

Identifying the Barriers and Drivers of IoT Deployment in Healthcare

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Abstract

Healthcare is an information-intensive sector and has always benefitted from novel ICT technologies. Utilizing these technologies provides numerous benefits to the stakeholders of healthcare sector such as alternative ways to manage patient's health records, improving the accessibility and affordability of healthcare services, minimizing the errors and making the healthcare providers more accountable. The patients benefit from round-the-clock monitoring of their health which leads to better satisfaction derived from these services. Even though the IoT based healthcare offers numerous advantages, the hospital administrations generally find it hard to deploy these services. A review of the extant literature reveals that there is a scarcity of relevant literature on the barriers and drivers of IoT deployment in healthcare. This paper identifies the key barriers and drivers that are relevant to IoT deployment in healthcare.

Key words: healthcare, IoT Deployment, barriers and drivers, ICT technologies.

Introduction

The Internet of things has the potential to provide many benefits for healthcare such as elderly care, children care, fitness programs, remote health monitoring and chronic diseases. Moreover, IoT comes with the benefits of controlling and sharing of information flow between objects, or, between humans, or, between humans and objects via the wireless sensor networks and the micro-electromechanical system (MEMS) or sensors. In this way, we can understand the IoT system to comprise of the imaging devices, diagnostic device and medical devices embedded with the smart sensors. The IoT-based health monitoring system allows the doctors to monitor his or her patients from anywhere and thus helping the reduction of visits by the patients to the physicians (Sebastian, 2018; Dauwed and Meri, 2019). As of now, this technology is not widely deployed; however, in the coming years, this technology will become popular. The health solutions and services provided through IoT devices are more precise and exact in the emerging IoT business scenario, thus offering multiple opportunities as well as challenges to the industry. The gaps in the literature motivated this study which failed to discuss in depth the drivers and barriers of IoT deployment in healthcare. This paper presents the current status of IoT deployment and also presents a synthesis of the drivers and obstacles of IoT deployment in healthcare.

IoT in healthcare

The term IoT defines a network of physical objects connected through the internet (Kulkarni and Sathe, 2014: 6230; Dauwed and Meri, 2019). These physical objects include technology to interact with the internal factors as well as with the external environment (Malunjkar, 2019a). The use of IoT in healthcare has grown significantly in recent years and is projected to continue to evolve. Various benefits offered by deploying IoT in healthcare include tracking staff, patients, and medical devices; automatic data collection; identification and authentication of people; and knowing the health status of patients. Offering these benefits, the IoT in healthcare is a useful solution for managing deployment costs. The IoT in healthcare allows stakeholders, in particular providers and

patients, to improve patient care and outcomes, reduce costs, minimize errors and improve patient care, and improve patient management IoT solutions and services are replacing traditional diagnosis and treatment procedures with advanced technology. The users of IoT in the healthcare field include hospitals, healthcare professionals, clinics, and patients (Malunjkar, 2019a). Government agencies, research institutions, and diagnostic laboratories also use IoT in healthcare technology to develop cost-effective and advanced products and solutions (Malunjkar, 2019b).

Table 1 lists the major factors driving the deployment of IoT technologies in healthcare.

Table 1. Drivers of IoT deployment in healthcare

Drivers of IoT Deployment	Sources
Need for Personalized healthcare	Manate et al., 2014; Agarwal, Sebastian and Agarwal, 2016; Zhang et al., 2017
Need for Connected healthcare	Marynissen and Demeulemeester, 2019
Need for Optimization of Workforce	Mieronkoski et al., 2017
Increase in Smartphones adoption	Farahani et al., 2018
Increased Adoption of Smart wearables	Atzori et al., 2010; Jeong et al., 2017
Need for Low-cost solutions	Mdhaffar et al., 2017
Timeliness of the services	Atzori et al., 2010

Factors driving the deployment of IoT in healthcare

There are defined factors that impact the deployment of IoT in healthcare:

