# Association between the 5G cost and reliability in healthcare

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Submitted to: Journal of Medical Internet Research
on: May 29, 2024

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## *Abstract*

In this article, we look at the hidden side of the prevailed advantages, specifically the reliability and cost issues associated with the implementation of 5G in healthcare. Healthcare is a safe industry and has a tolerance of margin of error to be zero to none. Given that healthcare is essential for mankind, the introduction of new technology has to be reliable. Furthermore, without a proper analysis of cost and funding, any decision of such investment will be bound to fail. In reliability, we have discussed how 5G interferes with the current proven successful healthcare practice, how 5G is susceptible to data theft and hacking and the misappropriate use of medical data for ulterior motives. In cost, the upgrade requirements needed, how costs are derived from one aspect to another and the funding to support the change are also discussed.

There are still many loopholes and questions left unanswered in this aspect, though it is believed to bring positive changes to the healthcare industry, through our findings, we conclude that this technology is unready, and the aforementioned problems have to be dealt with prior to introducing it to the society.

(JMIR Preprints 29/05/2024:62723)
DOI: https://doi.org/10.2196/preprints.62723

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Literature-Based Research

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# 1. Introduction

The fifth-generation (5G) of mobile technology will be a major step-up in the wireless communication industry and has given the impression to revolutionize society. 5G provides countless possibilities in modifying/upgrading the way the world operates to date. One of the most important industries which have supported mankind to survive and thrive in the healthcare industry. 5G is catalysed to upgrade the current system within the healthcare industry due to its unique functional features in terms of high speed, large connection, low latency, especially for artificial intelligence medical, telemedicine and rapid first aid (Ullah et al. 2019). “5G will usher in an era of personalized, self-directed healthcare, empowering patients with the ability to manage their health and medical conditions better” (Gross, 2019).

In this article, we look at the hidden side of the prevailed advantages, specifically the reliability and cost issues associated with the implementation of 5G in healthcare. Healthcare is a safe industry and has a tolerance of margin of error to be zero to none. Given that healthcare is essential for mankind, the introduction of new technology has to be reliable. Furthermore, without a proper analysis of cost and funding, any decision of such investment will be bound to fail. In reliability, we have discussed how 5G interferes with the current proven successful healthcare practice, how 5G is susceptible to data theft and hacking and the misappropriate use of medical data for ulterior motives. In cost, the upgrade requirements needed, how costs are derived from one aspect to another and the funding to support the change are also discussed.

There are still many loopholes and questions left unanswered in this aspect, though it is believed to bring positive changes to the healthcare industry, through our findings, we conclude that this technology is unready, and the aforementioned problems have to be dealt with prior to introducing it to the society.

# 2. Critical Evaluation

Oughton and Frias (2018) explored the cost, coverage and launch impact of the UK 5G network by inferring 4G Long-Term Evolution (LTE) and LTE-Advanced features between 2020 and 2030.

Oughton and Frias (2018) believe that by 2070, 90% of the British people will enjoy 5G networks. Among them, rural areas will be the main beneficiaries, and each rural user can reach a network of 10 Mbps, which is equivalent to the current fixed broadband universal service obligation in the UK (Oughton & Frias 2018). The cost of 5G-infrastructure intensification depends to a large extent on the required throughput density, periodic interest rates and the price of the base station. Oughton and Frias (2018) affirm that the fixed cost of network infrastructure delivery is very high, which was influenced by economies of scale and population density. However, they proposed a way to overcome this problem by providing "open" neutral small cell deployments to users of all service providers. Such shared infrastructure approach will encourage market entry by making the network more accessible to critical masses, thereby reducing costs. In addition, Oughton and Frias (2018) in the article defaulted the advantages of 5G networks technology, which is low latency and high reliability, but they did not display the supporting of reliability.

Comparing to Oughton’s and Frias's analysis of the cost of building infrastructure, Latif et al. (2017) analyze the cost issue from an individual perspective. Latif et al. (2017) believe that the current medical system has many challenges, such as high-quality medical services with high medical costs. Nonetheless, the Internet of Things (LoT) based on 5G technologies has the potential to enrich the user experiences, reduce medical costs and reduce the medical gap between rural and urban in developed and developing countries (Latif et al. 2017). Contrary to the article of Oughton and Frias, and Latif et al. expressed concerns about the reliability of 5G technology, while suggesting that there should be optimizations in methodology of technology, such as advanced MIMO and beamforming capability optimization issues (Latif et al. 2017). Although the two articles explained the cost will be reduced from different perspectives, there are some loopholes in their opinions and some omissions in some specific situations. Therefore, this article will analyse from the perspective of cost increase. In addition, Latif et.al (2017) rigorously analysed the unreliability of 5G technology. For this reason, this article provides some arguments to support the unreliability of 5G technology.

