Case study of the usage of Systems Engineering on Connected Health Care Through Teladoc Health

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Electrical Engineering Department

Introduction to Systems Engineering

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1. Introduction

Connected healthcare, also known as digital healthcare, e-health or telemedicine, refers to the use of technology and digital tools to improve the delivery and management of healthcare services. The field of connected healthcare has seen significant growth and advancement in recent years, and it continues to transform the way healthcare services are delivered to patients. The COVID-19 pandemic has highlighted the importance of telemedicine/connected healthcare in delivering healthcare services remotely, without the need for physical visits.

As telemedicine/connected healthcare continues to gain popularity, it is essential to examine the systems and processes behind its operation.

Teladoc is one of the leading telemedicine providers that connects patients with doctors via video or phone consultations (Teladoc Health, 2021). In this report, we will explore the concept of connected healthcare and the role of Teladoc in facilitating healthcare services.

This project will focus on Teladoc Health's telemedicine services and perform a comprehensive and in-depth analysis of its current systems and processes. The project will take into account various factors that contribute to the success of Teladoc Health's telemedicine services, such as technology utilization, stakeholder engagement, and overall effectiveness. The analysis will be performed using systems engineering methods, ensuring that all aspects of Teladoc Health's systems and processes are examined in a thorough and systematic manner.

The output of this project will be a deeper understanding of how Teladoc Health's telemedicine services are currently delivered and the factors that contribute to their success. The project will provide insights into the strengths and weaknesses of Teladoc Health's existing systems and processes, allowing for potential areas of improvement to be identified.

2. Background

2.1. History of Connected Healthcare/ Telemedicine:

Telemedicine has a rich history dating back to the early 20th century when radio was used to provide medical advice to ships at sea [1]. The development of telemedicine technology was slow until the 1950s when the first closed-circuit television system was used for medical consultations [2].

In the 1960s, the National Aeronautics and Space Administration (NASA) started using telemedicine to monitor astronauts in space [1]. In the 1970s, the University of Nebraska established a telemedicine network to provide healthcare services to rural areas [2]. This network marked the beginning of the use of telemedicine to address healthcare disparities in underserved areas. In the 1990s, the development of the internet and digital technology enabled the expansion of telemedicine services. The use of telemedicine received a significant boost in the 2000s when the US Department of Veterans Affairs (VA) implemented a telemedicine program to provide remote consultations to veterans [1]. The VA's telemedicine program resulted in significant cost savings and improved access to healthcare services for veterans.

In recent years, the development of mobile health technology and the COVID-19 pandemic has accelerated the adoption of telemedicine worldwide. The COVID-19 pandemic forced healthcare providers to limit in-person visits, leading to an increased reliance on telemedicine [3]. The pandemic has highlighted the potential of telemedicine to provide healthcare services while minimizing the risk of exposure to infectious diseases.

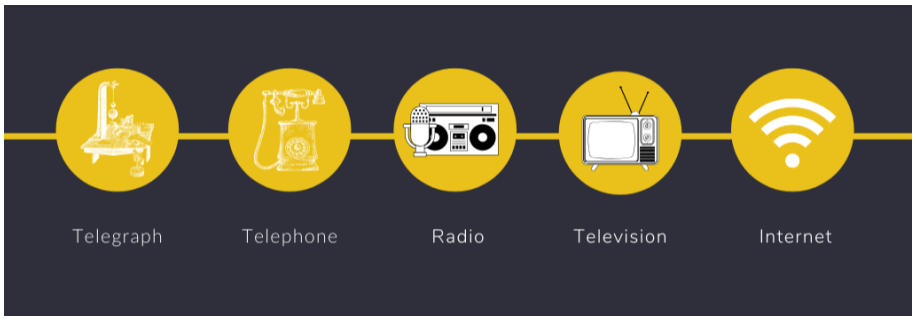


Fig 1. Represents Telemedicine through the ages

2.2. Components of Connected Healthcare:

There are several key components of connected healthcare that are essential for delivering effective and efficient healthcare services remotely. These components include:

