SMART HEALTH: SENSORS, BIG DATA, AND CLOUD COMPUTING IN THE U.A.E.

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ABSTRACT

The role of healthcare is critical in all communities, and the development of efficient healthcare systems is a top priority for governments and health organizations on a world-wide basis. With the technological advances of the past decades transforming almost every aspect of our lives, it is unsurprising that healthcare has become the subject of rapid, technologically-driven transformations under the concept of *smart health.* This is an umbrella term covering a range of underlying concepts and technologies, such as *wearable devices* and *sensors* and the use of *big data* and *cloud computing* in the broader context of health services and infrastructures (Imec, 2019). The purpose of this study is to explore these three main components of the *smart health* model, are integrated into, and affecting the smart health systems in the U.A.E.

Keywords:

SMART HEALTH: SENSORS, BIG DATA, CLOUD COMPUTING

1. INTRODUCTION

Health and well-being are, arguably, among the top priorities of most individuals around the world. As such, the role of healthcare is critical in all communities, and the development of efficient healthcare systems is a top priority for governments and health organizations on a world-wide basis (Yang, Leroy, & Ananiadou, 2013). With the technological advances of the past decades transforming almost every aspect of our lives, it is unsurprising that healthcare has become the subject of rapid, technologically-driven transformations under the concept of *smart health,* an umbrella term covering a range of underlying concepts and technologies, such as *wireless, wearable devices* and *sensors* and the use of *big data* and *cloud computing* in the broader context of health services and infrastructures (Imec, 2019).

Two of the key challenges stakeholders face in the ongoing transformation of health systems and the transition to smart health, are the improvement of the financial performance of health units and the subsequent reduction of organizational deficits. Both public and private health systems are facing multiple financial headwinds, such as funding pressure, rising prices, and long-term margins stagnating or declining. At the same time, demand increases, infrastructure upgrades, and clinical and technological advances, as well as spending driven by rising older populations, are also adding to the financial strain (Deloitte, 2018). In major regions around the world, combined healthcare spending is expected to reach $8.7 trillion by 2020, up from $7 trillion in 2015, following a long-established trend. As such, the aforementioned challenges are expected to remain a central focal point for the foreseeable future.

In the U.A.E., an ever-increasing population means that the effectiveness of the traditional patient-doctor appointment is being compromised. In this context, smart healthcare is becoming increasingly relevant on a regional basis (Sundaravadivel, Kougianos, Mohanty, & Ganapathiraju, 2017). This is evident on the steadily increasing demand for healthcare information technology over the past few years, with future projections also suggesting that the healthcare market will keep on growing for the foreseeable future. The government plays a major role in this growth, both in terms of setting the associated regulatory frameworks, and by means of the gradual introduction of electronic health records and health information sharing programs across the country over the past decade (U.S.-U.A.E. Business Council, 2019, Jan 14). It is, thus, important not only to analyze the benefits and challenges of the transition to smart health systems, but also to understand the underlying frameworks and restrictions that are unique to the U.A.E. ecosystem.

Based on these considerations, this study aims at briefly highlighting three of the main different components of the *smart health* model, namely the use of *wearables* and *sensors*, access to *big data*, and the adoption of *cloud computing* services, and their integration and effects on local healthcare ecosystem.

2. BACKGROUND OVERVIEW

2.1 Smart Health and Sensors

The use of *sensors* in medicine and public health has a long history. Embedded in a variety of medical devices for use in hospitals, clinics, and homes, sensors provide patients and their healthcare providers with insight into physiological and physical health conditions that are critical to detecting, diagnosing, treating, and managing diseases. Without devices such as thermometers, blood pressure monitors, glucose monitors and various forms of imaging sensors, much of modern medicine will not be practical and cost-effective (Ko et al., 2010). However, despite significant advancement in the monitoring device industry, there is still little progress in terms of the broader adoption of such technologies for medical practice purposes (Appelboom et al., 2014). While associated devices have been shown to be both reliable and beneficial, they tend to be rather underused in the healthcare sector. The broader integration of smart wearable sensors into daily patient care has the potential to improve physician-patient relationships, increase patient control and engagement in healthcare, and provide new remote monitoring methods that will revolutionize healthcare management and spending (Appelboom et al., 2014). As an example, recent developments in *wireless body sensors* and *wearable devices* have enabled the use of mobile health monitoring and warning systems. Such systems are designed to provide real-time updates on the health condition of the patient, while also providing alerts in the event of health-threatening conditions (Wang, Gui, Liu, Jin, & Chen, 2013).