1. *Need for personalized healthcare.* The increasing desire for people and patients to monitor one's health is a major factor propelling the demand for connected health devices (Manate, et al., 2014: 386-391; Agarwal, et al., 2016; Zhang, et al., 2017: e117). Wearable devices like fitness bracelets, blood glucose meters, and blood pressure monitors help people keep track of their activities throughout the day. This data is stored in connected devices, which can later be used to analyze the patient's health status. Thanks to the use of these devices, the costs of regular examinations can be significantly reduced, since the patient can analyze his medical parameters and adjust nutrition accordingly (Malunjkar, 2019a). These trends in self-health management and measurement have influenced the demand for IoT in health-monitoring devices and systems, thus, providing a potential opportunity for companies to develop devices for this purpose.

2. *Need for connected healthcare.* Connected health has come up from (i) consumerism in healthcare and a drive towards patient-centric healthcare (ii) efforts of individual physicians and healthcare organizations to provide better access, quality and efficiency of care, and (iii) changing dynamics of the healthcare economy such as rising costs and changing demographics (Marynissen and Demeulemeester, 2019: 407-419). This system of healthcare delivery intends to provide increased, flexible opportunities for patients to converse with clinicians and self-manage their care better, as well as, to maximize healthcare resources in a hospital (Malunjkar, 2019a). Connected health encompasses programs that often leverage existing technological frameworks such as connected devices using existing wireless networks and is associated with efforts to ameliorate the chronic care. It uses readily available consumer technologies to deliver patient care outside of the hospitals or from a doctor's office.

3. *Need for optimizing the workforce.* The need to optimize the productivity of healthcare workers is another critical element propelling IoT healthcare deployment

(Mieronkoski et al., 2017). The expansion of the network of connected devices to health workers has allowed the creation of a more combined system of operations, which will lead to improved communication between different departments. The Internet of Things has helped establish referrals in hospitals with disabilities and restructure relationships between patients and healthcare providers. Features supported by IoT, such as remote patient monitoring and improved patient care, can help reduce medical errors and malpractice complaints. IoT has the potential to automate many of the functions of healthcare organizations; thus improving the quality of monitoring systems and optimizing operations (Malunjkar, 2019b).

4. *Increase in adoption of smartphones.* Smartphones with built-in sensors, blue-tooth components, and mobile applications for storing health information are also driving the market for IoT in healthcare (Farahani, et al., 2018: 659-676; Malunjkar, 2019b). These apps can be connected directly to wearable devices to record the data. Applications such as blood pressure and heart rate monitoring using smart devices help people to improve the quality of monitoring and reduce their medical expenses.

5. *Increased adoption of smart wearable.* Smart wearable devices, such as smart bands, smart shoes, smart clothes, smart watches, sleep headphones, and other technologies, collect, transmit, and analyze patient information and data (Atzori, et al., 2010: 2787; Jeong, et al., 2017: 60). Many wearable devices receive great attention due to their capabilities, including devices designed for patients suffering from chronic diseases. In addition, some specific devices have additional features, such as buttons, that can immediately send emergency medical alerts to hospitals. These connected devices capture important patient health information throughout the day and transmit this data wirelessly to user / provider devices such as tablets, smartphones and computers. These devices are considered valuable tools in reducing medical costs and, therefore, are increasingly being used by people.

Challenges in IoT deployment in healthcare

IoT has substantially changed the healthcare management in a comparatively smaller period. For example, older people have an opportunity to live as long as possible using the technology of connected devices. They help in monitoring of the patients' chronic diseases by the physicians between his office visits and also allow them to take counseling from specialists across the world about complex cases. However, the advancement in technologies often comes with barriers, and IoT is no exception. Table 2 presents a list of challenges that the literature suggests regarding the deployment of IoT in healthcare. We now discuss each of these challenges along with the suggestions for healthcare practitioners to take care when they deploy healthcare IoT devices in their workplaces.

