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# Proposed Framework for Smart Healthcare Services

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A B S T R A C T
Smart healthcare is of great interest to researchers and governments due to the increasing development of new smart cities. However, there is no current standard practice to format the cloud computing infrastructure and to assist the healthcare system architect in designing a comprehensive solution for the basic services that are required by the healthcare users while taking into consideration a balanced approach towards their specific functional and non-functional needs such as openness, scalability, concurrency, interoperability and security factors.
The integration of smart healthcare services with cloud computing needs a concrete framework. The main objective of this paper is to analyze the different frameworks that discuss smart healthcare services and reach to a conclusion of the common factors to arrive at a unified and smart framework.

*Keywords: Healthcare services, Cloud-based Healthcare systems, Smart–Health Frameworks, Internet of Things for healthcare*

## 1. Introduction

Healthcare services have been exponentially increasing worldwide (Chondamrongkul & Chondamrongkul, 2017) as there is a significant volume of data generated on a daily basis by medical and clinical organizations (Pino & Salvo, 2013). This data is important and vital for decision-making (Aziz & Guled, 2016) and the lack of access to medical information may negatively affect the delivery of the best care for patients (Kyazze, Wesson, & Naude, 2014). Storing the records of patients electronically (Reddy and Reddy, 2013) facilitates the exchange and availability of information for healthcare processes (ATOS, 2011) and hence increases the productivity of any patient care

system that takes a central position and provides easy accessibility and usage (Reddy and Reddy, 2013). The



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introduction of the most recent technological innovations in cloud computing for the healthcare sector (Reddy and Reddy, 2013) is becoming a pressing requirement in order to optimize the resources in terms of computational and storage capabilities (Pino & Salvo, 2013). Cloud computing is a cost-effective means for facilitating data collection, data storage and exchange between healthcare communities (Aziz & Guled, 2016).
This paper is organized as follows: section 2 presents a brief introduction about the smart healthcare market, section 3 presents a comprehensive analysis of the different frameworks that proposed smart healthcare services during the last ten years, section 4 discusses the challenges to smart healthcare such as sensor integration, big data management and the cloud-based environment and human-computer interaction. And finally, section 5 presents conclusions and future work.

## 2. Smart Healthcare Services

According to Sundaravadivel et al. (Sundaravadivel, Kougianos, Mohanty, & Ganapathiraju, 2018) smart healthcare is becoming more demanding nowadays due to its enhancement of the user's quality and experience. It also helps in maximizing the available resources to their extreme potential. Smart healthcare provides remote observation of patients and aides in diminishing the expense of the treatment. Additionally, it provides a means for doctors to increase their services without any regional barriers. Figure 1 indicates the wide range of smart healthcare elements which mainly consist of services, medical devices, technologies used, applications, system management and end users.