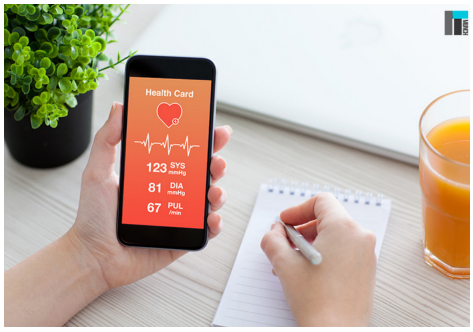
1. Telecommunication technology: The primary component of connected healthcare is the use of telecommunication technology to facilitate remote consultations between patients and healthcare providers. This can include phone calls, video conferencing, and messaging platforms that allow patients to communicate with healthcare providers from their homes or other remote locations. Telecommunication technology has been shown to improve patient outcomes and reduce healthcare costs [4].
2. Electronic health records (EHRs): EHRs are digital records of patient health information that can be accessed and updated by healthcare providers from any location. EHRs are an essential component of connected healthcare, as they allow healthcare providers to access patient information and provide accurate diagnoses and treatment plans remotely. EHRs can also improve healthcare quality and patient safety [5].
3. Remote monitoring devices: Remote monitoring devices allow healthcare providers to monitor patients' health remotely, without the need for in-person visits. Examples of remote monitoring devices include blood glucose monitors for patients with diabetes and wearable devices that track patients' activity levels and vital signs. Remote monitoring devices can improve patient outcomes and reduce healthcare costs [6].
4. Clinical decision support systems (CDSSs): CDSSs are software programs that provide healthcare providers with evidence-based recommendations for diagnosis and treatment based on patient data. CDSSs can be particularly useful in remote healthcare settings where healthcare providers may not have access to all of the diagnostic tools and resources that are available in traditional healthcare settings. CDSSs have been shown to improve healthcare quality and reduce healthcare costs [7].
5. Health information exchange (HIE): HIE is the process of sharing patient health information between different healthcare providers and organizations. HIE is an essential component of connected healthcare, as it allows healthcare providers to access patient information and coordinate care across different healthcare settings. HIE can improve healthcare quality and patient safety [8].

2.3. Existing Technologies in Telemedicine

With the growth of telemedicine, several technologies have been developed to support remote patient care. Some of the existing technologies used in telemedicine include:

1. Mobile applications: Mobile apps have become increasingly popular in telemedicine. These apps allow patients to monitor their health and communicate with healthcare providers remotely. For example, Teladoc and Doctor on Demand offer video consultations with doctors, while MyFitnessPal allows users to track their diet and exercise [9].
2. Remote monitoring systems: Remote monitoring systems enable healthcare providers to monitor patients' vital signs and other health data remotely. These systems use sensors and other devices to collect data on patients' health, which is then transmitted to healthcare providers. For example, remote monitoring systems can be used to monitor blood pressure, glucose levels, and heart rate [10].
3. Electronic health records: Electronic health records (EHRs) are digital records of patients' medical history, diagnoses, medications, and other health information. EHRs allow healthcare providers to access patient data remotely, which is essential for telemedicine. EHRs also facilitate communication between healthcare providers, enabling them to share patient information securely [11].
4. Wearable devices: Wearable devices such as smartwatches and fitness trackers can be used to monitor patients' health remotely. These devices can track patients' activity levels, heart rate, and other health metrics, which can be used to identify potential health issues. Wearable devices can also provide patients with feedback on their health and encourage them to make healthier choices [12].

