

# Smart Healthcare: A Primer

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**How to cite this paper:** Matthew N. O. Sadiku | Adedamola Omotoso | Sarhan M. Musa<sup>1</sup> "Smart Healthcare: A Primer" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-3 | Issue-4, June 2019, pp.1356-1359, URL: <https://www.ijtsrd.com/papers/ijtsrd25076.pdf>



IJTSRD25076

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Wireless technologies are the backbone of the smart healthcare systems. Different wireless technologies such as Wi-Fi, Bluetooth, radio frequency identification (RFID), wireless sensor network (WSN), wearable medical devices, smart mobile technologies, etc., as shown in Figure 1, play a vital role in exchanging the information among different physical elements [1]. RFID implant allows for user identification, movement detection, and automation, and enables the smart environment to react to the presence of the user. Wearable sensor nodes are those that measure vital and other important signs, including pulse, respiratory rate, and body temperature - as these are the essential signs for determination of critical health. Mobile technologies will play a crucial role as they have become the patient's constant companion. Wearable sensors are capable of sensing even very small changes in vital signs, which a human cannot easily observe. The familiar technologies such as the smart phone and smart watch will be developed further to include reliable health technology sensors and abilities. These new technologies will allow remote monitoring of patients, health data collection, medicine administration, medication compliance, and access to medical records.

## CONCEPT OF SMART HEALTHCARE

Smart healthcare is one of ten priority areas in the development of smart city. Other components include smart government, smart education, smart transportation, smart grid/smart energy, smart surveillance, smart environment, smart society, smart reporting, smart payment, and smart commerce [2]. Smart healthcare involves using smart

## ABSTRACT

The emergence of Internet-of-things (IoT), new computing/networking paradigms (such as cloud computing and fog computing), cloud computing, and machine learning has revolutionized traditional healthcare and led to the dawn of a new era of smart healthcare.

Smart healthcare is a huge market opportunity because it improves lots of lives with the smart health solutions. Stakeholders around the globe are seeking innovative, cost-effective ways to deliver patient-centered, technology-enabled smart health care, both inside and outside hospital walls. This paper provides a primer on smart healthcare.

**Keywords:** smart healthcare

## INTRODUCTION

Healthcare is an important aspect of our life. The healthcare industry across its entire spectrum of organizations and services is one of the largest and fastest growing industries in the world. Due to the ever-increasing world population, the traditional patient-doctor interaction has lost its effectiveness. The healthcare system is being transformed from reactive and hospital-centered to preventive and personalized. This has led to the emergence of the smart healthcare. Smart healthcare enables a doctor to monitor a patient's vitals from the office while the patient remains in home care. It empowers patients to self-manage some emergency situation [1]. Interactions between parties are efficient and patient centered.

technologies for health purposes. It is using smart technologies for better diagnosis of the disease, improved treatment of the patients, and enhanced quality of lives. Figure 2 shows the classification of the smart healthcare market, based on the services, medical devices, technologies used, applications, and users [1].

Smart healthcare is an interdisciplinary field that includes sensing, networking, computing, radio frequency identification (RFID), wireless sensor network (WSN), and artificial intelligence. Smart health technologies (mobile and electronic) include sensors, medicine dispensation, smart pills, smart surgeries, wearables, and early registration devices [3]. Smart healthcare combines smart technologies within the home, hospital, patient, and information exchange. A typical smart healthcare system is shown in Figure 3 [4].

There are different ways technologies are changing smart healthcare. Top healthcare technologies such as IoT, cloud computing, big data, machine learning, and advanced analytics have turned the traditional healthcare into smart healthcare. These are major technological innovations which have added the element of "smartness" in the healthcare industry [5].