Table 2. Barriers of IoT deployment in healthcare

Challenges of IoT Deployment	Sources
Complexity	Aceto et al., 2018; Fernandez and Pallis, 2014
Compatibility issues	Banafa, 2017
Security and privacy concerns	Tariq et al., 2019
Health-data size	Mohammadi, 2018; Sebastian, 2018
Infrastructure issues	Haider, 2019
Vulnerability issues	Boudko, 2019
User convenience	Chung, et al., 2016

Explanation of the Challenges of IoT Deployment

1. Complexity: The IoT healthcare entails collection, storage and dissemination of health information. However, an ever-increasing size of patients and their demand to have a faster and reliable service has made the management of health information most critical (Aceto, et al., 2018: 125-154; Fernandez and Pallis, 2014: 263-266). The availability and significance of a patient's health information has gained significance in the healthcare industry, primarily due to the growing complexity of the healthcare provisions. It has been identified that there is a chasm in communication among the groups of clinics, departments and even among the healthcare professionals. This ever-increasing complexity has been identified as a primary barrier of clinical safety and source of clinical errors, especially in tertiary care clinics.

2. Compatibility issues: Compatibility refers to "the degree to which the potential adopters perceive innovation as consistent with their values, previous experiences and needs" (Banafa, 2017). The physicians are very particular about their work style and expectation from new technology. Therefore, the IoT system should be made congruent to the needs and working styles of the physicians in order to motivate them to adopt this novel technology. The compatibility issues experienced by the physicians have the most prominent outcome on the actual usage of innovation initiatives in the hospitals.

3. Security and privacy concerns: Many healthcare providers and physicians take the security and privacy concerns of the patients so seriously that they continue to store the records of patients on local systems and computers that are not connected to the internet (Tariq et al., 2019: 1788). Most countries, including the developed countries, lack a uniform approach to record and retrieve the patient health data.

4. Enormous health data: The IoT devices and services generate a tremendous amount of data while monitoring the health parameters of the patients, which creates the issue of data-deluge (Mohammadi, et al. 2018). If the organizations fail to plan for this issue, they are bound to suffer from unforeseen problems related to proper handling and verification of the data (Sebastian, 2017: 396-403). Mohammadi et al. (2018: 2923-2960) predict that the healthcare sector will be generating the maximum amount of data compared to any other sector by 2025. It is quintessential for healthcare institutions to realize this issue related to IoT technology and should plan precisely towards handling this issue before moving towards the deployment of healthcare IoT. They will notice these differences by 2020. Moreover, the health industry should keep in mind the state and federal regulations and hence exhibit unprecedented care while managing patient's health data from IoT devices.

5. Infrastructure issues: Unlike the Manufacturing industry, the medical industry mostly relies on obsolete technologies and infrastructure. Overhauling of the infrastructure of the hospital can reinvigorate it for some time. However, in order to reap an extended benefit from IoT technology, hospitals need to upgrade to the state-of-the-art technology infrastructure. An old infrastructure has always plagued healthcare. Another issue that is linked to older infrastructure is the difficulty to find the staff to manage and overhaul the outdated technological infrastructure. Moreover, finding a prospective staff would be more challenging than expected, as the technical talent is always in high demand, and they do not want to work around outdated infrastructure. Lastly, many hospitals still lack an electronic health record system (EHR), which is quintessential to the deployment of healthcare IoT.

6. User convenience: It is defined as the ease of use, fitness or suitability of the technology for performing an action or fulfilling a requirement by the patients who are the end-users of these services (Chung, et al., 2016: 67-80). With the increasing complexity of the technology and fusion of technologies, the user convenience is sometimes given lesser priority, while deploying the technology. However, there should be a balance between the user convenience and complexity of technology for it to become successful.