Fig 2 and 3 represent Mobile applications and Wearable devices



3. Concept Development

3.1. Needs analysis

Connected healthcare, which encompasses telemedicine, telehealth, and other remote healthcare services, has emerged as a solution to the growing need for convenient and accessible healthcare. According to a report by Grand View Research, the global telemedicine market is expected to reach $185.6 billion by 2026, driven by the increasing demand for remote healthcare services and the growing prevalence of chronic diseases [13]. The need for connected healthcare is particularly acute in rural and remote areas, where access to healthcare services is limited. The American Telemedicine Association reports that telemedicine can help reduce healthcare disparities by providing remote access to specialists and other healthcare providers. Additionally, telemedicine can help reduce healthcare costs by providing more efficient and cost-effective care.

A study published in the Journal of Medical Systems in 2020 found that telemedicine has the potential to improve healthcare access for rural populations, improve quality of care, and reduce healthcare costs [14]. The study also found that telemedicine can improve patient satisfaction, reduce patient wait times, and increase the efficiency of healthcare delivery.

Another study published in the Journal of Telemedicine and Telecare in 2021 examined the use of telehealth for the management of chronic conditions such as diabetes and heart disease. The study found that telehealth can improve patient outcomes, reduce hospitalizations and emergency room visits, and increase patient adherence to treatment regimens. The study also highlighted the potential cost savings associated with telehealth, particularly for patients with multiple chronic conditions [15].

Furthermore, the COVID-19 pandemic has accelerated the adoption of telemedicine and other connected healthcare services. A study published in the Journal of Medical Internet Research in 2020 found that the use of telemedicine increased significantly during the pandemic, particularly for mental health services and follow-up care. The study also found that patients were generally satisfied with the quality of care provided through telemedicine [16].

3.2. Concept exploration

Connected healthcare, also known as digital healthcare or eHealth, is a new paradigm for healthcare delivery that leverages digital technologies such as mobile health (mHealth), electronic health records (EHRs), telemedicine, and remote patient monitoring (RPM) to connect patients, healthcare providers, and other stakeholders in the healthcare ecosystem. The potential benefits of connected healthcare include improving healthcare efficiency and quality while reducing costs, empowering patients to manage their health conditions, and enabling healthcare providers to monitor patients' health remotely, reducing the need for hospital visits and readmissions. According to a report by Grand View Research[13], the global market for mHealth applications is expected to reach $111.8 billion by 2025, and the global telemedicine market is expected to reach $185.66 billion by 2026, according to a report by Fortune Business Insights [18].

However, significant challenges must be addressed for connected healthcare to reach its full potential. One major challenge is the interoperability of digital health systems. Different healthcare providers often use different systems that are not compatible with each other, making it difficult to share patient data across systems. Additionally, there are concerns about the security and privacy of patient data. As more patient data is collected and shared across systems, there is a risk of data breaches and cyber attacks. Finally, there is a need for regulatory frameworks to ensure that digital health technologies meet the same standards of safety and effectiveness as traditional healthcare delivery methods. Despite these challenges, significant progress has been made in recent years. According to a report by the Healthcare Information and Management Systems Society (HIMSS) [18], 84% of hospitals in the United States have adopted at least a basic EHR system, up from 9% in 2008. Further research and development are needed to address the challenges and realize the full potential of connected healthcare.

3.3. Concept definition

3.3.1 Connected Healthcare

Connected healthcare refers to the use of technology to provide healthcare services remotely, without the need for patients and healthcare providers to be physically present in the same location. It encompasses various applications such as telemedicine, remote patient monitoring, and mobile health (mHealth). Connected healthcare aims to improve access to healthcare services, reduce costs, and enhance the quality of care.

3.3.2 Teladoc

Teladoc is a telemedicine company that offers virtual medical consultations through phone or video calls with licensed physicians and other healthcare providers. Patients can use Teladoc to consult with healthcare professionals for non-emergency medical conditions such as allergies, cold and flu symptoms, and skin infections. Teladoc provides access to healthcare services anytime and anywhere, without the need for an appointment or travel.

