) during the COVID-19 pandemic. To examine whether there is a statistically significant difference in telemedicine use in the two time periods, a one-sample t-test is conducted (Appendix XVIII). The mean of telemedicine use before the pandemic with a value of 1.84 (1 = Use; 2 = No use) was compared to the mean of telemedicine use during the pandemic with a value of 1.53. The t-test demonstrates that there is a statistically significant difference (increase) in the personal use of telemedicine during COVID-19 at a 1% level of significance ($p< 0.01$).
Thus, hypothesis H3 can be accepted as the use of telemedicine by physicians is higher during the COVID-19 pandemic than before.

To gain further insights into patterns of telemedicine use, physicians who use telemedicine during the pandemic (n=38) were asked to indicate their frequency and type of telemedicine use. Most physicians use the service either weekly (65.50%) or daily (23.50%) and primarily for *doctor-to-doctor meetings* (51%), followed by *doctor-to-patient sessions* (25.50%) and finally *“other types of telemedicine”* (23.50%).
The respondents named additional applications, most frequently mentioned were *“doctor-to-student meetings in the context of medical university lectures”* (2x), as well as *“advanced medical training in doctor-to-doctor interactions”* (2x).

3.3.4.1 Influence of Benefits on the Use of Telemedicine

After analyzing the benefits of telemedicine, it is important to examine which benefits have a significant impact on physicians’ use of telemedicine during the COVID-19 pandemic. To test whether individual benefits have a significant impact on the use of telemedicine, a multiple linear regression was run (Appendix XIX).
The results show that the benefit *Interaction* has a statistically significant effect on the use of telemedicine during the COVID-19 pandemic on a 1% level of significance ($p\text{-value} < 0.01$). The more physicians rate the benefit *Interaction* as important, the more likely they are to use telemedicine, on average. The finding is comprehensible, given that most surveyed physicians use telemedicine in a doctor-to-doctor interaction and thus better interaction between colleagues makes the service more attractive. No further statistically significant associations were found between the *benefit* variables and the variable *Tele_Use_During (telemedicine use during COVID-19).*

3.3.4.2 Influence of Demographic Factors on the Use of Telemedicine

In the following, the hypotheses regarding the demographic variables *Age* and *Gender* and their impact on the use of telemedicine during the COVID-19 pandemic are tested. For this purpose, a multiple linear regression is performed (Appendix XXa). The independent variable *Gender* has no statically significant impact on the dependent variable *Tele_Use_During.* In contrast, the independent variable *Age* has a statistically significant impact on the dependent variable. Since *Age* is used as a numerical variable in the survey, it was transformed into dummy variables in order to compare the impact of the different age groups more precisely in the regression (Appendix XXb). The results show that only the variable *Age5* (*age between 55 and 64*) has a statistically significant impact on the dependent variable *Tele_Use_During* on a 5% level of significance ($p\text{-value}<0.05$). Compared to the constant when physicians are in the age group

Age5 the coefficient of *Tele_Use_During* increases by 0.729 points on average (meaning less use as 1 = Use; 2 = No use). This result demonstrates that telemedicine use of physicians who are between 55 and 64 years during the pandemic is significantly lower compared to the constant (see Appendix XXb).

Thus, hypothesis H7a can be accepted as older physicians are statistically significantly more likely not to use telemedicine and hypothesis H7b can be rejected as gender does not have a statistically significant influence on telemedicine use.

3.3.4.3 Influence of Technological Skills on the Use of Telemedicine

The linear regression (Appendix XXI) reveals that the technological skills *Tech_Skills* have a statistically significant impact on the use of telemedicine during the COVID-19 pandemic on a 5% level of significance (p-value <0.05). For each unit increase of the variable *Tech_Skills* (meaning lower skills as 1 = very good; 5 = very limited) the coefficient of *Tele_Use_During* increases by 0.16 points on average (meaning less use as 1 = Use; 2 = No use). Thus, the lower the technological competence of physicians, the less likely they are to use telemedicine. Since the variable *Tech_Skills* is metric, it can conversely be said that the higher the technological skills of the physicians, the more likely they are to use telemedicine.

Hence, hypothesis H4 can be accepted as the technological skills of physicians have a statistically significant influence on the use of telemedicine.

3.3.4.4 Influence of the Work Environment on the Use of Telemedicine

Finally, it is examined whether physicians' work environments have an influence on the use of telemedicine during the pandemic. To measure the influence, a multiple linear regression is carried out with the independent variables *Medical_Facility (type of medical facility)* and *Medical_Facility_Location (size of city where the medical facility is located)* on the dependent variable *Tele_Use_During*. From Appendix XXII, it becomes apparent that the variable *Medical_Facility3* (= Medical practices) has a statistically significant impact on *Tele_Use_During* at a 1% significance level (p-value <0.01). Physicians who work in medical practices have a decreased use of telemedicine compared to the constant (see Appendix XXII). The influence of the variable *Medical_Facility_Location* has no statistically significant effect on the use of telemedicine (see Appendix XXII).

Thus, hypothesis H6a can be accepted as the type of medical facility has a statistically significant impact on the use of telemedicine. Hypothesis H6b can be rejected as the size of the city of the medical facility has no statistically significant influence on telemedicine use.

4. Discussion of Results and Managerial Implications

In this chapter, the results of the expert interviews and the online survey are interpreted. The aim is to discuss the key attributes of telemedicine and to explore the steps leading to an increased acceptance and use of telemedicine among physicians in Germany.

4.1 Key Attributes of Telemedicine

Saving time vs. technical difficulties

After analyzing the benefits, it is obvious that telemedicine offers practical advantages in several areas. Particularly noteworthy is the benefit of saving travel time. 87,50% of the surveyed physicians believe that saved travel time is either partly or strongly beneficial (survey results). On the one hand, patients can save commuting time to the doctor's office (Expert #2), and immobile patients have an opportunity to receive medical treatment (#5). On the other hand, physicians can benefit because daily consultations or interdisciplinary conferences can be held online, save time, increase comfort, and avoid the need for travel (#1, #4).

However, 85% of the surveyed physicians agree that technical difficulties are a major disadvantage of telemedicine. These difficulties include connectivity issues (#2, 5, 6), software problems (#1, 2,5), or server crashes (#2), which are common problems in German medical facilities today.

Implication

Health IT failures, respectively a lack of operational feasibility is a barrier to the adoption of telemedicine. As a consequence, telemedicine/health solution providers should consider building more robust services, updating their software, and providing ongoing technical support for their clients. Moreover, regulators should improve the telematics infrastructure nationwide. In addition, good broadband internet connections (especially in rural areas) should become the norm. Finally, addressing the technological deficiencies will help to make telemedicine more user-friendly and convince skeptical physicians to try telemedicine.

Improved physician interactions vs. the absence of physical patient contact

The benefit of improved interaction among physicians through telemedicine has a statistically significant impact on telemedicine use (survey results). This result could be explained by the fact that most of the surveyed physicians use telemedicine in a doctor-to-doctor environment (survey results). Telemedicine makes it easier to seek advice from specialists, diagnoses can be shared virtually and interdisciplinary conferences can take place remotely. Furthermore,

telemedicine enables physician interactions to be more structured and time efficient.
In contrast, providing a diagnosis via telemedicine can be difficult, establishing a trusting patient relationship can be challenging and for some medical specialties a physical examination is mandatory.