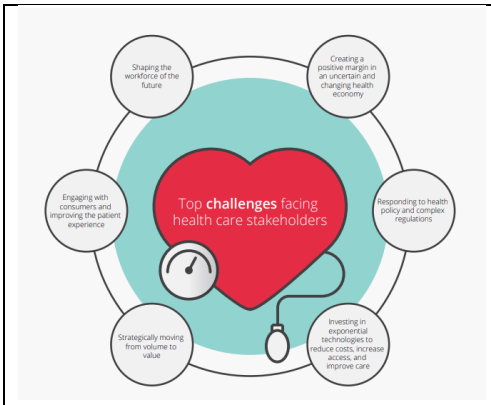

Figure 1: Key issues in global healthcare

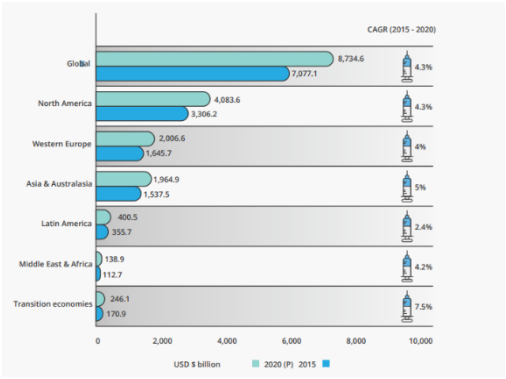

Figure 2: Key issues in global healthcare

On a broader scope, despite the fact that smart sensors have not been yet adopted in healthcare as broadly as in other areas, the technological advances in low-power networked systems over the past years has led to certain advances in the use of *wireless sensor networks* (WSNs). Systems utilizing the latter, come with the promise of changing and extending the quality of care dramatically across a wide range of environments and for different segments of the population. An example of this is *Ambient Assistive Living*, a platform that aims at the rapidly growing aging population, and the associated health and social care challenges (Al-khafajiy et al., 2019).

Despite their obvious benefits, one must also acknowledge that such systems are also prone to a wide range of faults and anomalies that can hinder their operations. This can be particularly

significant in the context of health systems when compared to similar applications in other disciplines, as such inconsistencies are not just undesirable, but rather unacceptable in healthcare. As such, various fault detection mechanisms are being developed to combat the underlying issues (Ko et al., 2010). Until thoroughly tested, secure systems, and solid regulatory frameworks are in place, any conversation related to the widespread use of sensors in healthcare must take into account their efficiency and reliability based on authoritative background work and systematic evaluations. However, the rapid advances in the sensors and wearables market guarantees that such inconsistencies will be addressed in the near future, making these devices the obvious choice for healthcare purposes.

Figure 3: Medical information tag (Welsh, 2010)

2.2 Smart Health and Big Data

Recent developments in the field of *information and communication technology* (ICT), and the apparent emergence of *big data* concept, inevitably affect organizational innovation and growth. Such developments, and the broad adaptation of omnipresent technology, provide numerous opportunities for businesses and governments to rethink their vision and systems, and their expectations from healthcare as a whole. It is, thus, unsurprising that the relationship between big data and smart healthcare systems is currently attracting attention from both the academia and the industry, while being also a popular and prominent area of interest of individual researchers (Pramanik, Lau, Demirkan, & Azad, 2017).

Big data analytics (BDA) offer significant advantages in terms of managing large quantities of data. Such processes and approaches use predefined and structured models to categorize and analyze data, like the '4 Vs' model using *Volume, Velocity, Variety*, and *Veracity* of data, in order to handle dynamic information delivering operational flexibility and improved performance in various day-to-day applications and tasks. Healthcare is one of the industries that utilize such processes and models, as not only the data collected and produced in its domain fit in with the different analytical categories of the analytics systems, but also its growth and size warrants such an approach (Basco & Senthilkumar, 2017).

In addition to *scale*, *pace*, *diversity*, and *variety* of health data are some of the key areas that pose significant challenges to the healthcare sector. The improved *versatility, diversity*, and *connectivity* of modern data capture devices mean that additional data is generated at increasingly high speeds.

Similarly, decision support can be made available almost in real-time. For example, heterogeneous information from managed and unmanaged sources (e.g. social media, air travel) can be processed, mined, and turned into decisive actions for controlling the outbreak of an influenza pandemic (Andreu-Perez, Poon, Merrifield, Wong, & Yang, 2015). In this context, the use of big data and the associated, contemporary technological workflows and solutions, can offer viable solutions to such challenges.