# 3. Literature Review

## 3.1 Reliability Perspective

### 3.1.1 Lack of consideration in mental and risk in infrastructure

5G networks are like a wider road, providing a path for the Internet, big data, artificial intelligence, and other technologies. Compared to 4G, 5G far exceeds the user experience rate by 10 times, only 1-millisecond transmission delay, 10 times the connection number density and other performances (Soldani et al. 2017, pp.1-5). These performances make the industry looking forward to introducing Wireless Tele Surgery into medical treatment. 4G networks neither carry out medical live broadcast, the transmission speed nor stable, the visual field definition is not enough, in contrast, in the 5G environment, the small bleeding point can be achieved, thus, the convenience and safety of the operation can be greatly improved (Soldani et al. 2017,pp.1-5).

The developments of medical technology and the improvement of people's living standards have made many people become healthier. Yet, due to the uneven distribution of medical resources, especially in developing countries or rural areas, there are still large design flaws. To solve this problem, a teleconferencing system based on video conferencing and Wireless Tele Surgery were

deployed to break the limitations of medical resources in terms of time and space (Soldani et al. 2017, pp. 1-5). By outsourcing the medical resources of large hospitals to rural and remote hospitals, high-quality medical resources can be shared in this way, not only achieving higher rescue rates, but also improving the utilization of medical resources. The telemedicine system based on 5G networks can alleviate the physical illness of urban and rural patients to a certain extent, but whether this system reliable or not? The answer may be fuzzy; Chen et al. (2017) believe that this remote treatment system lack of consideration that patients struggle with mental illness. Although Chen et al. proposed a solution to this problem by constructing a 5G-perception system, which allows doctors to capture the patient's emotions, this method also has a problem that cannot be ignored, that is, it is highly dependent on 5G infrastructure (Chen et al. 2017, p.2).

Abubakar et al. (2017, p.612) unveiled the veil of 5G wireless networking technologies. The operation of 5G wireless networks is based on electronic devices, electromagnetic devices and other systems. It has a high-speed data connection and can be used as a network transceiver station for the Internet of Things (IoT). However, the imbalance of electromagnetic interference and electromagnetic compatibility in 5G wireless networks can easily lead to electromagnetic pulse effects, which can cause signal interference problems. Taking medical equipment as an example, hospital MRI scanners, security analysis, and data processing, and even personal medical care such as pacemakers will suffer unexpected signal chaos, which generates increasing physical risk that patients have to face (Abubakar et al. 2017, p.612).

### 3.1.2 Insufficient empirical evidence on the privacy of 5G in healthcare

Since 5G technology offers an excellent opportunity for Information and Communication Technology (ICT) to be more efficient and effective, ICT will be widely used in the healthcare field, such as mobile health, personalized health, and smart health (Aceto et al. 2018). Reflected by the essentialness of ICT in the healthcare industry, the core requirement is responsiveness of 5G technology, whereas a huge number of sensors and medical devices are incapable to handle complex packet encryption (‘Content of premarket submissions for management of cybersecurity in medical devices’ 2014). Therefore, 5G technology is more susceptible to vulnerabilities in big data environments. Apart from deficiency of small devices, 5G collects more extensive and sensitive information than 4G because using 5G usage in the healthcare industry extends network security to personal security because personal security will be extended from network security when 5G technology is applied to healthcare industry. In other words, 5G technology can make it easier to 'manipulate' people's lives and health (Singh et al. 2013). For example, the high bandwidth and low latency of 5G enables sensors to improve the information transmission between patients and health professionals through uninterrupted communication services (Latif et al. 2017). Thus, this also drives more hackers to seek illegal benefits, so that the possibility of attack is greater. Accordingly, when 5G get wide coverage for Internet device within the healthcare industry, it is more likely for hackers to seek illegal profits by attacking the database to attain enormous information. This information comprises medical fraud personal data. Therefore, the motivation for this study is not sufficient to study the privacy of 5G applications in the medical industry.