Implication

Due to its virtual nature, telemedicine cannot replace the physical component of an examination and should therefore only be offered for specific cases where a clear benefit can be identified. Additionally, the importance of the interpersonal level of the doctor-patient relationship is underlined by existing literature (Bächle & Wernick, 2019; Haserück, 2020). Indications for doctor-to-patient telemedicine should be well-defined to ensure optimal care and satisfaction and the outcome should be evaluated critically. It is expected that video consultations will effectively complement traditional doctor-patient communication after the pandemic (Stiftung Gesundheit, 2020). Clinical guidelines for its use should be determined.

4.2 Steps to increase Acceptance and Use of Telemedicine

Training for technologically unskilled and elderly physicians to foster telemedicine use

The results of the survey show that physicians who have better technological skills are more likely to use telemedicine. This finding may not be surprising; however, it shows that good technological skills are essential for the use of telemedicine. More than half of the interviewed experts believe that technology training for physicians (and patients) could increase the use of telemedicine. Elderly physicians (and patients) are sometimes unable or have difficulties using telemedicine, which could lead to a reluctance to accept and use telemedicine. From the survey, it appears that older age is negatively correlated with the use of telemedicine. This finding is consistent with the results of a representative study on video consultation use in Germany among physicians and psychotherapists (Stiftung Gesundheit & health innovation hub, 2020). By far the largest user group were physicians younger than 40 years and usage of video consultations decreased with increasing physician age. The same applies to patients using telemedicine (EPatient Analytics, 2020).

Implication

Physicians and patients with low technological competence could benefit from training. Samerski & Müller (2019) argue that digital health literacy is necessary for the digitization of the healthcare system, but it is not yet sufficiently supported in Germany. As a consequence,

training of digital capabilities should be offered to the general public and specific groups, to avoid digital exclusion. Two experts even argue that it should be a competent of medical education at university (#1,4).

In 2018, nearly 50% of all physicians in Germany were older than 50 years and among physicians in medical practices, the proportion of doctors over 59 years was 30,7% (Destatis, 2021). Since older physicians tend not to use telemedicine and make up a large proportion of the medical workforce in Germany, they should be given special attention in the promotion and training of telemedicine. In addition, providers of telemedicine services could offer their customers continuous support to ensure a simple and straightforward service.

The work environment influences the opinion on telemedicine – resident physicians as infrequent users

Being a physician working in a medical practice is negatively correlated with using telemedicine (survey results). Medical practice physicians are almost 50% less likely to use telemedicine compared to university hospital physicians (survey results). Expert #3 argues that telemedicine is more suitable for larger (university) hospitals, as they possess a more sophisticated technical infrastructure. The different working conditions for physicians in medical practices and the absence of a specialized IT department, which large hospitals typically have, result in practice owners having to solve IT problems themselves (Haserück, 2021). In addition, medical practice owners have high investment costs to set up the telemedicine infrastructure. Only if a clear added value for their institution is created, physicians will accept digital health services (Haserück, 2021). In addition, the lack of reimbursements for telemedicine services was a major barrier to the adoption (Häckl, 2010; Haserück, 2021).

However, even among medical practice physicians, the number of telemedicine users is higher during the COVID-19 pandemic than before (survey results). This trend is supported by the results of another survey, which found that the percentage of resident physicians offering video consultations increased from 6% before the pandemic to 17% during the pandemic (Bitkom, 2021). Improved reimbursement (18 %) and attractive offers from software providers (19 %) encouraged medical practice physicians to offer video consultations during the pandemic (Albrecht et al., 2020).

Implication

These results show that steps in the right direction are already taken, but promotion of telemedicine is necessary, especially among medical practice physicians. Appropriate remuneration and clearly defined regulations for telemedicine services even after the pandemic would contribute to the advance of telemedicine.

First strengthen the acceptance, then increase the use of telemedicine by physicians

The survey results show that slightly less than 50% of physicians have used telemedicine to date. About 70% of the users, use it on a weekly basis, but only about 25% use it in a doctor-patient interaction (survey results). In the expert interviews, only one physician noted frequent use of telemedicine with patients (#5) and three doctors mentioned rare instances of remote patient consultations since the outbreak of the pandemic (#1,2,6). These numbers indicate that telemedicine has not yet reached mass adoption in Germany, but is still in its infancy, as the total number of users and the frequency of use are still modest.

However, due to COVID-19, there is already a significant increase in the use of telemedicine among physicians in Germany compared to pre-pandemic times. In addition, nearly 90% of the surveyed physicians believe that telemedicine has proven useful during the COVID-19 pandemic. The acceptance of telemedicine among physicians is significantly higher in the ongoing COVID-19 pandemic than before (survey results).

Implication

It appears that the general consensus on telemedicine is positive, but that some aspects need to be improved. However, the widespread acceptance of the service could serve as a foundation to build upon. Five of the six interviewed physicians expect telemedicine to be used (a lot) more in the post-pandemic years. Expert #3 believes that telemedicine will be used much more as soon as the technical issues have been resolved. Once the technical infrastructure is better developed, telemedicine use can be extended to more medical specialties and to smaller facilities (Expert #5). Consequently, telemedicine providers, regulators and policy makers should focus on solving these technical and infrastructural issues.

5. Conclusion

5.1 Main findings

This thesis aimed to explore the impact of the COVID-19 pandemic on the acceptance and use of telemedicine by physicians in Germany. Moreover, it explored the main benefits and limitations to the adoption of telemedicine by physicians.

The survey results show that during the COVID-19 pandemic the acceptance of telemedicine is higher than before with almost 90% of the surveyed physicians valuing telemedicine as a useful tool. Concerning telemedicine use, the research findings indicate that around half of the surveyed physicians use telemedicine during the pandemic, compared to less than 20% before the pandemic. Telemedicine is mostly used on a weekly basis and mainly takes place in a doctor-to-doctor environment. Although telemedicine has not yet reached mass adoption, the outlook is promising as five of the six interviewed physicians expect a (strong) increase in use in the post-pandemic years.

The main benefits of telemedicine are saved travel time for physicians and patients, as well as improved interaction between physicians. Essential limitations of telemedicine are technical difficulties and the lack of physical patient examinations.

The experts mentioned several points of improvement for telemedicine such as an improvement of the telematics infrastructure, financial incentives, and technology training. The German government and telemedicine providers could improve these points to foster telemedicine use. Other aspects such as financial reimbursement, policies and legislation and healthcare organization could also be considered to increase the adoption of telemedicine.

Analyzing the socio-demographic data, physicians from university hospitals, who are younger than 40 years and who are technologically skilled, are the main users of telemedicine. Among physicians in medical practices and physicians of older age, the adoption is a lot lower.

The future shortage of physicians and the ageing population in Germany might force the healthcare system to make greater use of digital health solutions due to insufficient capacity (Bundesministerium für Gesundheit, 2020a; Klauber et al., 2019; Bächle & Wernick, 2019).

5.2 Limitations and Future Research

The results of both, the qualitative and quantitative research in this thesis might be influenced by possible limitations of the methodology.

The results may be biased to some extent, because the sample size of 80 participants was rather small and some demographic groups could be under- or overrepresented. A larger sample size might have altered the survey results and the analysis could be susceptible to a Type II error

(Columb & Atkinson, 2016). Moreover, people with a high technological affinity are more likely to take part in an online survey which might lead to a bias in results.
In addition, the survey included a limited number of variables for telemedicine benefits and limitations, so it may not have captured all relevant aspects that may influence telemedicine use. Also, patients as drivers of telemedicine were not subject of this study due to the limited scope of research.
Furthermore, findings such as the great importance of the variable *protection against infectious diseases* and the increased acceptance and use of telemedicine in the ongoing COVID-19 pandemic may only be temporary and could diminish as the pandemic subsides.
Another limitation is that this study focused on Germany with its complex healthcare system. Therefore, researchers must consider that the findings and implications may not be equally applicable to other countries.