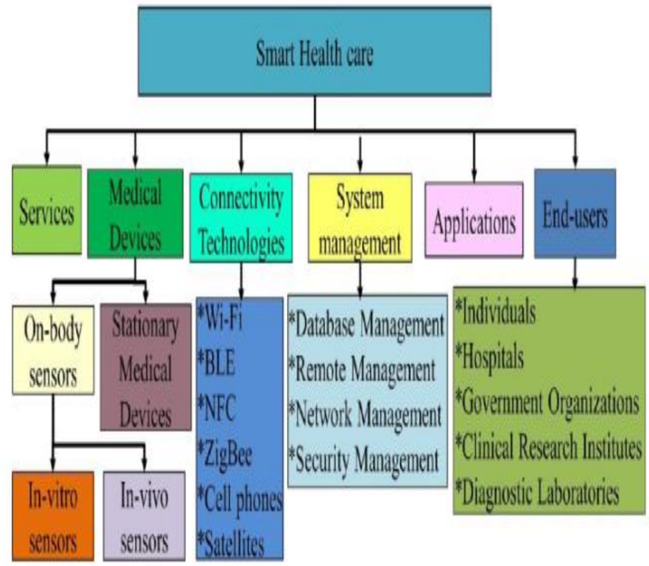


**Figure 1:** Smart Healthcare Elements (adapted from (Sundaravadivel, Kougianos, Mohanty, & Ganapathiraju, 2018))

Sundaravadivel et al. (Sundaravadivel, Kougianos, Mohanty, & Ganapathiraju, 2018) discussed the features of a smart healthcare architecture. They first talked about the requirements of the architecture and divided it to functional requirements which should be specific per component, and non-functional requirements that include performance requirements and ethical requirements. The components of the smart healthcare architecture according to Sundaravadivel et al. (Sundaravadivel, Kougianos, Mohanty, & Ganapathiraju, 2018) are sensors and actuators, computing devices, data storage, and networking components. The three categories for classifying the characteristics of smart healthcare are: App-oriented; which is the transmission of smartphone application's data to sensors, Things-oriented; which is application-based adaptation such as real time monitoring, or Semantics-oriented; which is the creation of behavioral patterns dependent on the recently gained data. The framework for the smart healthcare

architecture should include the libraries and environments being used in the healthcare platforms.

## 3. Previous Smart Healthcare Frameworks

In 2005, Reid et al. (Reid, Compton, Grossman, & Fanjiang, 2005) introduced a Framework for a Systems Approach to Health Care which is based on four main levels:

- Patient: whose necessities and inclinations ought to be the characterizing factors in a patient-centered health care system. Therefore, the function of the sick person has changed from ordinary patient accepting instructions to a greater energetic participant in care delivery.
- Care team: which consists of health physicians, patients' family members, and others who help in offering care to the patients.
- Organization: it is the third level of the health care system such as hospitals or clinics. They are responsible for the infrastructure and additional resources needed for the development of care teams and clinical microsystems.
- Environment: it consists of the political and economic environment that incorporates administrative, money related, and installment systems. It also consists of entities that impact the structure and execution of health care organizations and all other levels of the system.

Their layered framework is illustrated in figure 2:

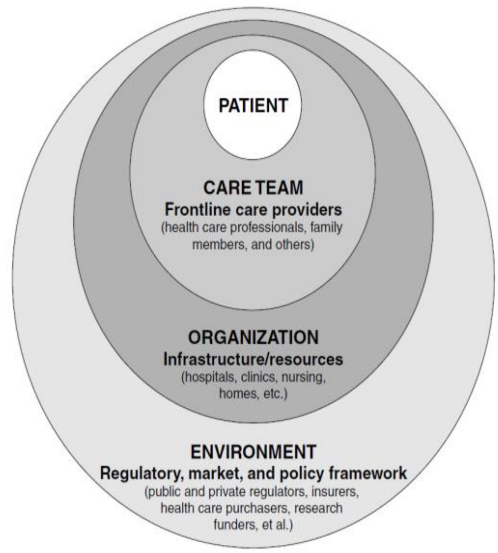


**Figure 2:** Four-Level Health Care System (adapted from (Reid, Compton, Grossman, & Fanjiang, 2005))

According to Reid et al. (Reid, Compton, Grossman, & Fanjiang, 2005), patients should have access to the same information offered to the physicians and care team in order to be interrelated to the health care system which leads to speeding up the process of diagnosis and treatment. Moreover, in order to have a professional care team system, physicians in this system should have on-request access to basic clinical and authoritative data, as much as the executives, correspondence, and choice help data, along with having access to the instructive devices to blend, dissect, and utilize that data. They think that in order for care teams or clinical microsystems to become the primary agents of patient-centered clinical care then the rules of engagement between them and the patients should change. For example, care teams have to be receptive to the requirements and inclinations of



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patients and include them and their families in the plan and execution of care. Moreover, care groups should give patients ceaseless, advantageous, convenient access to quality care. One individual from the care team has to be liable for guaranteeing successful correspondence and coordination between the patient and different individuals from the care group.

