International Journal of General Medicine and Pharmacy (IJGMP)
ISSN(P): 2319–3999; ISSN(E): 2319–4006
Vol. 9, Issue 4, Jun–Jul 2020; 1-4
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International Academy of Science, Engineering and Technology
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OPPORTUNITIES AND CHALLENGES OF INTERNET OF THINGS IN HEALTHCARE

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ABSTRACT

The use of Internet of Things (IoT) devices besides gaining popularity in our daily lives, are gaining speedy entry into the healthcare arena and are being appropriately termed as Internet of Healthcare Things IoHT). Most of these devices are wearable and allow continuous monitoring of physiological functions without manual intervention. Some of these are catalyzing remote healthcare, such as Telehealth and eHeath. However, their use in healthcare poses a special challenge due to accuracy and security requirements of the health information. The health data between the IoHT devices and remote sites is mostly transferred wirelessly and is apt to interception as these devices being tiny to small lack the necessary processing power for encryption. Despite this drawback, the future of IoHT devices appears bright due to advancements in nanotechnology and Arterial Intelligence being incorporated in them.

KEYWORDS: *eHealth, IoHT, IoMT, IoT, Telemedicine, Medical Sensors, Wearable Devices*

Article History

Received: ***19 Apr 2020*** **|** ***Revised:*** ***12 May 2020*** **|** ***Accepted:*** ***04 Jun 2020***

INTRODUCTION

The rapidly evolving use of *Internet of Things (IoT)* in healthcare has led to new term of *Internet of Healthcare Things (IoHT)* and/or *Internet of Medical Things (IoMT).* Some examples of their use are Real-Time monitoring and alerts via the connected devices in the event of medical emergencies (heart failure, asthma attacks, falls, diabetes); collecting and transferring real-time health data (heart rate, blood pressure, oxygen and blood sugar, weight, and EKGs)[1]; sinking hearing aids with smart phones[2]; enabling interoperability through Bluetooth, Wi-Fi, Z-wave, ZigBee technologies[3]; and remote medical assistance through Telehealth, Telemedicine and Mobile Health (mHealth)[4]. IoHT is also helping people to stay healthy through monitoring their daily physical activities, calories intake and used, monitoring blood pressure and blood glucose with wearable devices as smart watches and implanted devices and delivering insulin through insulin pumps[5]. These IoHT/IoMT devices can also feed information directly to the EHR (Electronic Health Record) of the respective patient(s) in diverse healthcare settings[6].

OPPORTUNITIES FOR IoHT/IoMT DEVICES

The *future* of IoHT/IoMT would include Artificial Intelligence (AI); ingestible sensors (ePills) that are pill-sized devices to monitor internal physiology and act as diagnostic devices sending medical information and images to outside connected devices; nano-devices that beside monitoring human physiology would deliver drugs to targeted areas like cancer cells[7]; connected lenses that would determine tear glucose and eyes diseases[8]; blood clot monitoring sensors to avert heart attacks[9]; nursing and medical assisting robots[10]; smart hospitals[11], and virtual clinics and microsurgery[12, 13]. As more lowcost, low-power consuming IoHT devices and sensors become available, IoHT technology will continue to scale up supporting the use and integration of millions or even billions of devices sending data and messages. Multiple vendors (e.g. AWS, Microsoft, Oracle)[14] have developed excellent processes and techniques for data collection and analysis, device registration, management and monitoring, along with the ability to build applications and solutions using Artificial Intelligence and Machine Learning (AI&ML) algorithms to predict and classify objects and patterns in noisy areas. The noise occurs when multiple devices using similar communication protocols and channels interfere with each other thereby reducing the quality of communication or even interrupting data transmission. One such typical example is the new 5G networks that is feared to interfere with some IoHT devices that may communicate in that frequency band while otherwise greatly enhancing communication speed of IoHT devices. Improvement in their security and speed will further catalyze their deployment in variety of healthcare setting. Resultantly, their global market will soar to $ 534.3 billion by 2025 (Grand View Research, 2019)[15].