Further research should address the influence of patients and other stakeholders on telemedicine use to obtain a more complete picture. In the future, when the COVID-19 pandemic has been overcome, the acceptance and use of telemedicine should be critically reevaluated, and it should be examined whether the partial transition from offline to online medical care was only a temporary effect or whether it is a significant permanent structural change towards more digital health solutions.

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7. Appendix

Appendix List

Appendix I: Expert Interview #1
Appendix II: Expert Interview #2
Appendix III: Expert Interview #3
Appendix IV: Expert Interview #4
Appendix V: Expert Interview #5
Appendix VI: Expert Interview #6
Appendix VII: Qualtrics Online Survey
Appendix VIIIa: Table - Socio-demographic Data of the Participants
Appendix VIIIb: Table - Work Environment of the Participants
Appendix IX: Table - Response Distributions for Telemedicine Benefits
Appendix X: Reliability Analysis - Benefits of Telemedicine
Appendix XI: Table - Importance Rating of Telemedicine Benefits
Appendix XII: One-sample T-tests - Benefits of Telemedicine
Appendix XIII: Table - Importance Rating of Telemedicine Limitations
Appendix XIV: One-sample T-tests - Limitations of Telemedicine
Appendix XV: Opinion on Telemedicine before and during the COVID-19 pandemic
Appendix XVI: One-sample T-test – Opinion on Telemedicine
Appendix XVII: Personal Use of Telemedicine before and during the COVID-19 pandemic
Appendix XVIII: One-sample T-test – Use of Telemedicine
Appendix XIX: Multiple Linear Regression – Impact of Benefits on Telemedicine Use
Appendix XX: Multiple Linear Regression – Impact of Demographic Factors on Telemedicine Use
Appendix XXI: Linear Regression – Impact of Technological Skills on Telemedicine Use
Appendix XXII: Multiple Linear Regression – Impact of Work Environment on Telemedicine Use

Appendix I - Expert Interview #1

Date: 14.7.2021, Duration: 25 minutes
Position: University hospital physician
Reason for selection: Regular telemedicine user (Doc-to-Doc)

1. Do you believe that the COVID-19 pandemic affected the progress of digital health services, especially telemedicine, in Germany? What were the benefits of telemedicine?

Yes, I think that a lot has happened in Germany as a result of COVID-19 regarding digitization, in particular video consultation hours have been established. Patients even specifically asked for such consultations as they no longer wanted to come to the hospitals and doctor's practices in order to avoid physical contacts. Also, patients and doctors could save a commute to the hospital, which leads to more convenient treatments and time savings, but mainly for patients. So, there was pressure from the demand side, which ultimately lead to change and good results in terms of provision and quality of healthcare.

2. Do you yourself use telemedicine in your daily work? What are the reasons for or against it?

In my department, we use video conferences for our weekly institute meeting, which previously took place on-site with 20 people in a room, but now happens via zoom or other providers. This makes the meeting more convenient for us, as we can participate in a meeting from home or our department and can save time to walk/drive to the physical meeting room. As it worked out well, for special requests, we even started to have patient consultations remotely via video conferences, but those cases are very rare.

However, colleagues from other disciplines in my hospital frequently (on a daily basis) use video consultations and they ensure that it works very well. It is also internally discussed to keep (and expand) the service for certain disciplines after the pandemic and extend the offerings to other departments as well.

3. Which limitations does the telemedicine service have in your opinion?

There is a certain inhibition of patients to speak freely and dare to ask any question if you are sitting in front of a device and not in a physical meeting with the doctor. Also, there is always the risk that the technology does not work 100%. Sometimes there are complications with the connection, or the software does not work optimally. Also, some patients (mainly older patients) have difficulties to work with video conferences.

4. What improvement points do you think are pertinent to telemedicine?

First of all, we need tools and more training to understand the equipment. The basic infrastructure is there with microphones and webcams, but more modern and high-quality equipment would definitely help. There also must be a standardized system to charge for the telemedicine offerings with chip cards for example that is not present yet.

A careful selection of patients that are suitable for telemedicine treatment is necessary. In my field, human genetics, for the first presentation a personal contact would be beneficial and future treatment could be done remotely with certain patients. For example, in the "findings meeting" of our research, where the results are evaluated, we personally called in patients again before the pandemic, but that you could theoretically shift to a permanent digital-only appointment in the future.

5. What outlook do you see for the future of telemedicine?

I believe the potential is very huge and the service will aid us to provide care. But I also believe that the technology and especially the use is still in its infancy. There are not too many incentives from the government for physicians to use telemedicine. There is still an insufficient infrastructure and not all hospitals make use of telemedicine. I think that the government should provide more incentives and that they have the duty to drive digital healthcare in Germany forward. Then, telemedicine will have a bright future.

Appendix II - Expert Interview #2

Date: 18.7.2021, Duration: 40 minutes
Position: General practitioner
Reason for selection: Occasional telemedicine user (Doc-to-Patient)

1. What are the benefits of telemedicine in your opinion?

As a physician in the countryside, I see that telemedicine enables patients to have access to health care, who would otherwise have a hard time to come to the doctor's office. In addition, they also save travel time, especially to specialists, of up to one or two hours per way. For me as an independent general practitioner, telemedicine services such as video consultations do not pose many benefits as I have a very large number of patients to handle in a day and do not have the time for many telemedicine appointments.

2. Do you yourself use telemedicine in your daily work? What are the reasons for or against it?
I use telemedicine to consult other doctors when I have patients with severe, rare diseases. I rarely use telemedicine services with patients, because for me it is an additional expenditure of time. There was a slight increase of this service during the last months, as some patients did not want to come to the doctor's office due to COVID-19.

3. Which limitations does the telemedicine service have in your opinion?
The most serve problem of telemedicine is that there are many technical problems with the software systems and the technical infrastructure. Some of the technical features simply do not work and other times the service crashes. Also, the card reader sometimes poses problems, which makes it difficult to use the service reliably. Additionally, the IT costs for our doctor's office are increasing tremendously and we are obligated to be connected to the telematics infrastructure, which costs us more than it benefits us. If the services would work reliably, telemedicine would be very useful.

4. What improvement points do you think are pertinent to telemedicine?
The telematics infrastructure needs to be improved in order to provide good telemedicine. Also, the government should support (small) doctor's offices with financial incentives to tackle the ever-increasing IT-related costs. Moreover, telemedicine services should be better compensated. As the services require the same time and the same quality (when applied correctly to suitable patients), it should be at the same level as regular in person visits, which is not the case yet. Also, additional digital services such as providing a digital vaccination card must be renumerated adequately, which is not the case. Another issue is that patients need to be trained and perhaps financially supported to properly use telemedicine services.

5. What outlook do you see for the future of telemedicine?
I believe that telemedicine potentially provides great advantages, but only if the mentioned issues are solved. If that is the case, the share of digital medical services will probably become larger. But only in 5-10 years' time. Moreover, training for medical practices should be provided and health data transmission should be advanced. Blood sugar levels, blood pressure and vital parameters could be measured by nurses or other medically trained staff. Then you would not need a doctor in small villages, and the nurse could transfer the data live to a doctor.