Reid et al. (Reid, Compton, Grossman, & Fanjiang, 2005) placed the organization at the third level of the health care system as it includes the decision-making systems, information systems, operating systems, and procedures to facilitate the exercises of various care groups and supporting units and deal with the flow of human, material, and money resources and information on the side of care groups. The organization is the business level, the level at which most investments are made in information systems and infrastructure, process management systems, and system tools. However, the environmental level which is the last level of the health care system has many factors and forces such as some administrative approaches that do not support the goals and objectives of the patient-centered, superior well-being care organizations or the social insurance conveyance framework.

Reid et al. (Reid, Compton, Grossman, & Fanjiang, 2005) discussed that the optimization of performance of a system can be decided upon based on different metrics such as the efficiency of a unit, the quality of service, the utilization of physical assets, or a blend of these. Moreover, optimization of a system is based on the optimization of its subsystems such as a health care system, its subsystems could be: 1. the amount of supporting staff, 2. the quantity of independent doctors, 3. the degree of capital interest in instrumentation, and 4. the degree of interest in the information/communications technologies infrastructure. However, it is very difficult to ensure the independency of these subsystems in order to achieve an overall optimization. Accordingly, to optimize the overall health care system whether this optimization is based on wellbeing, consumer loyalty, cost, or all of these, it is important to take into consideration the parameters that have to be perceived and included.

Finally, Reid et al. (Reid, Compton, Grossman, & Fanjiang, 2005) suggested that the usage of information/communications systems helps in speeding the exchange of information such as:

- Patient-based information: laboratory results, current diagnoses and medications
- Institution-based information: drug-resistance to different antibiotics
- Profession-based information: clinical-practice rules along with best practices for different circumstances
- Real-time decision support: cautions about potential medication cooperation or dosing designs in a patient with an undermined medication digestion system
- Practice-surveillance support: updates about forthcoming screening tests prescribed for a patient
- Population health data: for epidemiological research, disease and biohazard observation, notice of post presentation adverse medication occasions.

In 2013, Demirkan (Demirkan, 2013) proposed a “Smart Healthcare Systems framework for conceptualizing data-driven and mobile- and cloud-enabled smart healthcare systems.” According to Demirkan (Demirkan, 2013) “Healthcare spending increases reflect longer life expectancies, advances in developing countries’ standard of living, and the corresponding ability to afford high-quality medical treatments, and technological advances that create new possibilities for curing diseases and delivering services.” Cloud plus electronic health records plus medical sensors / wearable devices lead to delivering automated, intelligent, and sustainable healthcare services. A Smart Healthcare Systems Framework (SHSF) offers healthcare organizations to deploy platform-, technology-, and location-independent solutions. SHSF is divided into three major layers: business processes, service-oriented architecture, and service-oriented infrastructure all under a cloud services execution architecture that manages services to each layer's role. SHSF also, includes a conceptual model of an intra- and inter-organizational business process. Moreover, one of the main components of the SHSF's services and resource execution architectures is the inter-organizational supply chain which is based on using smart docking stations.

Demirkan (Demirkan, 2013) proved that the adoption of smart healthcare systems through offering four organizations who used parts of the SHSF or a similar framework namely are:

1. The EU-supported SmartHealth project focusing on cancer diagnostics which offered an open integrated architecture which showed that healthcare quality highly improved with earlier detection.
2. The University of Pittsburgh Medical Center's SmartRoom technology which used an intelligent system with three different screens for: patient, caregiver, and nurses and aides. Each of these screens offers the appropriate patient's data according to the user.
3. The Mayo Clinic's data-driven care which used an algorithm for brain aneurysms (swelling of blood vessel in the brain) detection and the results were 95% accurate.
4. Ambient Assisted Living which is a home-care mobile monitoring solution resulted in effective services.