Tensions between institutions and patients may hinder the development of the healthcare industry (Gunter & Terry 2005). Improper use of patient information and hacking the database are the two main causes of tensions. Tensions between regulators and healthcare organizations are often concurrently with tensions between doctors and patients when health care providers fail to protect private information. One of the main reasons for data loss has been that healthcare organization have

inappropriately used patient information to link healthcare organizations to business health plans, and increasingly use the vast amounts of medical data they collect to conduct research, making them a new profitable product, and even some commercial companies conduct business based on this data (Schiano et al. 2018). Another factor that causes tension is the hacker's attack, which only considers the hacker's attack on the database, while lacks the consideration that the malicious entity can easily destroy or control the communication between the sensor and the medical device under the open 5G communication network (Schiano et al. 2018). To be more precise, hackers can manipulate sensors and medical devices in three different ways. The first intentionally delays data transmission, which causes the 5G network to become unstable and difficult to control (Morgado et al. 2018). Meanwhile, it is misleading to access to data, as well as misleading smart medical devices or doctors to make false judgments by changing the intention of the signal (Morgado et al. 2018). Furthermore, the current low-security precautions in the healthcare industry, because the fact that the high-end complexity of 5G usage in healthcare, in addition, most 5G networks are public which means that everyone can access and read the data (Jalali & Kaiser 2018).
Therefore, it is relatively easy to fully control devices and database treatment. For instance, remote control during the patient's treatment triggers the built-in automatic stop mechanism, which causes the data transmission service to terminate and cannot continue treatment (Schiano et al. 2018).

## 3.2 Cost Perspective

### 3.2.1 Systemic factors in the adoption of 5G mobile technology in healthcare

Prior to implementing 5G technology into the healthcare industry, the 5G infrastructure backbone has to be materialised around society. For this to be possible, Latif et al. (2017) mentioned that involvement of several other technologies such as Device-to-Device communications, Internet of Things, Massive Multiple Input-Multiple-Output, millimetre wave communications, and full-duplex transmissions are required to provide coverage throughout the area. This is significant because many of these translates to having the need to modify the current telecommunication infrastructure, and it requires an enormous amount of money, resulting cost to be the biggest issue for bringing 5G into light (Latif et al. 2017).

5G requires data rates to increase by roughly 1000 times than 4G to meet the increasing demands. To achieve these rates the cost per link should not increase. To achieve this, Joules per bit and cost per bit will need to fall by at least 100 times. Similarly small cells used in 5G should be 10-100 times more cost-efficient than macro-cells (Andrews et al. 2014)Ideally the cost of smaller base stations should be cheaper than Wi-Fi nodes etc, but the cost of maintaining backhaul, the large monthly rental site fees for base station, obtaining permits for base stations are a major disadvantage. In this sense, Wi-Fi access points and femtocells are a much more cost-effective option than 5G (Andrews et al. 2014). Using 5G huge amount of sensor data is handled with the help of Artificial intelligence and big data analytics and IoT. According to a report by McKinsey & Company advantages of IoT in healthcare will reduce costs by about 170 billion USD -1.6 Trillion by the year 2025. On the contrary, (Standing and Standing 2018) refers to the healthcare industry as ‘conservative’. In the field of medicine, the time gap between an action and its consequence is huge. The results of the steps taken today might not be evident until months. A system that favours cost-effectiveness generally tends to support short term reductions only, but their long-term benefits are not known. Hence, the conservative healthcare system will take time to adopt new methods.

### 3.2.2 Derivation of cost of 5G in healthcare

Revolutionising the healthcare industry with 5G gives rise to several other cost issues. Latif et al. (2017) specifically expressed that a 5G integrated healthcare system will require an additional cost of time and human capital resources (Latif et al. 2017). This is correlates with Anwar and Prasad's findings where they gave an example of people from the technical and medical background has different knowledge and work behaviours (Anwar & Prasad 2018). Which is significant as this creates unnecessary friction between solving a medical problem and adaptation of technologies, resulting in an inefficient use of human resources on the field. Besides human resources, the need for an upgrade in the existing medical equipment to be 5G compatible will render it useless, this not only increases the capital expenditure cost, but it also requires time and human labour resources by the providers (Gross 2019).

The question that arises is that who is going to pay for this transition from the old to the new infrastructure. According to (Standing and Standing 2018) if the stakeholders (government / insurance agency) agree to bear the cost of the shift then only the mobile healthcare will be able to achieve its objectives. The other two stakeholders being the patients (who avail the service) and the doctors (who drive the cost). All three stakeholders' viewpoints need to be taken into account means administrative or cost advantages and quality of care to patients both aspects need to be emphasized on. It is also crucial to understand that the lack of transparency in the healthcare industry is leading to the lack of interest from the private sector to invest in the healthcare industry Anwar and Prasad says (Anwar & Prasad 2018). Hence, D'Arcy (2019) foresees the increase in costs from every aspect to be borne by the end customers, in this case, as patients' medical expenses (D'Arcy 2019).