Appendix III - Expert Interview #3

Date: 21.7.2021, Duration: 30 minutes
Position: General practitioner
Reason for selection: Telemedicine critic, non-telemedicine user

1. What are the benefits of telemedicine in your opinion?

In my opinion, telemedicine only offers limited benefits. It was implemented in order to cope with the glaring shortage of doctors to make up with the gaps in the health care system. However, it can make sense for immobile patients who otherwise cannot see a doctor. Moreover, our doctor's office could benefit from a digital appointment overview system, which would facilitate the work of our nurses that still do the appointment planning with pen and paper. For functional practices, with patients who have similar illnesses, telemedicine would make sense and appointment scheduling works better as appointment times can be predicted easier.

2. Do you yourself use telemedicine in your daily work? What are the reasons for or against it?

I do not use telemedicine, as I believe it does not lead to an increase in health care quality. In my opinion, telemedicine is only a way for the German health insurance companies to save costs.

3. Which limitations does the telemedicine service have in your opinion?

I fundamentally do not believe that telemedicine in the doctor-patient relationship is useful. In my opinion, the personal and psychological component is very important for patients and can only be sufficiently achieved when the patient visit the doctor physically, in-person. Moreover, I believe that providing a diagnosis via video consultation is very difficult and poses a high risk of misdiagnosis. Thus, high-quality health care cannot be achieved via telemedicine.

4. What improvement points do you think are pertinent to telemedicine?

I do not think that the services pose a lot of benefits and I do not see a large use in the future. I heard from colleagues that digital services not always work perfectly. So, fixing the technical problems could make the current telemedicine services better.

5. What outlook do you see for the future of telemedicine?

I see telemedicine as a substitute procedure to solve problems that cannot otherwise be solved, especially during the times of COVID-19. I would always prefer the physical doctor-patient

appointment. I speak as a doctor that works in a small general practice in the countryside. When I used to work in a larger hospital, I worked with telemedicine when we had stroke patients. Then, internists and neurologists were connected with a camera, a physical live examination was performed, and x-rays were discussed to optimally treat the patients in a multidisciplinary team. As a conclusion, for other institutions or specialties telemedicine may be indeed beneficial.

Appendix IV - Expert Interview #4

Date: 24.7.2021, Duration: 30 minutes
Position: University hospital physician
Reason for selection: Regular telemedicine user (Doc-to-Doc)

1. What are the benefits of telemedicine in your opinion?

Briefly summarized, the universal access to health care is a very important point for telemedicine. In Germany, there is a great shortage of rural doctors, which makes telemedicine even more important. Patients could even receive treatment from medical doctors outside of Germany when certain specialists are present there or when there are free capacities. In addition, patients save travel time when using telemedicine services.

Another point is the better interaction between doctors through telemedicine. In our hospital, "specialist conferences" are held online instead of in physical presence. This makes participation more comfortable and enables more people to participate. In the COVID-19 pandemic it is a solution to maintain meetings. Furthermore, telemedicine could be used for patients with mild symptoms, where a short initial assessment is made via video consultation, and it could be evaluated how acute the problem is and in which direction the problem goes. That could save us physicians time. However, it is very important to see the patient in-person, to give a more accurate diagnosis.

2. Do you yourself use telemedicine in your daily work? What are the reasons for or against it?

We have now partially used telemedicine in our clinic with doctor-to-doctor services. However, for my field, surgery, it is very difficult to use telemedicine with patients. For the first contact or initial consultation with patients it could be possible to use the service. Then the patients could describe their problem and possibly show the results from other doctor visits. This procedure is in discussion in the future.

In the course of the Corona crisis, many meetings like the morning meetings, handovers of weekend or night shifts and tumor board meetings with different specialists are held remotely via Zoom or Microsoft Teams. This works pretty well and saves time as you do not have to walk around our large campus. Another benefit is, that it was easier to share the medical findings as you do not have to print them out.
Also, due to the COVID-19 pandemic, nearly all results of the aftercare are delivered to the patient by telephone, especially for people that live far away. This not only saves them travel and sometimes long waiting times, but also is beneficial because many patients do not want to come to the hospital because they fear the risk of being infected (COVID-19).

3. Which limitations does the telemedicine service have in your opinion?
The biggest limitation of telemedicine for surgery is that it is very important to see the patient in-person to make a good diagnosis. So, the use is limited to the previously mentioned cases in my field. Additionally, there is unfortunately no ideal technical infrastructure in Germany with good internet connections. Sometimes the picture or the sound are asynchronous, which makes the use difficult at times. Also, data security is a big topic, because many services are still subject to harsh legislation, which makes implementation long-lasting and bureaucratically difficult. Another issue is that many (older) colleagues, especially in medical practices do have difficulties using telemedicine as the use is not always easy and straight forward.

4. What improvement points do you think are pertinent to telemedicine?
As mentioned before, the technological infrastructure needs to be optimized and expanded for a better use of the service. Moreover, telemedicine should be more present with politicians and patients so that the service gets more funding and more adoption in society. I further believe that technical know-how and new trends (such as AI, Big Data) should be part of the medical training at university so that doctors have sufficient knowledge on these topics when they start working. In addition, training and conferences should be offered to interested patients and doctors in order to support a better telemedicine treatment experience.

5. What outlook do you see for the future of telemedicine?
If you look at the digitization trend today, I think that there will also be more and more digital solutions in the healthcare industry, such as telemedicine or surgical robots. People are becoming more and more comfortable and no longer want to drive to the doctor's office, but

rather visit them from home, just as they consume other things. The justification for telemedicine already exists today and will increase a lot in the future.

6. Are there any other points you would like to mention?

During a working experience in Australia, I saw small medical facilities where medical staff performed medical measurements for patients who could not attend a hospital far away. The results were sent to foreign doctors, who gave a diagnosis, and the patients could be treated by the staff on the distant site in many cases. This enabled many people to get at least some kind of medical treatment who would otherwise have no access to healthcare. Perhaps a similar model could make sense in rural areas in Germany or in elderly care as well.

Appendix V - Expert Interview #5

Date: 26.7.2021, Duration: 35 minutes
Position: General hospital physician
Reason for selection: Regular telemedicine user (Doc-to-Doc, Doc-to-Patient)

1. What are the benefits of telemedicine for physicians?

A benefit is that we can use telemedicine as a consultation medium among physicians. For example, we use it for our morning meetings with the whole department. There, we discuss the plan for the day and the incidents that happened overnight. We use the videoconferences to show findings and share laboratory results. It saves quite a lot of time when you have to do it more than once a day. Videoconferences have another main advantage because we have the possibility to further pursue patients remotely, which is helpful for capacity reasons, especially room capacities. Many times, waiting room capacities are overcrowded and we simply could not see the same quantity of patients physically. This changed with the introduction of video consultations, especially for chronically ill patients. Also, we doctors can provide healthcare services via telemedicine to people who are not mobile or fear infection with SARS-COV2.

2. What are the advantages of telemedicine for patients in your opinion?

For patients the personalized fixed appointments are a huge benefit, because we doctors have to plan out our day that we show up for the previously planned online appointment. Many times, patients must wait 2-3 hours in the real waiting room when something comes up, because they do not have a fixed appointment time. So, online scheduling definitely helps patients, but not necessarily physicians. As previously mentioned, saved travel time is a benefit, for patients as well as the saved travelling costs. It is also more convenient for patients, especially when they

do not feel well or have illnesses such as diarrhea, which is an obstacle to come to the hospital. In such cases, telemedicine helps.