In 2014, Basaez et al. (Basaez, Muhammad, Aranda, & Stantchev, 2014) carried out an exploratory study to evaluate the transition progress of traditional e-healthcare system into smart healthcare services. They reviewed the implementation of different information and communication technologies (ICTs) such as internet of things (IoT), cloud computing, and the usage of smart item technology such as wireless sensor networks (WSN), and radio frequency identification devices (RFID). They showed that the enhancement of e-healthcare system to smart healthcare services, leads to empowering physicians to follow-up the patients remotely while carrying out their ordinary day schedule. Accordingly, the patient receives high-caliber healthcare services along with saving time and eliminating health costs leading to the enhancement of healthcare quality service and the gratification of patients.

Basaez et al. (Basaez, Muhammad, Aranda, & Stantchev, 2014) extracted from the many researches they reviewed the essential elements to propose a complete cloud based framework for smart healthcare services. This framework endeavors to represent the new extent of e-healthcare by using WSN-RFID smart items and representing a smart healthcare scenario. The scenario is based on extracting information from patients using smart items then transferring them to the cloud. Healthcare institutions can then use the patient's personal health information (PHI) in the cloud such as PHR, EMR, EHR to screen patients' crucial parameters and take the appropriate action such as diagnostics, treatment, rehabilitation. Their framework is based on two main groups of clients: i. Healthcare organizations such as physicians and care staff, and ii. Family unit individuals such as patients and family members. Both groups can access the data at any time through the EMR and Patient care portal, respectively.

Based on Basaez el al.'s (Basaez, Muhammad, Aranda, & Stantchev, 2014) readings, their proposed

framework is divided into five levels coming from different researches:
1. Patient input level
2. Smart item level
3. Data aggregation level
4. Cloud computing level
5. Monitoring output level

Figure 3 shows the relationship between the above mentioned five levels in the proposed cloud based framework for smart healthcare services:
In 2019, Al-Azzam et al. (Al-Azzam, & Alazzam, 2019) proposed how to mingle mobile health with smart cities to get a smart health framework
. They explained how the healthcare services have developed from doctor’s visits to patients at home up till the amplified m-health which results in s-health.

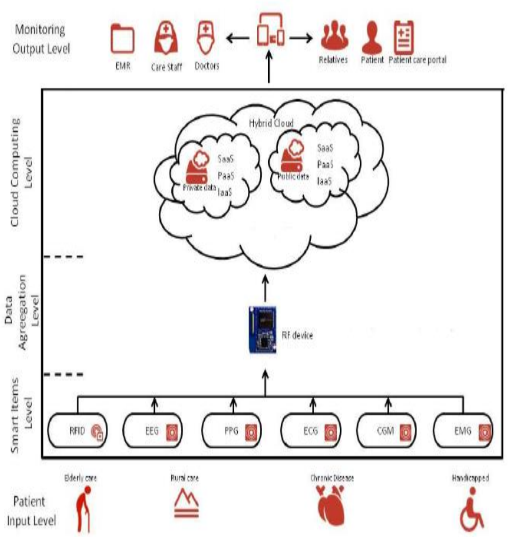


**Figure 3:** Cloud based framework for smart healthcare services (adapted from(Basaez, Muhammad, Aranda, & Stantchev, 2014))

The example used for the extended m-health was how the traffic lights can be adjusted if a cyclist did an accident and the smart city is notified through a wearable band at the hand of the cyclist in order for the ambulance to reach the cyclist in minimum time. Moreover, they made a comparison between m-health and s-health from the source and flow of information point of views. M-health source of information comes from the patient while in s-health it comes also from the smart city sensing infrastructure. Regarding the flow of information; m-health is user-focused or personalized approach, while s-health has the city-centric as an additional approach. Al-Azzam et al. (Al-Azzam, & Alazzam, 2019) presented two of the challenges that can face s-health which are multidisciplinary research and interaction, and security and privacy which will be further discussed in the following section. On the other hand, they presented 7 opportunities for s-health namely:
1. Data collection, presentation, and analysis
2. Prevention as well as administration of critical incidents
3. Effectiveness and environmental assessment
4. Engaging patients and families in managing their health
5. Improving policy decisions
6. Epidemic control
7. Cost saving