## ➤ IoT in Healthcare:

IoT helps extend the benefits of Internet such as remote access, data sharing, and connectivity to various other application domains such as healthcare, transportation,

parking activities, agriculture, and surveillance. IoT in healthcare technologies is also popularly known as Internet of Medical Things (IoMT). The Internet of things (IoT) allow all entities be connected to each other through wired or wireless communication means. The healthcare industry is among the fastest to adopt the Internet of things. The primary goal of IoT in healthcare is to connect doctors with patients through a smart device. Healthcare providers are expecting the IoT to revolutionize the gathering of healthcare data and care delivery [6]. Communications related to Internet of Things for healthcare can be classified into two major categories: short-range communications and long-range communications. ECG data are gathered using a wearable monitoring node and are transmitted directly to the IoT cloud using Wi-Fi. IoMT is particularly a boon for a burdened healthcare system. IoMT devices on the other hand not only help the elderly to keep a close track of their medications and vitals like heart rate, glucose levels, and sleep patterns. Designing a wearable sensor for continuously monitoring blood pressure remains a challenge in healthcare IoT [7].

#### ➤ **Big Data in Healthcare:**

The healthcare industry is responsible for generating an unprecedented amount of data on daily basis. This big data is partly related to patient healthcare and well-being. It is created by mass adoption of the Internet and digitization of healthcare information, including health records such as demographic data, historical data, illness related information, test results, imaging data, costs, discharge summaries, pharmacies, insurance companies, medical imaging, genomics, social media, smart phones, wearables, sensors, and other IoT devices. Big data is commonly characterized by the so-called 5 V's - volume, velocity, variety, veracity and value. It has been noticed that the governments across the globe are working towards building an effective healthcare infrastructure, with big data being the very foundation.

#### ➤ **Cloud computing in Healthcare:**

Cloud computing is a new means of providing computing resources and services. It offers large scalable computing and storage, data sharing, on-demand anytime and anywhere access to resources. It encourages cost savings, scalability, and system flexibility. Application areas include emergency healthcare, home healthcare, assistive healthcare, telemedicine, storage, sharing and processing of large medical resources. There three primary services that can be provided by cloud technologies in healthcare environments: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). Cloud computing can support healthcare organizations to share information such as EHR, prescriptions, insurance information, and test results. The cloud makes it easier to archive and use patient records and medical images. The cloud also makes it easier to collaborate and offer care as a team. The demand for cloud computing healthcare solutions has grown exponentially.

#### ➤ **Machine Learning in Healthcare:**

Machine learning (ML) is the discipline that gives computers the ability to learn without being explicitly programmed. In medicine, the bottom line is to use machine learning to augment patient care, save more lives, improve more care, while saving money at the same time. ML can automate the manual processes carried out by practitioners, which are usually time-consuming and subjective. Machine learning

performs diagnostics or treatment plans would be extremely valuable in a healthcare scenarios. Thus, using ML can save time for practitioners and provide unbiased, repeatable results [8]. The application of machine learning in the healthcare systems has opened up new avenues in the smart healthcare market. Personalized care has been the hallmark of smart healthcare solutions, which can be easily gained through machine learning.

#### ➤ **Nanomedicine:**

This is a unique branch of medicine that involves the development and application of materials and technologies with nanometer length scales. It is an interdisciplinary discipline that combines nanoscience, nanoengineering, nanotechnology, nanoelectronics, and life sciences. The interest in nanomedicine spans a wide area in medicine such as drug delivery, vaccine development, antibacterial, diagnosis and imaging tools, wearable devices, implants, and high-throughput screening platforms. The most prominent areas of nanomedical research and drug approvals are cancer treatments, imaging contrast agents, and drug delivery. Nanodevices can repair DNA or replace the defective part of DNA. Nanomedicine will lead to many more exciting medical breakthroughs [9].

### **APPLICATIONS AND SERVICES**

With the increasing demand for automated, remote, and real-time healthcare services in smart cities, smart healthcare monitoring is necessary to provide complete care to residents. Smart healthcare applications and services require collection and analysis of raw sensory data.

#### ➤ **Smart Home Healthcare:**

This centers on providing care in the home for outpatients, the elderly, and those with disabilities. It allows patients to communicate their current health status to healthcare provider from home. It has the potential for managing chronic illnesses of the aging population. The technology is designed to assist the homes' residents accomplishing their daily-living activities. An elderly person should be monitored constantly if he/she has health-related issues. Smart Homes can be cost-effective and allow greater independence and quality of life while reducing the chance of social-isolation. Robotics is an area that has merits in the field of home assistance. A robot at home is a robot which takes care of patients at home. The home of tomorrow will be substantially different and smart [10].