Telemedicine is also beneficial for patients who have been in treatment for a long time. Patients who have been examined physically in our outpatient department can make follow-up video consultations, if the medical case allows it.

3. Do you yourself use telemedicine in your daily work? What are the reasons for or against it?

I personally use telemedicine when I have changed the therapy to control how it is working after a couple of weeks. For this kind of appointments, I simply want to see and talk to the patient again, whereas a personal visit is not necessary.

4. Which limitations does the telemedicine service have in your opinion?

It is noticeable that older colleagues in my department do not get on so well with technology. A colleague in his mid-60s is not tech-savvy and has little use for telemedicine. With telemedicine, of course, I cannot physically examine the patient, which is always an important part of my job. Another issue is that the telematics infrastructure did not fully work in the beginning. Sometimes the services did not work at all and sometimes only partly. A constant optimal connection to the telematics infrastructure must be ensured.

5. What improvement points do you think are pertinent to telemedicine?

An integration of the telemedicine services into the existing hospital systems would be important. It would be easier for the healthcare personnel to have all features, such as appointment schedules and videoconferencing in one system, which is not the case right now. Several logins into the systems are necessary and information must be transferred manually by hand in some cases. A harmonization of the systems would be timesaving and ease the use. Data protection is also an issue, as written consent is required from patients who want to participate in a video consultation for telemedicine treatment. This must be obtained before the treatment, which has not been easy in times when you could not see the patient on site.

You can also have the patients give their verbal consent beforehand and get written consent afterwards, but that is a big bureaucratic act. A change to a completely digital consent would simplify the use significantly, ensure data protection and save us doctors a lot of effort and time.

6. What outlook do you see for the future of telemedicine?

Telemedicine will certainly be used much more because it is simply more efficient in patient care and therefore it will become much more important. Our department stands at the beginning with telemedicine, but in our hospital, there are other specialties in which an appointment in-person is easier to replace. Thus, in my opinion, the distances to hospitals can be significantly reduced in many cases through telemedicine.

7. Are there any other points you would like to mention?

Unfortunately, the German healthcare system is very bureaucratic. For example, at the present time, complete telemedical treatments are not possible without a lot of correspondence between stakeholders, because the referrals are still paper-bound and still have to be sent by mail. In other words, we are still not close to being fully electronic and the administrative burden is enormous. For a future widespread use of telemedicine, in addition to improving the infrastructure in the hospitals, legislation, as well as the bureaucratic hurdles must also improve.

Appendix VI - Expert Interview #6

Date: 27.7.2021, Duration: 20 minutes
Position: University hospital physician
Reason for selection: Regular telemedicine user (Doc-to-Doc)

1. What are the benefits of telemedicine in your opinion?

I believe that telemedicine can support physicians who have limited capacity. It can enable more effective scheduling, saving patients travel time and giving doctors a more structured appointment calendar with fixed times. Other benefits include access to health care, for example, for people in rural areas who can now get treatment that they might not have been able to get before because they are immobile, very old and frail, or live in areas that are not so well developed. I believe that some people would go to the doctor more often when less effort would be involved, when they would not have to drive there and when there is no waiting in the (physical) waiting room. This in turn can enhance the convenience and probably the quality of healthcare for some patients. Moreover, it can save patients money needed for transportation.

2. Do you yourself use telemedicine in your daily work? What are the reasons for or against it?

I use telemedicine very frequently for meetings with my colleagues and to a minor extent with patients. For some carefully selected patients, video conferencing can be used to give a gaze

diagnosis for their eye condition. However, this only works with adequate equipment and when the video quality, light, and connection work very well. We just started with pilot projects, but the first results so far are convincing.

3. Which limitations does the telemedicine service have in your opinion?

The biggest limitation in my profession is that I have to see and touch the patients in-person to give them the best possible treatment. This cannot be substituted by the means of telemedicine. Another current limitation is that a solid technical infrastructure is not ensured in all cases today. The connection is not always ideal and an appropriate quality of the video meetings must be ensured at all times. We also found out that devices from different suppliers are differently suited for telemedicine. Perhaps a universal software should be used so that all patients can benefit equally from telemedicine.

4. What improvement points do you think are pertinent to telemedicine?

It would help us enormously if there were a portal in which one could have both a clear overview of appointments and combine them directly with the video consultations. Also, telemedicine is still in its infancy, and it would make sense for health insurance companies and the Federal Ministry of Health to further support and push the technology. More new studies should be launched and campaigns for further awareness and use would be useful for greater acceptance.

5. What outlook do you see for the future of telemedicine?

I think telemedicine has an enormous potential and is also of great importance for medicine because some regular doctor visits are quite inefficient. A lot of time is spent waiting to pick up a prescription or to change a few sentences with the doctor. This can be done easily from home via video call. Therefore, I think that for some areas of medicine where you don't need complete physical examinations, telemedicine could be completely predominant.

Appendix VII – Qualtrics Online Survey

Master thesis Qualtrics Survey | Telemedicine & COVID-19

Dear participants,
Thank you for taking the time to support my master thesis by participating in this survey. The survey includes questions about **telemedicine** and **COVID-19** and is intended for **physicians**. Please note that there are no wrong or right answers and that you answer the questions truthfully. The data collected is not personal and will be kept strictly confidential and anonymous. The survey will take about **5 minutes** to complete. Thank you for your help!

Start of Block: Benefits of telemedicine

What is telemedicine?
Telemedicine is a collective term for different medical care concepts. One goal is the medical care of the population with spatial (and temporal) distance by means of information and communication technologies. Another goal is the communication between physicians, which takes place via video consultations, video conferences, telephone calls, e-mail or messenger services.

Q1 In your opinion, how applicable are the following benefits of telemedicine?

	Strongly agree (1)	Somewhat agree (2)	Neutral (3)	Somewhat disagree (4)	Strongly disagree (5)
Easy access to health care (1)	○	○	○	○	○
Improved interaction between physicians (2)	○	○	○	○	○
Convenient care (3)	○	○	○	○	○
Save travel time for patient/physician (4)	○	○	○	○	○
Protection against infectious diseases (5)	○	○	○	○	○
Effective scheduling for physicians (6)	○	○	○	○	○

Q2 Would you like to note any additional benefits of telemedicine?

○ Yes (1)

○ No (2)

Display This Question:

If Would you like to note any additional benefits of telemedicine? = Yes

Q2.1 Please list other benefits of telemedicine in the table. (One to max. three advantages)

	Strongly agree (1)	Somewhat agree (2)
Benefit 1 (1)	○	○
Benefit 2 (2)	○	○
Benefit 3 (3)	○	○

End of Block: Benefits of telemedicine

Start of Block: Limitations of telemedicine

Q3 In your opinion, how applicable are the following limitations of telemedicine?

	Strongly agree (1)	Somewhat agree (2)	Neutral (3)	Somewhat disagree (4)	Strongly disagree (5)
Technical difficulties (1)	○	○	○	○	○
No physical contact with patients (2)	○	○	○	○	○
Insufficient technological infrastructure (3)	○	○	○	○	○
Lack of technological know-how of patient/physician (4)	○	○	○	○	○
Lower healthcare quality (5)	○	○	○	○	○
High IT costs (6)	○	○	○	○	○

Q4 Would you like to mention additional limitations of telemedicine?