Figure 4: Six V's of Big Data, which also apply to health data (Andreu-Perez, Poon, Merrifield, Wong, & Yang, 2015)

2.3 Smart Health and Cloud Computing

Wireless Body Area Networks (WBANs) are among the key areas of study in relation to the improvement of the quality of healthcare. IT professionals are currently expanding WBANs by integrating them into *cloud computing* systems. A large amount of patient data is extracted from WBANs and transmitted to cloud servers, with the aim to improve *scalability, real-time usability*, and *storage* and *processing capacity*. The impact of this extension, commonly known as S-CI, is rather significant and difficult to ignore in the healthcare domain (Masood, Wang, Daud, Aljohani, & Dawood, 2018).

The fast growth of cloud computing technology has also led to a new computing model, namely, *mobile cloud computing* (MCC). The latter describes the use of *mobile devices* to acquire various physiological signals from a set of *ambient body sensors*, and perform lightweight onsite diagnostic tasks. MCC allows the user to access almost unlimited computing power and online storage space. This approach not only allows users to enjoy simple, flexible, and effective computing facilities, but also makes it possible to provide customized, accurate medical diagnosis and treatment off-site (Wang et al., 2013).

The potential of cloud computing, and its integration of various models and technologies, such as *cloud storage*, and *mobile computing,* unlocks new potential across different areas, and while also providing strong technical support for remote healthcare services (Zhiqiang, Lingsong, Hang, & Cong, 2015). The promise of mobile and cloud-based telemedicine systems in terms of continuous monitoring of patient health status and prompt treatment and care is rather evident, with a large body of literature and research being carried out in this direction (Wang et al., 2013).

Figure 5: Telemedicine application based on the cloud (Wang, 2013)

3. DISCUSSION

In the U.A.E., the Dubai Health Authority is specifically interested in businesses that utilize and deliver the latest technology. This view is evident in the region, in the form of widespread adoption and welcoming attitude towards new technologies that can improve conditions for both patients and doctors. A tangible example of this is the statements issued by Dr. Mohammed Al Redha, Director of DHA's Project Management Office, Informatics and Smart Health, that such initiatives *"will help improve the overall health sector and provide patients with the highest standards of care using the latest technology"*, and that *"patient-centered care is a priority, and there is enormous potential for technology to improve patient care"* (Omnia Health, 2015, Mar 28). A working example of current uses of modern technologies in healthcare in the region is that of *Affordsens Vitalgram*, a small wearable *ECG* patch type device. The device can be coordinated to receive data 24/7, over 365 days a year. This can help in the prevention of significant emergencies and, thus, play a significant role in disease prevention. The device is small enough to be held in the palm of one's hand and is equipped with multiple sensors that can measure vital parameters and perform various tasks and analyses, such as electrocardiograms, measurements of body

temperature and blood pressure, sweat analysis and detection of levels of potassium, sodium, magnesium, lactase, and glucose, and measurement of heart rate variability, among various other vital life-saving measures (Omnia Health, 2015, Mar 28). The device works well for seniors or for individuals who may not be able to visit hospitals for regular check-ups. This lightweight device transmits all information to a phone or cloud network for continuous monitoring of healthcare parameters. It can set off an alarm in case of an emergency, alerting healthcare professionals at a hospital. Such tools provide clinicians with an overview of each one of their patients, enabling them to monitor and adjust care plans, or interfere, if and when necessary (Omnia Health, 2015, Mar 28).

With U.A.E. at the forefront of the worldwide rush to technology adoption and integration, and a population of 10 million people demanding an improved customer experience, companies are naturally looking for ways to improve their operation and workflows. More specifically, two key areas most local companies try to improve on through technological integration are a) the achievement of faster decision-making and the flexibility to adjust the decision-making process and direction at any given point of the process, and b) the efficient monitoring of consumer needs and the supply of the appropriate solutions in real-time. Big data analytics appears to be a prime choice for both tasks, and it should come as no surprise that a surge of big data usage in the region is observed. Notable examples of this are the cases of *Dnata* that is focusing on travel experiences based on AI, the delivery of demographic content by Netflix, and the Smart Data Summit in April 2019, showcasing an ongoing shift to a new technological and cultural framework with big data at its core (Sood, 2019, Mar 10). The services offered by big data companies to the U.A.E. span across a wide range of applications and solutions, such as traffic management, mobility facilities, parking solutions, shopping experiences, and social and public events. A recent report indicated that big data, business intelligence, and analytics are estimated to reach $12.38 trillion in the Middle East market by 2020 (Sood, 2019, Mar 10). In relation to the regional effect of big data in terms of healthcare, improvements are expected in terms of the connectivity of available biomedical data sources, as well as data diversity and complexity. Access to a larger pool of data and advanced analytical capabilities will allow for qualitative and quantitative analysis, offering increased opportunities for observational evidence to address medical questions that are difficult to be answered by randomized trials alone. In a broader scope, issues related with generalizing results based on a narrow spectrum of participants could be addressed by leveraging the ability of large data for longitudinal studies (Andreu-Perez et al., 2015).