In conclusion, Al-Azzam et al. (Al-Azzam, & Alazzam, 2019), believed that the new concept of smart health (s-health) can be of great interest to researchers working on the development of m-health and smart cities. Their challenges and opportunities list for s-health can be considered as a pavement for the development and implementation of s-health.

## 4. Challenges for Smart Healthcare

According to Solanas et al. (Solanas, Patsakis, Conti, Vlachos, Ramos, Falcone, Postolache, Pérez-Martínez, Pietro, Perrea, & Martínez-Ballesté, 2014) in 2014 and later Al-Azzam et al. (Al-Azzam, & Alazzam, 2019) in 2019, one of the challenges of smart health is multidisciplinary research and interaction where their concern lies in that different researchers are studying the concept of s-health in different places in the world and they are not communicating their immediate outputs at the same time accordingly, they don't have an integrative solution. Therefore, Solanas et al. (Solanas, Patsakis, Conti, Vlachos, Ramos, Falcone, Postolache, Pérez-Martínez, Pietro, Perrea, & Martínez-Ballesté, 2014) and Al-Azzam et al. (Al-Azzam, & Alazzam, 2019) suggested that there has to be an interaction and association between different parties such as physicians, governments, researchers, etc. to reach a common mutual understanding for the concept of s-health in order to avoid the unnecessary redesign and the over-spending. The second challenge for smart healthcare also mentioned by both Solanas et al. (Solanas, Patsakis, Conti, Vlachos, Ramos, Falcone, Postolache, Pérez-Martínez, Pietro, Perrea, & Martínez-Ballesté, 2014) and Al-Azzam et al. (Al-Azzam, & Alazzam, 2019) is security and privacy where smart cities collect a lot of information about their citizens such as habits, social status, religion, and their health status. This information is highly sensitive and delicate that could endanger the privacy of citizens; therefore, it is a great challenge for researchers to find a solution for protecting privacy and securing the infrastructure.

Moreover, Solanas et al. (Solanas, Patsakis, Conti, Vlachos, Ramos, Falcone, Postolache, Pérez-Martínez, Pietro, Perrea, & Martínez-Ballesté, 2014) discussed other challenges to smart healthcare such as sensor integration, big data management and the cloud, and usability and human-computer interaction. Sensor integration is how to take into consideration the coexistence of the heterogeneous systems when implementing the ambient intelligence scenarios. Big data management and the cloud deals with the idea of storing a massive amount of different types of data that needs to be analyzed instantly. The data is referred to by the 3 Vs: variety (temperature, pollution, allergens), velocity (quick analysis to offer a better service to citizens/patients), and volume (output measurement of thousands of sensors). The concept of cloud computing could be a solution for storing this enormous amount of data. However, privacy, security, multi-tenancy, access control, and the mining and analysis of this huge amount of data could act as barriers to depend on the cloud. Finally, usability and human-computer interaction deals with structuring better wearable sensors, improving minimization and weight, expanding self-governance, simplifying the interaction processes, and improving dependability.

## 5. Conclusion

This survey showed that there is currently no standard smart framework for healthcare. Our research's goal is to provide the medical community with the accurate and timely information about the patients to take the right decision at the right time. It acknowledges the importance of time and security for critical cases and hence, the data offered to physicians should also satisfy the main non-functional requirements of accuracy, punctuality, and confidentiality. This survey should help us identify the basic healthcare service components to pave the way for our research aim which is to create a cloud computing reference architecture for smart healthcare services framework that captures the best practices and that introduces innovative features to suit the target users.



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