○ Yes (1)

○ No (2)

Display This Question:

If Would you like to mention additional limitations of telemedicine? = Yes

Q4.1 Please list other limitations of telemedicine in the table. (One to max. three limitations)

	Strongly agree (1)	Somewhat agree (2)
Limitation 1 (1)	○	○
Limitation 2 (2)	○	○
Limitation 3 (3)	○	○

End of Block: Limitations of telemedicine

Start of Block: Personal opinion towards telemedicine

Q5 What was your personal opinion on the use of telemedicine **BEFORE** the COVID-19 pandemic?

○ Very useful (1)

○ Partly useful (2)

○ Neutral (3)

○ Not useful (4)

○ Not at all useful (5)

Q6 What is your personal opinion on the use of telemedicine **DURING** the COVID-19 pandemic?

○ Very useful (1)

○ Partly useful (2)

○ Neutral (3)

○ Not useful (4)

○ Not at all useful (5)

End of Block: Personal opinion towards telemedicine

Start of Block: Personal use of telemedicine

Q7 Have you used telemedicine **BEFORE** the COVID-19 pandemic?

○ Yes (1)

○ No (2)

Q8 Do you use telemedicine **DURING** the COVID-19 pandemic?

○ Yes (1)

○ No (2)

Display This Question:

*If Do you use telemedicine **DURING** the COVID-19 pandemic? = Yes*

Q8.1 How often do you use telemedicine DURING the COVID-19 pandemic?

- ○ Daily (1)
- ○ Weekly (2)
- ○ Monthly (3)
- ○ Only on a trial basis (4)

Display This Question:

*If Do you use telemedicine **DURING** the COVID-19 pandemic? = Yes*

Q8.2 What type of telemedicine do you use? (**Multiple answers possible**)

- ▢ Doctor to doctor meetings (1)
- ▢ Doctor to patient meetings (2)
- ▢ Oher type (3) ____

End of Block: Personal use of telemedicine

Start of Block: General assessment of telemedicine

Q9 Do you believe telemedicine is as effective as a comparable, in-person doctor visit?

- ○ Strongly agree (1)
- ○ Somewhat agree (2)
- ○ Neutral (3)
- ○ Somewhat disagree (4)
- ○ Strongly disagree (5)

Q10 In your opinion, does telemedicine treatment provide the same patient satisfaction as comparable, in-person treatment?

- ○ Strongly agree (1)
- ○ Somewhat agree (2)
- ○ Neutral (3)
- ○ Somewhat disagree (4)
- ○ Strongly disagree (5)

End of Block: General assessment of telemedicine

Start of Block: The impact of COVID-19 on telemedicine

Q11 In your opinion, was the technological environment at your workplace adequate for telemedicine use **BEFORE** the COVID-19 pandemic? (E.g. Good internet connection and equipment, techn. support, etc.)

- ◯ Fully sufficient (1)
- ◯ Partially sufficient (2)
- ◯ Neutral (3)
- ◯ Partially insufficient (4)
- ◯ Fully insufficient (5)

Q12 Has the technological environment in your workplace improved **DURING** the COVID-19 pandemic?

- ◯ Strongly agree (1)
- ◯ Somewhat agree (2)
- ◯ Neutral (3)
- ◯ Somewhat disagree (4)
- ◯ Strongly disagree (5)

Q13 In your opinion, was financial reimbursement for telemedicine services adequate **BEFORE** the COVID-19 pandemic?

- ◯ Fully sufficient (1)
- ◯ Partially sufficient (2)
- ◯ Neutral (3)
- ◯ Partially insufficient (4)
- ◯ Fully insufficient (5)

Q14 Did the special regulations **DURING** the COVID-19 pandemic result in adequate reimbursement for telemedicine services?

- ◯ Strongly agree (1)
- ◯ Somewhat agree (2)
- ◯ Neutral (3)
- ◯ Somewhat disagree (4)
- ◯ Strongly disagree (5)

Display This Question:

*If Did the special regulations **DURING** the COVID-19 pandemic result in adequate reimbursement for telemedicine services? = Somewhat disagree Or = Strongly disagree*

Q15 How high do you think the compensation for a video consultation should be?

End of Block: The impact of COVID-19 on telemedicine

Start of Block: Personal data

Q16 What is your profession?

- ◯ Physician (1)
- ◯ Healthcare professional (2)
- ◯ Other medical profession (3) ____
- ◯ Other non-medical profession (4)

Q17 In what type of medical facility do you work?

- ◯ University hospital (1)
- ◯ (General-)hospital (2)
- ◯ Medical practice (3)
- ◯ Other medical facility (4) ____

Q18 Where is your medical facility located?

- ◯ Large city (100,000 inhabitants or more) (1)
- ◯ Medium-sized city (20,000 to 100,000 inhabitants) (2)
- ◯ Rural region (under 20,000 inhabitants) (3)

Q19 How would you evaluate your technological skills?
(E.g. use of computers/smartphones, technology at work. etc.)

- ◯ Very good (1)
- ◯ Good (2)
- ◯ Moderate (3)
- ◯ Limited (4)
- ◯ Very limited (5)

Q20 What is your gender?

- Male (1)
- Female (2)
- Diverse (3)

Q21 What is your age?

- 18 - 24 (1)
- 25 - 34 (2)
- 35 - 44 (3)
- 45 - 54 (4)
- 55 - 65 (5)
- Above 65 (6)

End of Block: Personal data

Start of Block: Concluding remarks

Q22 Would you like to make any further comments or add anything you consider important?

____

End of Block: Concluding remarks

Appendix VIIIa: Table - Socio-demographic Data of the Participants

Variable	Count (n)	Frequency in %
Gender		
Male	42	52.50%
Female	38	47.50%
Divers	0	0.00%
Age		
18-24	2	2.50%
25-34	29	36.25%
35-44	14	17.50%
45-54	9	11.25%
55-65	25	31.25%
Above 65	1	1.25%
Profession		
Physician	76	95.00%
Healthcare professional	2	2.50%
Other medical profession	2	2.50%
Technological skills		
Very good	23	28.75%
Good	39	48.75%
Moderate	15	18.75%
Limited	3	3.75%
Very limited	0	0.00%

Appendix VIIIb: Table - Work Environment of the Participants

Variable	Count (n)	Frequency in %
Type of medical facility		
University hospital	33	41.25%
(General-) hospital	17	21.25%
Medical practice	26	32.50%
Other medical facility	4	5.00%
Location of medical facility		
Large city	56	70.00%
Medium-sized city	18	22.50%
Rural area	6	7.50%

Appendix IX: Table – Response Distributions for Telemedicine Benefits

#	Field	Strongly agree (1)	Somewhat agree (2)	Neutral (3)	Somewhat disagree (4)	Strongly disagree (5)	Total (n)
1	Easy access to healthcare	n=25 31.25%	n=43 53.75%	n=7 8.75%	n=4 5.00%	n=1 1.25%	n=80
2	Improved interaction between physicians	32 40.00%	28 35.00%	12 15.00%	7 8.75%	1 1.25%	80
3	Convenient care	25 31.25%	32 40.00%	11 13.75%	9 11.25%	3 3.75%	80
4	Save travel time for patient/physician	47 58.75%	23 28.75%	2 2.50%	8 10.00%	0 0.00%	80
5	Protection against infectious diseases	45 56.25%	19 23.75%	8 10.00%	5 6.25%	3 3.75%	80
6	Effective scheduling for physicians	18 22.50%	33 41.25%	19 23.75%	7 8.75%	3 3.75%	80