Up until now, 5G may seem to only bring about an increase in costs for healthcare and that may not necessarily be the case because according to D'Arcy (2019), he quoted a study by Market Research Future has reported that the telemedicine market is expected to grow with a growth rate of about 16 percent in the next five years starting from 2017. This tells us that it will reduce the costs of healthcare because he mentioned that doctors predicted a reduction in hospital costs by up to 16 percent in the years to come (D'Arcy 2019). This shows that an increase in cost from the implementation of 5G in healthcare to be a short-term problem. One way to further mitigate such problem is to encourage the widespread use of the next-generation healthcare, where Latif et al. (2017) proposed to have new policies that would promote incentives for such services, and it is believed that this policy should be self-sufficient where it will be able to fund its finances and even promote future up-gradation (Latif et al. 2017).

## 4. Conclusion

In this article we discussed the potential pitfalls of implementation of 5G in the healthcare industry. We categorised our findings into two main problems, reliability and cost. In the first half of reliability, we explored the actual reliability of 5G in healthcare. Although by outsourcing telemedicine can alleviate the physical illness of urban and rural patients to a certain degree, this method neglects patients suffering mental illnesses and may bring controversy in the future. On top of that, many current medical devices operate electrically, and 5G's technology is based on electronic devices which emits electromagnetic waves, which poses an imbalance of electromagnetic interference between each other. The second part discusses the potential misuse and vulnerability of medical big data associated with 5G. 5G has a high bandwidth and low latency attribute to improve information transmission between patients and health professionals. This is a double-edged sword as

it also an opportunity for hackers to tamper with the data transferred for ulterior motives. Ultimately this has caused an uproar between institutions and patients and may hinder the development of healthcare industry.

Cost is another existing problem that we have discussed. In order to upgrade the current healthcare facility, the need to upgrade from the current mobile infrastructure to the 5G infrastructure is mandatory. The upgrade involves many sub-components to be installed and the cost of maintaining it, exceeds the cost of current Wi-Fi node technology, causing an unattractive technological evolvement.

Besides that, the indirect cost of 5G in healthcare comes from the lack of adaptability of people within the medical field. This is because the people in the technical field is responsible for setting up the whole infrastructure, however the people from the medical field remains unfamiliar to the complexity of change in the medical devices. On top of that, the successful change of medical devices will result the current medical devices to be obsolete. The lack of funding support to finance such changes will cause a ripple effect towards the end consumers. As long as the source of funds is left unanswered, it is probable to foresee the patients (end consumers) to bear it as a form of increase in the medical expenses.

Through our findings, we are confident to conclude even with the great benefits of 5G in healthcare will bring upon, there are still many challenges to be attended to. Until that happens, the implementation of 5G in healthcare shall be put on a halt as it is a conservative industry in society.

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# Appendix

Australian Government
Australian Institute of Health and Welfare

Australia's health 2016





## 4.1 Social determinants of health

Our health is influenced by the choices that we make—whether we smoke, drink alcohol, are immunised, have a healthy diet or undertake regular physical activity. Health prevention and promotion, and timely and effective treatment and care, are also important contributors to good health. Less well recognised is the influence of broader social factors on health (see 'Chapter 1.1 What is health?').

Evidence on the close relationship between living and working conditions and health outcomes has led to a renewed appreciation of how human health is sensitive to the social environment. Factors such as income, education, conditions of employment, power and social support act to strengthen or undermine the health of individuals and communities. Because of their potent and underlying effects, these health-determining factors are known as the 'social determinants of health' (Wilkinson & Marmot 2003).

The World Health Organization (WHO) has described social determinants as:

> …the circumstances in which people grow, live, work, and age, and the systems put in place to deal with illness. The conditions in which people live and die are, in turn, shaped by political, social, and economic forces (CSDH 2008).

According to WHO, the social conditions in which people are born, live and work is the single most important determinant of good health or ill health. As factors that affect health, social determinants can be seen as 'causes of the causes'—that is, as the foundational determinants which influence other health determinants. In keeping with this model, Figure 4.1.1 illustrates how social determinants extend inward to affect other factors, including health behaviours and biomedical factors that are part of a person's individual lifestyle and genetic make-up.