CHALLENGES OF IoHT DEVICES

The major challenges for the use of IoHT devices emanates from three aspects: lack of standards and protocols for interoperability, data security and privacy[16] and data aggregation and analysis.

Since these devices besides communicating with each other are supposed to send data and messages to the mainstream systems of the healthcare facilities, that being highly vendor-specific, lack interoperability. *Interpretability* implies ability of the systems or component of systems to communicate with each other. In today's healthcare environment countless IoHT devices of different vendors, brands and technical specs and standard, make interoperability a great challenge. There appears some initiatives by the IEEE (Institute of Electrical and Electronic Engineers), an international organization that develops standards for the communication technology like the Internet, and EU (European Union) for developing standards for the IoT devices, which will also be applicable to IoHT/IoMT devices using the same underlying working principles[17]. This is a reminder of the early development days of vendor-specific personal computers and communication protocols (Mac, Novel, HP) till they were standardized for interoperability.

The other major challenge of IoHT devices is *Data Security and Privacy* as health data containing sensitive information travels on the Internet and is stored mostly now-a-days in the Cloud. The IoHT devices transmit data wirelessly travelling through the atmosphere. Being very small, they do not possess enough computing power to *encrypt* (encode) data, although some medical grade cell phones and devices have started to do. They also are not equipped for updating the security patches due to their permanently embedded operating system, unlike computers that allow installing, updating and patching software. The health data, thus, both in the *transient* and *stationary* forms can be accessed, hacked, modified, corrupted and even rendered unusable. From *security* aspect, every linked device creates vulnerability and poses a threat from attackers or malicious software. Since the IoHT devices collect personal health data with identifiable information, they have potential of being hacked, operationally disrupted, or caused to malfunction. The wirelessly transmitted *unencrypted Protected Health Information (PHI)* by IoHT devices is subject to interception and hacking by anyone, anytime and from anywhere beside being accessed as stored *unencrypted* data. The health information management professionals, thus, should possess sound knowledge of the vulnerabilities and security measures of wirelessly transmitted health data by IoHT devices.

Yet another challenge of the extensive use of IoHT devices is the aggregation and analysis of the huge amount of data collected by them. This aspect of IoHT devices would need skills in h*ealth data analytics* to sort, interpret and display health data for meaningful use in healthcare decision making. This skill of health-IT professionals would require mastery of statistics, programming, and data analytics tools.

Associated with these challenges, is the inability of the IoHT devices to deploy of security patches. With servers, laptops, and even phones, operating system patches are regularly provided and often automatically applied protecting consumers from the latest security threats and vulnerabilities. An IoHT device may have major software or configuration issues that can't be patched because of deployment location, design constraints and embedded software. The longer an unpatched device stays in the field, the more likely vulnerability could be exploited.

MITIGATION IoHT CHALLENGES

With the implementation of appropriate technology and policies, IoHT managers can mitigate data interoperability and data privacy and security issues using some of the following technologies and policies.

Technologies

- The use of *Block Chain* technology to protect data in IoHT devices can enhance security. *The Bock Chain*[18] is a distributed decentralized ledger with underlying *encryption* technology comprising secure, authenticated and verifiable transactions. Some IoHT manufacturers have started incorporating this technology in their devices. The major IoHT players (Cisco, IBM, Intel, Infineon, Symantec, Google) are investigating the security aspect of their IoT technology applicable in healthcare using this technology.
- Enable IoHT devices to use *Authentication* to validate user identity and access privileges.
- Enable IoHT devices to use *encryption* for all health-related communication.
- Enable *Integrity* on IoHT devices to verify devices to ensure that they are unaltered and uninterrupted.
- Ensure IoHT devices are *patched* and *updated* to avert any vulnerability.

Policies

- Ensure that IoHT devices use the principle of *"least privilege"* ensuring only the required actions and types of communication.
- Log all user activities and events and monitor themregularly for *unusual* activities, like duplicate unique device identifiers or elevation in privileges.
- Review data analysis results regularly to identify unusualtrends and patterns.
- Stay current with the IoHT technology trends including AI/ML, data analytics and *security best practices* associated with protecting and securing sensitive data through formal education, training workshops, certifications, and participation in conferences.

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