Appendix X: Reliability Analysis - Benefits of Telemedicine

```
Reliability analysis
Call: psych::alpha(x = reliabilityofbenefits)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
      0.85      0.86    0.86       0.5   6 0.025    2 0.77      0.5

 lower alpha upper     95% confidence boundaries
0.81 0.85 0.9

 Reliability if an item is dropped:
         raw_alpha std.alpha G6(smc) average_r S/N alpha se  var.r med.r
benefit1      0.84      0.84    0.82      0.51 5.3    0.029 0.0062  0.51
benefit2      0.84      0.84    0.84      0.52 5.4    0.028 0.0181  0.55
benefit3      0.82      0.82    0.81      0.48 4.5    0.032 0.0124  0.49
benefit4      0.81      0.81    0.80      0.46 4.2    0.034 0.0137  0.45
benefit5      0.83      0.83    0.83      0.50 5.0    0.030 0.0174  0.51
benefit6      0.85      0.85    0.84      0.53 5.7    0.027 0.0116  0.56

 Item statistics
          n raw.r std.r r.cor r.drop mean   sd
benefit1 80  0.71  0.73  0.68   0.60  1.9 0.84
benefit2 80  0.73  0.72  0.64   0.59  2.0 1.01
benefit3 80  0.82  0.81  0.78   0.71  2.2 1.10
benefit4 80  0.85  0.86  0.84   0.78  1.6 0.94
benefit5 80  0.78  0.77  0.70   0.65  1.8 1.10
benefit6 80  0.69  0.69  0.59   0.55  2.3 1.03
```

To see, how much the six *benefit* variables correlate with each other and how reliably these variables measure the concept of telemedicine benefits, a reliability analysis using Cronbach's Alpha was conducted (Appendix XII). The results show a raw alpha with a coefficient of 0.85 and all individual items with alpha coefficients >0.80. These high values reveal a good overall reliability of the variables *(Tavakol & Dennick, 2011; Bland & Altman, 1997).*

Appendix XI: Table - Importance Rating of Telemedicine Benefits

#	Field	Minimum	Maximum	**Mean**	Std deviation	Variance	Count
1	Easy access to healthcare *(Access)*	1.00	5.00	**1.93**	0.84	0.70	80
2	Improved interaction between physicians *(Interaction)*	1.00	5.00	**1.96**	1.01	1.01	80
3	Convenient care *(Convenience)*	1.00	5.00	**2.18**	1.10	1.21	80
4	Save travel time for patient/physician *(Travel)*	1.00	4.00	**1.64**	0.94	0.88	80
5	Protection against infectious diseases *(Protection)*	1.00	5.00	**1.75**	1.10	1.20	80
6	Effective scheduling for physicians *(Scheduling)*	1.00	5.00	**2.33**	1.03	1.06	80

(Scale: 1 = strongly agree; 5 = strongly disagree)

Appendix XII: One-sample T-tests - Benefits of Telemedicine

```
        One Sample t-test

data:  finaldata$Benefit_1_Access
t = -0.39999, df = 79, p-value = 0.6902
alternative hypothesis: true mean is not equal to 1.9625
95 percent confidence interval:
 1.73839 2.11161
sample estimates:
mean of x
    1.925
```

```
        One Sample t-test

data:  finaldata$Benefit_2_Interaction
t = 0, df = 79, p-value = 1
alternative hypothesis: true mean is not equal to 1.9625
95 percent confidence interval:
 1.737318 2.187682
sample estimates:
mean of x
   1.9625
```

```
        One Sample t-test

data:  finaldata$Benefit_3_Convenience
t = 1.7282, df = 79, p-value = 0.08785
alternative hypothesis: true mean is not equal to 1.9625
95 percent confidence interval:
 1.930258 2.419742
sample estimates:
mean of x
    2.175
```

```
        One Sample t-test

data:  finaldata$Benefit_4_Travel
t = -3.0774, df = 79, p-value = 0.00287
alternative hypothesis: true mean is not equal to 1.9625
95 percent confidence interval:
 1.427292 1.847708
sample estimates:
mean of x
   1.6375
```

```
        One Sample t-test

data:  finaldata$Benefit_5_Protection
t = -1.7332, df = 79, p-value = 0.08696
alternative hypothesis: true mean is not equal to 1.9625
95 percent confidence interval:
 1.505964 1.994036
sample estimates:
mean of x
     1.75
```

```
        One Sample t-test

data:  finaldata$Benefit_6_Scheduling
t = 3.1528, df = 79, p-value = 0.002286
alternative hypothesis: true mean is not equal to 1.9625
95 percent confidence interval:
 2.096142 2.553858
sample estimates:
mean of x
    2.325
```

Appendix XIII: Table - Importance Rating of Telemedicine Limitations

#	Field	Minimum	Maximum	**Mean**	Std deviation	Variance	Count
1	Technical difficulties *(Technical)*	1.00	5.00	**1.83**	0.85	0.73	80
2	No physical contact with patients *(Physical Contact)*	1.00	4.00	**1.38**	0.68	0.46	80
3	Insufficient technological infrastructure *(Infrastructure)*	1.00	5.00	**1.89**	1.03	1.06	80
4	Lack of technological know-how of patient/ physician *(Know-how)*	1.00	4.00	**2.09**	1.01	1.02	80
5	Lower healthcare quality *(Quality)*	1.00	5.00	**2.35**	1.10	1.21	80
6	High IT costs *(Costs)*	1.00	5.00	**2.84**	1.12	1.26	80

(Scale: 1 = strongly agree; 5 = strongly disagree)

Appendix XIV: One-sample T-tests - Limitations of Telemedicine

```
	One Sample t-test

data:  finaldata$Limitation_1_Technical
t = -2.4627, df = 79, p-value = 0.01597
alternative hypothesis: true mean is not equal to 2.06
95 percent confidence interval:
 1.63506 2.01494
sample estimates:
mean of x
    1.825
```

```
	One Sample t-test

data:  finaldata$Limitation_2_PhysicalContact
t = -8.983, df = 79, p-value = 1.05e-13
alternative hypothesis: true mean is not equal to 2.06
95 percent confidence interval:
 1.223218 1.526782
sample estimates:
mean of x
    1.375
```

```
	One Sample t-test

data:  finaldata$Limitation_3_Infrastructure
t = -1.4964, df = 79, p-value = 0.1385
alternative hypothesis: true mean is not equal to 2.06
95 percent confidence interval:
 1.658044 2.116956
sample estimates:
mean of x
   1.8875
```

```
	One Sample t-test

data:  finaldata$Limitation_4_KnowHow
t = 0.24384, df = 79, p-value = 0.808
alternative hypothesis: true mean is not equal to 2.06
95 percent confidence interval:
 1.863015 2.311985
sample estimates:
mean of x
   2.0875
```

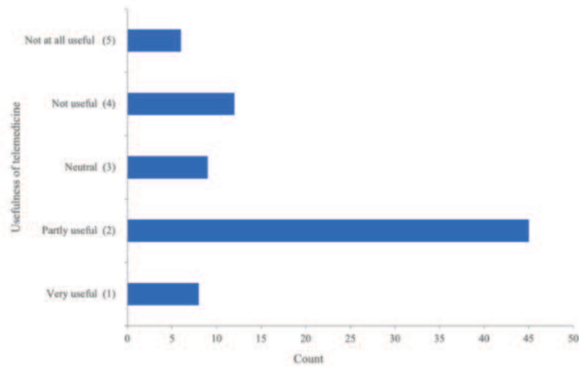
```
	One Sample t-test

data:  finaldata$Limitation_5_Quality
t = 2.4275, df = 79, p-value = 0.01748
alternative hypothesis: true mean is not equal to 2.06
95 percent confidence interval:
 2.112209 2.587791
sample estimates:
mean of x
     2.35
```