3.3.3 Other Applications

There are several other applications that use technology to provide healthcare services. For instance, Doctor on Demand is a telemedicine application that provides video consultations with licensed physicians, psychologists, and psychiatrists for a variety of health conditions. Another application is MyChart, which is a patient portal that allows patients to access their medical records, schedule appointments, and communicate with their healthcare providers securely. Additionally, there are several remote patient monitoring applications, such as HealthPatch MD and AliveCor, that use wearable devices to monitor patients' health remotely and alert healthcare providers if any abnormality is detected.

4. Benefits of Connected Healthcare

Connected healthcare has been shown to improve patient outcomes by enabling patients to manage their health conditions more effectively. A study published in the Journal of Medical Internet Research found that patients with chronic conditions who used mobile health applications reported improved medication adherence, self-efficacy, and disease knowledge [19]. Telemedicine can also allow healthcare providers to monitor patients' health remotely, reducing the need for hospital visits and readmissions. A study published in the Journal of Telemedicine and Telecare found that telemedicine reduced hospital readmissions by 38% [20].

Connected healthcare has the potential to increase healthcare efficiency and reduce costs. Telemedicine can reduce the need for in-person consultations and hospital visits, which can be costly and time-consuming. A study published in the Journal of the American Medical Association found that telemedicine reduced costs by an average of $126 per visit [21]. Additionally, electronic health records (EHRs) can streamline administrative tasks such as scheduling appointments, processing prescriptions, and managing patient data, which can save time and reduce errors.

Connected healthcare can improve the patient experience by providing more convenient and personalized healthcare services. A study published in the Journal of Medical Internet Research found that telemedicine improved patient satisfaction and reduced travel time and expenses [22]. Mobile health applications can provide patients with personalized health information and reminders, empowering them to take a more active role in their healthcare. A study published in the Journal of Diabetes Science and Technology found that patients who used mobile health applications reported improved self-care behaviors and diabetes-related quality of life [23].

Connected healthcare can also enable healthcare providers and policymakers to better manage population health by collecting and analyzing data on patients' health status and healthcare utilization patterns. This data can be used to identify health trends and disparities, target interventions to high-risk populations, and monitor the effectiveness of healthcare interventions over time.

Overall, these findings suggest that connected healthcare has the potential to provide significant benefits to patients, healthcare providers, and the healthcare system as a whole, highlighting the importance of continued investment and innovation in this field.

5. Challenges

Despite the potential benefits of connected healthcare and telemedicine, there are several challenges that need to be addressed. These challenges include:

5.1. Privacy and Security

The use of technology in healthcare raises concerns about patient privacy and data security. Telemedicine and other connected healthcare applications require the exchange of sensitive medical information between patients and healthcare providers. Therefore, it is essential to ensure that these applications comply with privacy and security regulations, such as the Health Insurance Portability and Accountability Act (HIPAA) [24].

5.2. Access and Adoption

Although connected healthcare has the potential to improve access to healthcare services, it is not accessible to everyone. Access to connected healthcare services depends on factors such as internet connectivity, digital literacy, and access to technology. [25] Additionally, some patients may be resistant to using telemedicine and other connected healthcare applications due to a lack of familiarity or trust in technology.

5.3. Reimbursement and Regulation

Another challenge faced by connected healthcare and telemedicine is reimbursement and regulation.[26] Many healthcare systems and insurance providers are not equipped to handle the reimbursement of telemedicine services, which can limit the availability and adoption of these services. Additionally, the regulatory landscape for telemedicine and other connected healthcare applications is complex and varies from state to state.

5.4. Ethical and Legal Issues

Connected healthcare and telemedicine also raise ethical and legal concerns. For instance, telemedicine can limit the ability of healthcare providers to conduct physical examinations and may lead to misdiagnosis or missed diagnoses [27]. Moreover, there are concerns about the appropriate use of patient data and the potential for breaches of

confidentiality and privacy [28]. These issues need to be addressed to ensure the safe and effective use of connected healthcare and telemedicine.

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