#### ➤ **Patient Monitoring:**

Smart healthcare monitoring is necessary to provide improved and complete care to residents. This allows the doctor to monitor patients' conditions for providing treatment even from remote locations. (This may be done using cognitive computing.) Wireless body area networks (WBANs) are the basic components of community healthcare monitoring. They entail having small sensors placed on body of a patient to monitor various health parameters like blood pressure, heart beat, temperature and prolonged electrocardiogram [11].

#### ➤ **Smart Healthcare in Hospitals:**

Due to cost pressure, hospitals are facing challenges like less financial resources. As a result, reduction of labor cost becomes the critical criterion for the implementation of smart items infrastructure in a stationary setting [12].

### ➤ Virtual clinics:

These are online clinics that provide 24-hour online access for patients. Smart mobile devices now have an application called "Virtual Clinic" that allows doctors in the healthcare network to answer questions to patients in real time.

### BENEFITS AND CHALLENGES

Smart healthcare technology has many obvious advantages in system integration, information sharing, and intelligent processing. With the Internet of things, mutual sharing of information becomes easy and convenient. With Internet-enabled smart devices, smart healthcare has become reality in which patients receive medical treatment from anywhere across the globe. Smart healthcare systems analyze patient data to both enhance the quality of patient care and reduce healthcare costs.

There are definite challenges, e.g. the infrastructure and competencies needed to incorporate smart health technologies in daily operations. Sharing patients' sensitive information over the Internet leads to serious security and privacy concerns. Security is a challenging requirement during data collection from patients. Confidentiality is an important security requirement in smart healthcare. The smart healthcare system is vulnerable to cyber-attack [13]. A major challenge is practitioners' hesitation and unwillingness to use these new technologies in medical practice.

### CONCLUSION

The integration of healthcare and smart cities has led to the utilization of information and communication technologies (ICT) into medical practices around the world. The integration has improved the quality of the residents in the smart cities [14]. The smart healthcare systems are constantly developing and providing better healthcare services in smart communities. It is not exaggeration to say that smart healthcare systems have become one of the most sought-after technological innovations by healthcare organizations.

Smart health technologies will be commonplace in the near future. They are still in their infancy and their prevalence is still limited. Demand for smart healthcare engineers is anticipated to grow. There is a need to continuously adapt engineering curricula and foster future generations of smart healthcare engineers [15]. More information about smart healthcare can be found in the book in [16].

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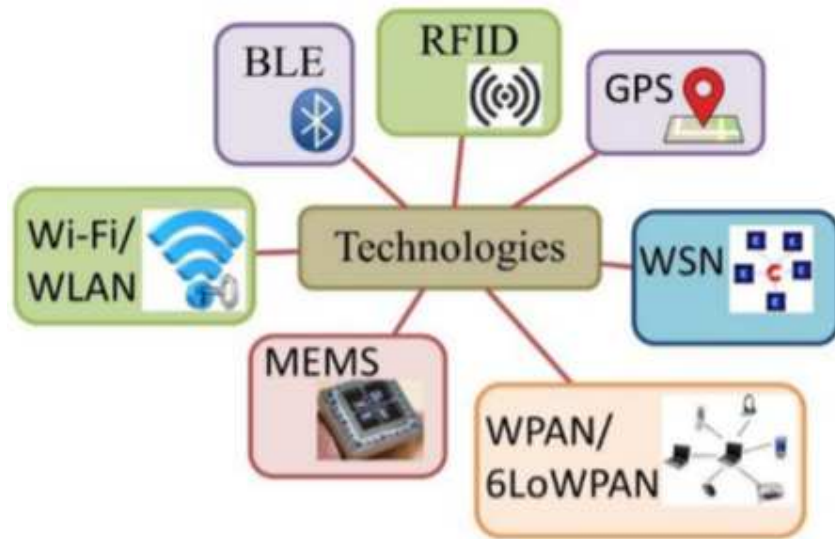


Figure 1 Technologies used to deploy smart healthcare [1].