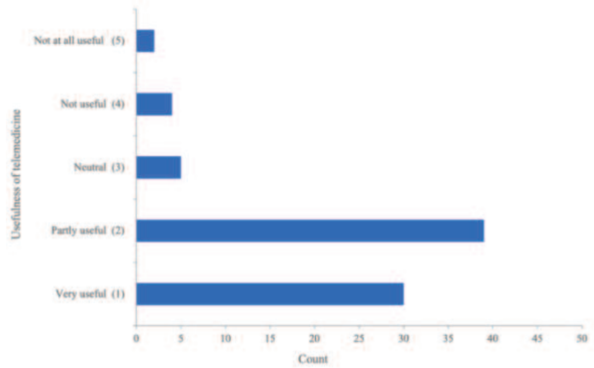
```
	One Sample t-test

data:  finaldata$Limitation_6_Costs
t = 6.2795, df = 79, p-value = 1.716e-08
alternative hypothesis: true mean is not equal to 2.06
95 percent confidence interval:
 2.591051 3.083949
sample estimates:
mean of x
   2.8375
```

Appendix XV: Opinion on Telemedicine before and during the COVID-19 pandemic



a) Before



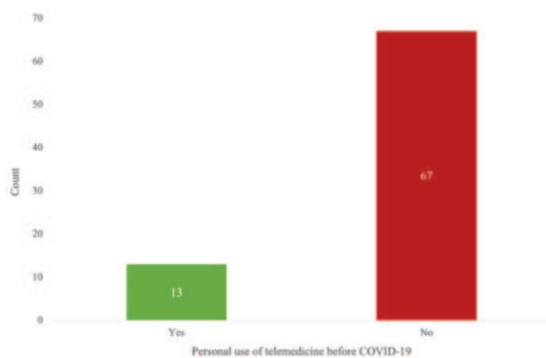
b) During

Appendix XVI: One-sample T-test – Opinion on Telemedicine

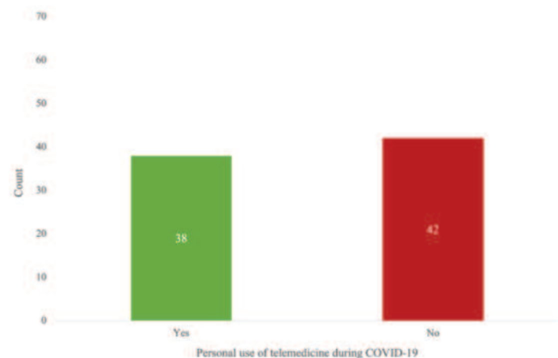
```
        One Sample t-test

data:  finaldata$Tele_Opinion_During
t = -6.9281, df = 79, p-value = 1.025e-09
alternative hypothesis: true mean is not equal to 2.587
95 percent confidence interval:
 1.670441 2.079559
sample estimates:
mean of x
    1.875
```

Appendix XVII: Personal Use of Telemedicine before and during the COVID-19 pandemic



a) Before



b) During

Appendix XVIII: One-sample T-test – Use of Telemedicine

```
        One Sample t-test

data:  finaldata$Tele_Use_During
t = -5.5621, df = 79, p-value = 3.511e-07
alternative hypothesis: true mean is not equal to 1.8375
95 percent confidence interval:
 1.413168 1.636832
sample estimates:
mean of x
    1.525
```

Appendix XIX: Multiple Linear Regression – Impact of Benefits on Telemedicine Use

```
===================================================
                          Dependent variable:
                      ---------------------------
                            Tele_Use_During
---------------------------------------------------
Benefit_1_Access                  0.089
                                 (0.090)
Benefit_2_Interaction           0.260***
                                 (0.063)
Benefit_3_Convenience             0.010
                                 (0.072)
Benefit_4_Travel                  0.030
                                 (0.087)
Benefit_5_Protection             -0.100
                                 (0.063)
Benefit_6_Scheduling             -0.111*
                                 (0.062)
Constant                        1.203***
                                 (0.158)
---------------------------------------------------
Observations                        80
R2                                0.264
Adjusted R2                       0.203
Residual Std. Error         0.449 (df = 73)
F Statistic              4.354*** (df = 6; 73)
===================================================
Note:                  *p<0.1; **p<0.05; ***p<0.01
```

Appendix XX: Multiple Linear Regression – Impact of Demographic Factors on Telemedicine Use

```
===================================================
                           Dependent variable:
                      ---------------------------
                             Tele_Use_During
---------------------------------------------------
Age                               0.099**
                                  (0.042)
Gender                             0.018
                                  (0.113)
Constant                         1.160***
                                  (0.251)
---------------------------------------------------
Observations                         80
R2                                 0.070
Adjusted R2                        0.046
Residual Std. Error           0.491 (df = 77)
F Statistic                 2.894* (df = 2; 77)
===================================================
Note:                   *p<0.1; **p<0.05; ***p<0.01
```

a) Age as a numeric variable

```
===================================================
                          Dependent variable:
                      ---------------------------
                            Tele_Use_During
---------------------------------------------------
Age2                              0.496
                                 (0.363)
Age3                              0.282
                                 (0.373)
Age4                              0.441
                                 (0.385)
Age5                             0.729**
                                 (0.357)
Age6                              0.994
                                 (0.606)
Gender                            0.006
                                 (0.119)
Constant                        0.994***
                                 (0.363)
---------------------------------------------------
Observations                        80
R2                                0.138
Adjusted R2                       0.067
Residual Std. Error         0.485 (df = 73)
F Statistic               1.950* (df = 6; 73)
===================================================
Note:                  *p<0.1; **p<0.05; ***p<0.01
```

b) Age with dummy variables

*The constant includes the omitted variables *Age1*(= Physicians < 25years) & *Male Gender*

Appendix XXI: Linear Regression – Impact of Technological Skills on Telemedicine Use

	Dependent variable:
	Tele_Use_During
Tech_Skills	0.160**
	(0.067)
Constant	1.203***
	(0.146)
Observations	80
R2	0.068
Adjusted R2	0.056
Residual Std. Error	0.488 (df = 78)
F Statistic	5.686** (df = 1; 78)
Note:	*p<0.1; **p<0.05; ***p<0.01

Appendix XXII: Multiple Linear Regression – Impact of Work Environment on Telemedicine Use

	Dependent variable:
	Tele_Use_During
Medical_Facility2	0.234
	(0.143)
Medical_Facility3	0.492***
	(0.151)
Medical_Facility4	-0.051
	(0.247)
Medical_Facility_Location2	-0.145
	(0.145)
Medical_Facility_Location3	0.170
	(0.230)
Constant	1.338***
	(0.081)
Observations	80
R2	0.205
Adjusted R2	0.152
Residual Std. Error	0.463 (df = 74)
F Statistic	3.824*** (df = 5; 74)
Note:	*p<0.1; **p<0.05; ***p<0.01

a) Both variables as factors

*The constant includes the omitted variables *Medical_Facility_1*
& *Medical_Facility_Location1* (= University hospital & Large cities)