**Figure 4.1.1: A framework for determinants of health**


*Source:* Dahlgren & Whitehead 1991.



Australian Institute of Health and Welfare 2016. *Australia's health 2016*. Australia's health series no. 15. Cat. no. AUS 199. Canberra: AIHW.

# 5G Mobile Systems for Healthcare

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***Abstract*—This paper focuses on 5G Mobile Systems for ultra-reliable low latency communications applied to the healthcare use cases, specifically: *Wireless Tele Surgery* (WTS) – using a mobile console and robotic platforms with video, audio and haptic feed-back; and *Wireless Service Robots* (WSR) - companion robots or service robots performing tasks of social caretakers, professional personnel or family members. *Cyber-sickness* and *latency* between robotic platforms and reasoning servers are the new technical problems the 5G mobile systems are expected to solve, e.g. in hospices, hospitals, homes and campus areas. We firstly describe the 5G functional architecture and key enabling technologies to meet the associated performance requirements. This is followed by a comprehensive analysis of costs and revenues *operators* and *healthcare providers* would meet to deliver the corresponding services, if 5G systems were deployed. Business case calculations for the two players show an immediate Return on Investment (RoI) for carriers, whereas the breakeven point for healthcare providers is highly sensitive to the robotic platform price.**

***Keywords—5G; New Radio; Edge Computing; Healthcare***

## I. INTRODUCTION

The next generation of mobile broadband infrastructure or International Mobile Telecommunications (IMT) for 2020 and beyond (5G) will expand and support diverse usage scenarios and applications with respect to previous network generations, purposed primarily for the support of improved voice, mobile internet and video experience. The agreed scenarios for 5G include [1]: "Enhanced mobile broadband (eMBB)" addressing human-centric use cases for access to multimedia content, services and data; "Ultra-reliable-low latency communications (URLLC)" with strict requirements, especially in terms of end to end latency and reliability; and "Massive machine type communications (mMTC)" for a huge number of connected devices, typically transmitting a relatively low volume of non-delay-sensitive information. In this work, we focus on URLLC for connecting remote controlled robots or autonomous robotic platforms with intelligence in the edge cloud.

The first use case is about Wireless Tele Surgery (WTS), where surgeons in one location perform an operation in another with the aid of a robot [2]. The target with 5G is to stay below the necessary thresholds in terms of latency between wireless communication-rich hospital campuses and use robotic surgical devices that can be operated remotely by an expert surgeon, who may be based hundreds of miles away. The expert surgeon may perform remote robotic surgery in a decentralized hospital system at any hospital within the system (better access); he or she can be consulted at anytime from anywhere (time saving). (In general, robotic surgery reduces hospitalization time, pain and discomfort and recovery time; it infers smaller incisions, reduced risk of infection, reduced blood loss and transfusions, minimal scarring and better quality.) In order to attain the same sense of touch as in conventional interventions, without the remote surgeon experiencing *cyber-sickness*, the 5G system needs to provide the guaranteed low latency and indispensable communication stability in transmitting *haptic feedback* (tactile and/or kinesthetic) and improved wireless data rates for better visualization, enhanced dexterity, and greater precision, well beyond todays Da Vinci system from Intuitive Surgical.

The second use case is about connecting Wireless Service Robots (WSR), i.e. robotic platform with Artificial Intelligence (AI) in the edge cloud [3]. The target is to stay below and above the required latency and throughput, respectively, with a high degree of reliability, between the wireless robotic platform and edge computing servers, and use robotic care devices to assist patients and old people in hospital, hospices and their campus areas, and at home. The edge cloud (reasoning system) runs complex algorithms to interpret human emotions, enable the service robot to interact naturally and perform complex care or household tasks. The main objective is to reduce care costs and, especially, help people to remain active and independent with a good quality of life. The deployment of 5G wireless will make it possible to replace cables and thus enable a massive adoption and utilization of robotic platforms, globally.

In Section II, we describe in detail the above use cases, and clarify what the main technical challenges for 5G wireless are. Section III presents the target 5G functional architecture, its building blocks, and 5G key enabling technologies to meet the related performance requirements. In Section IV, we introduce the value chain and business models. Section V consolidates business case calculations and results for connectivity and care service providers. Conclusions on the business viability of the proposed technical solution are drawn in Section VI.