7. Social exclusion: Due to the increasing use of the technology, physicians can remotely monitor the patients (Sebastian, 2018: 2060-2065). On one hand, it reduced the number of visits to the hospitals, but, on the other hand, it removed the bond between the doctor and patient, which develops when the patients visit the hospitals. This is one of the challenges that the hospital administrators need to address with IoT deployment in healthcare.

Successful Use-cases

1. Smart continuous glucose monitoring (CGM) and insulin pens: The first CGM system was approved in 1999 by the US Food and Drug Administration (FDA). CGMs are a boon to the diabetic patients, since it measures the blood glucose level of the patients at regular intervals throughout the day and thus monitors and regulated for any change from the prescribed levels (Olczuk and Priefer, 2018: 181-187). Today various types of intelligent CGMs are available in the market, such as Freestyle Libre and Eversense. These smart CGMs measure the blood glucose level and communicate this information of the smartphones of the patients for easy viewing and also send these data to the healthcare providers. The National Health Service (NHS), UK has also decided to include it in their health scheme since 2018. Patients suffering from Type 1 diabetes will be provided the FreeStyle Libre smart CGM on the prescription of the physicians. This would significantly boost the estimates number of CGM users in the UK from 3-5% to 20-25% (Lu and Bao, 2018).

2. NIOX VERO: It is developed by Circassia Ltd. and is an advanced version of NIOX MINO. It measures the patient's personal best fraction of exhaled nitric oxide (FeNO) levels and compares against the base levels and thus calculates the threshold level for the inhaled corticosteroid (ICS) treatment. This is an accurate and objective assessment of the airway inflammation, pertaining to chronic cough, shortness of breath or other pulmonary conditions (Crater, et al., 2017: 139-148). It also identifies the patients who may benefit from the biologics. It is estimated that NIOX devices have been used to test over 20 million times till date (Feno Knowhow, 2019).

3. Proteus Digital Health and its ingestible sensors: These are examples of using the IoT technology in the form of smart medicine to measure the discipline in medicine intake by the patients. Paulino, Thomas, Lee and Cooper (2019) found that over fifty percent of the patients worldwide fail to take the medicines as directed by the physicians. Proteus has tried to fill this chasm by creating smart pills. These pills, when ingested by the patient, gets dissolved and emits signals which can be read by the wearable sensor and then transmitted to the patients and providers (Zdeblick, et al., 2018: 968).

4. Apple's ResearchKit for Parkinson's disease: Parkinson's disease is a progressive nervous system disorder which harshly impairs the physical movement of the people suffering from it. Apple added a new application programming interface named 'Movement Disorder API' to its Research Kit in 2018. This interface allowed patients to monitor symptoms of Parkinson's disease on their Apple watches. Moreover, a regular fluctuation in the symptoms is presented on the smartphones via mobile-apps. Apple has been doing significant work to use the technology to monitor and improve the health

conditions of its users. The earlier initiatives of the open-source ResearchKit by apple includes monitoring of arthritis and epilepsy symptoms using sensors present in the Apple watches (Kvedar, et al., 2016: 239).

Conclusion

This paper presented the state of the art in IoT deployment and identified the drivers and barriers in the deployment of IoT in healthcare. Although this paper discussed the diverse IoT-deployment barriers linked with healthcare IoT initiatives, healthcare practitioners need not feel disheartened about using IoT. Identifying the barriers is the embarkation towards building up of more efficient and decisive solutions in any technology deployment. With solutions such as patient monitoring, smart pills, and low-energy location solutions, IoT helps in improving the quality of life for a larger population, hence leading to the reduction of healthcare expenditures. In spite of these obstacles, there has been a surge in the adoption rates due to the enormous benefits being offered by IoT. With a thorough understanding of the drivers and barriers facing the deployment of healthcare IoT initiatives, stakeholders can be better equipped to develop and deploy the solutions. Increasing the number of drivers and reducing the number of barriers for the IoT deployment in the healthcare sector are topics suggested for future research.

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