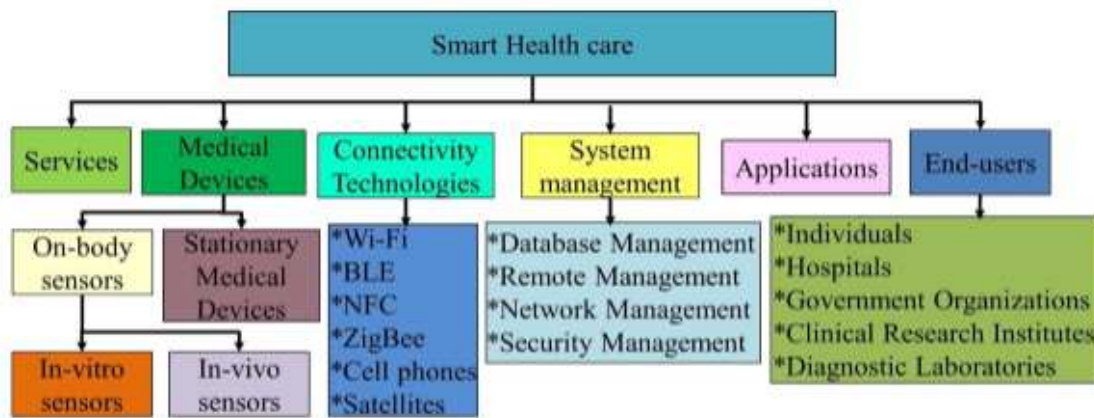


Figure 2 Classification of the smart healthcare [1].

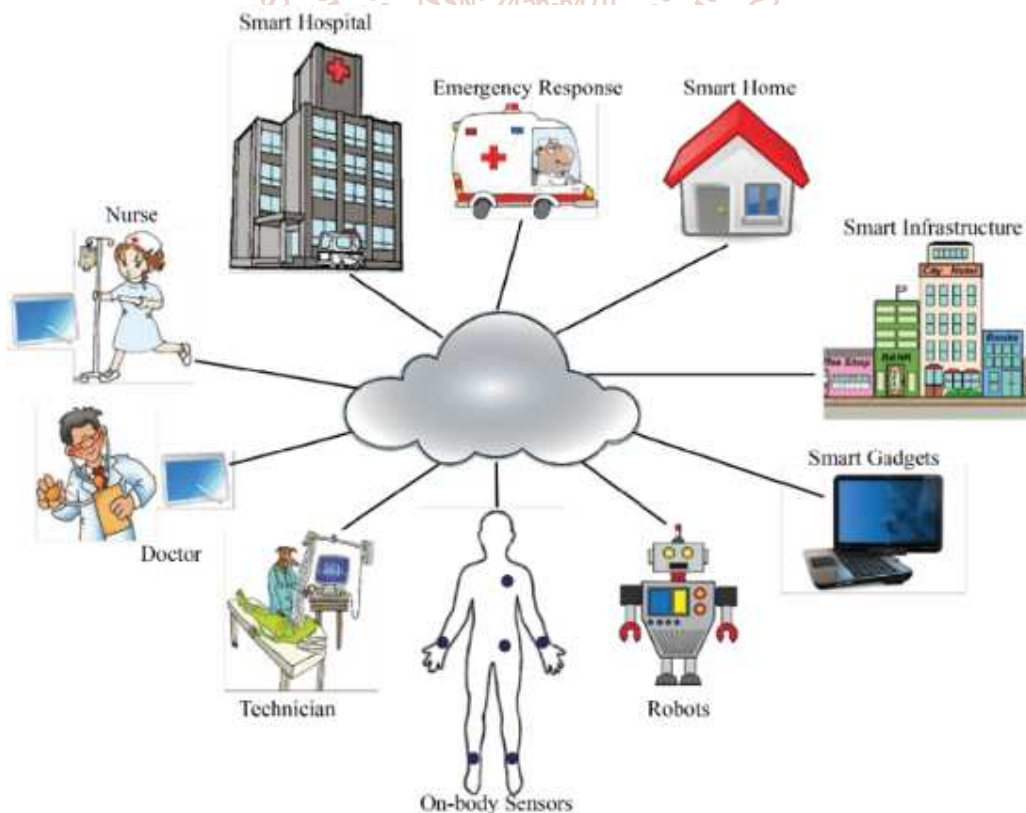


Figure 3 A typical smart healthcare system [4].