In terms of *cloud computing services* and *infrastructure* in the U.A.E., a key factor for wider adoption is the evaluation of the regional cloud environment. While cloud computing is widely utilized in other geographical areas and regions, the appropriate level of integration of such services, as well as its extent and scope in the U.A.E. can be debatable. As a general comment, it is suggested that more research in this area is needed in order to explore and identify the views and concerns of local companies regarding a more widespread adoption of cloud computing in the region (Omnia Health, 2015, Mar 28). In the context of healthcare, it is also possible that the wider adoption of cloud technology could bring certain benefits to the local healthcare industry. However, it is also possible that certain challenges and questions will also arise. As mentioned, a solid understanding of the local healthcare ecosystem and of the views and concerns of local companies and regulatory institutions in terms of the adoption of such platforms, may be required in order to gauge the appropriate scope and extent for it. In the U.A.E., from a regulatory

perspective, certain issues may arise due to the large volume of files processed and managed by healthcare entities. Information relating to patients is generally considered highly sensitive and the U.A.E. has certain restrictions in relation to where and how patient data is stored. Unique conditions and restrictions such as these need to be taken into account when considering the optimal levels and format of cloud integration in the region. (Christina Sochacki, 2018). Finally, it must be stressed that in terms of regulatory frameworks, a robust data protection and security strategy for healthcare has not been enforced yet in the region. The 2013 DHCC Health Data Protection Regulation prohibits the disclosure of patient health data to organizations operating in Dubai Healthcare City ('DHCC'), unless certain conditions are met. It also sets out patience requirements and the reporting cap. The regulation goes as far as to define the jurisdictions that have an appropriate level of protection, thereby requiring the transfer of patient health data to those jurisdictions after the transfer is approved by the patient, or the transfer is deemed necessary for the continued delivery of healthcare services to the patient. (Christina Sochacki, 2018). Ultimately, such frameworks need to become even more specific and tailored to the unique characteristics and challenges of a broader smart health strategy, potentially under the umbrella of a formal, structured regulatory framework that provides guidance and control measures for such complex and rapidly changing technological platforms.

4. CONCLUSION

With the technological advances of the past decades transforming almost every aspect of our lives, it is unsurprising that healthcare has become the subject of rapid, technologically-driven transformations under the concept of *smart health,* an umbrella term covering a range of underlying concepts and technologies, such as *wireless, wearable devices* and *sensors* and the use of *big data* and *cloud computing* in the broader context of health services and infrastructures (Imec, 2019).

In the U.A.E., an ever-increasing population means that the effectiveness of the traditional patient-doctor appointment is being compromised. In this context, smart healthcare is becoming increasingly relevant on a regional basis (Sundaravadivel, Kougianos, Mohanty, & Ganapathiraju, 2017). This is evident on the steadily increasing demand for healthcare information technology over the past few years, with future projections also suggesting that the healthcare market will keep on growing for the foreseeable future. The government plays a major role in this growth, both in terms of setting the associated regulatory frameworks, and by means of the gradual introduction of electronic health records and health information sharing programs across the country over the past decade (U.S.-U.A.E. Business Council, 2019, Jan 14). It is, thus, important not only to analyze the benefits and challenges of the transition to smart health systems, but also to understand the underlying frameworks and restrictions that are unique to the U.A.E. ecosystem.

The main aim of this preliminary study was to briefly highlight three of the main different components of the *smart health* model, namely the use of *wearables* and *sensors*, access to *big data*, and the adoption of *cloud computing* services, and their integration and effects on local healthcare ecosystem. Although the widespread adoption of such technologies under the broader transition to smart health systems is evident in the region, and the benefits from this transition are undisputed, a number of issues and challenges are also arising from it. Some of these issues and challenges have to do with technological innovation and the approach and mentality of institution

and individuals towards them. Such issues are bound to be eventually addressed as the reliability and effectiveness of the underlying systems become apparent through further technological progress. Issues that have to do with the structural, ethical and legal aspects of this transition, may need to be addressed through the development of solid, structured regulatory frameworks on a regional basis.

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