## II. USE CASES AND TECHNICAL REQUIREMENTS

### A. Wireless Tele Surgery

As shown in Figure 1, the target is to provide a remote surgeon, who could be located hundreds of kilometers away from patients, the same sense of touch (essential for localizing hard tissue or nodules) while substituting doctor's hands in interventions with robotic probes (arm or finger). To achieve such an experience in remote intervention, delay and stability

978-1-5090-5932-4/17/$31.00 ©2017 IEEE

# How 5G (and concomitant technologies) will revolutionize healthcare

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***Abstract*—In this paper, we build the case that 5G and concomitant emerging technologies (such as IoT, big data, artificial intelligence, and machine learning) will transform global healthcare systems in the near future. Our optimism around 5G-enabled healthcare stems from a confluence of significant technical pushes that are already at play: apart from the availability of high-throughput low-latency wireless connectivity, other significant factors include the democratization of computing through cloud computing; the democratization of AI and cognitive computing (e.g., IBM Watson); and the commoditization of data through crowdsourcing and digital exhaust. These technologies together can finally crack a dysfunctional healthcare system that has largely been impervious to technological innovations. We highlight the persistent deficiencies of the current healthcare system, and then demonstrate how the 5G-enabled healthcare revolution can fix these deficiencies. We also highlight open technical research challenges, and potential pitfalls, that may hinder the development of such a 5G-enabled health revolution.**

***Index Terms*—Healthcare, 5G, Internet of Things, big data analytics, artificial intelligence and machine learning**

## I. Introduction

Good health has a constructive effect on all aspects of human and social well-being including personal happiness, workforce productivity, and economic growth. Recognizing the importance of healthcare, facilitating affordable universal access to healthcare is already enshrined as an important goal of the United Nations' new Sustainable Development Goals (SDG) that defines the UN's development agenda for the next 15 years. In the words of the Nobel Laureate Amartya Sen, "*Health is a critically significant constituent of human capabilities which we have reason to value*". It has been shown in literature that investment in healthcare pays huge dividends. In the Economists' Declaration, originally launched in 2015 with 267 high-profile economist signatories, world-leading economists called on global policymakers to plead for a pro-poor pathway to universal health coverage as an essential pillar of sustainable development[1]. A case was made that healthcare investments make perfect economic sense since according to the Global Health 2035 report by the Lancet Commission on Investing in Health, every dollar invested in the healthcare of poor countries has a nine-fold or higher return.

[1]http://universalhealthcoverageday.org/economists-declaration/

Despite the core role of human health in human development and progress, today's healthcare system is largely dysfunctional and in the need of a major overhaul. Broadly speaking, the ills of the healthcare system can be categorized into four major deficiencies (illustrated in Figure 1).

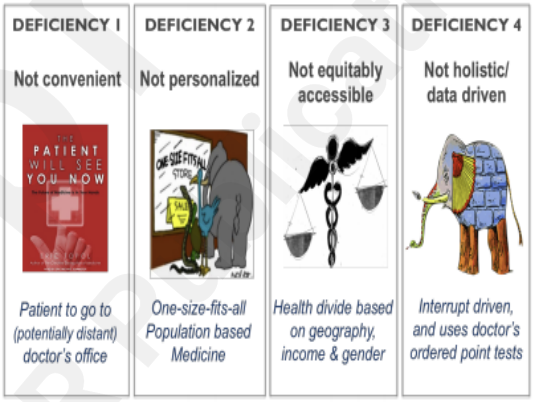


Fig. 1: The four major deficiencies of conventional healthcare systems

*Firstly*, the current healthcare system is *not convenient* for patients since the current healthcare system is not patient-centric. As an example, the patient has to go, or be taken, to a doctor's office or a hospital for any non-trivial illness which is inconvenient for the patient (who would likely prefer to rest) and also for the patient's caregivers (e.g., the patient's guardian or family member who must take the patient to the clinic). The patients also need to slot in their health related appointments in their busy schedule and this sometimes lead to carelessness in giving due attention to regular and required health-checks with doctors.

*Secondly*, the current healthcare system is *not personalized* according to the individual patient. Doctors prescribe medications based on population averages rather than the individual characteristics. As today, it is very difficult and costly to adopt tailored treatments based on individuals' medical history and genetic profile.

*Thirdly*, the current healthcare system is *not equitably accessible*. Similar kinds of healthcare facilities are not equally accessible to patients or utilized by only a certain groups of people, based on their ethnicity, socioeconomic status, and

# Supplementary Files