Review Article

Integration of Wearable Technologies into Patients' Electronic Medical Records

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ABSTRACT

Health Wearable Technologies are becoming more popular all around the world. Smart watches and fitness trackers are currently being used by many and the utilization is expected to continue to grow. The innovative technology will certainly play a key role to the optimal operating of future society, especially with applications in healthcare. This article will introduce the concept of wearable technology with advantages and challenges of its application in the healthcare industry.

Keywords: Health; Technology; Wearable technology; Healthcare; Patient protection

Introduction

In March 2010, the U.S. Congress passed, and President Barack Obama signed into law, the most comprehensive and far-reaching health policy legislation in decades – the Patient Protection and Affordable Care Act (P.L. 111-148), as amended by the Health Care and Education Reconciliation Act (P.L. 111-152). The Affordable Care Act (ACA), as the combined legislation is known, is considered a landmark law in the history of health and social welfare policy in the United States, the most significant since the Social Security Act of 1935 and the Medicare and Medicaid Act of 1965. The Act ignited an interest in introducing novel ideas and practices into the delivery of healthcare.

Features and Types of Health Wearable Technology (HWT)

The development of affordable and portable sensor nodes has been attributed to different factors, such as the inception of wireless communication. These nodes have the capability to sense, process and communicate different signs and therefore can be used for health monitoring purposes.[1] This led to the development of wearable technologies in the forms of wearable devices, electronics or computers. Health wearable technologies (HWTs) refer to electronic tools that are fitted into items that can be embedded into the body. They are application-enabled computing devices that accept and process inputs. These technological tools can be fixed on clothing, patches adhesive to the skin, integrated in accessories such as watches and glasses and can also be fixed inside the body of a patient by surgical procedures.[2] A main feature of the HWTs is that they have a hands-free function that could enable users to access own health data while performing daily routine tasks. Other features include accessibility, wearability, comfortability, portability, multi-functionality, usefulness, reliability, and practicability.[3] The Food and Drug Administration (FDA) approves some of these devices, such as insulin monitors and cardiac event monitors.

HWTs are commonly available as fitness trackers, insulin pumps, cardiovascular defibrillators, and vital signs monitors. By using Accelerometers and Micro-Electro-Mechanical Systems (MEMS), HWTs have the added advantage of tracking and monitoring physical activities (PA) and vital signs, which are related to medical and fitness and wellness. Some of these measurable parameters are heart rate, blood pressure, pulse rate, muscle activity, glucose level, sleeping pattern, electrocardiogram (ECG), core temperature, oxygen saturation, stress levels and monitoring eating habits. Each of these functions requires specific type of sensors at a certain part of the human body. There are three integral components to these devices; 1. sensing and data collection hardware, 2. communication devices that convey data to a remote center, and 3. data analysis tools or techniques used in extracting and analyzing important health information for the purpose of health and wellness.[4]

HWTs are designed to collect data automatically and analyze them in a real-time base. Fitbit fitness band, for example, is a tool that underpin the benefits of HWTs in collecting data. It monitors activity data such as the number of steps taken, speed, pace, calories burnt, distance traveled, skin temperature, heart rate, perspiration level, dietary information, and sleeping hours.[5] Sport and fitness HWTs are mostly targeted by athletes and people interested in fitness, however, it could also be used to encourage obese and diabetic patients to exercise and monitor their daily food intake. Studying collected data by trainers or nutritionists will help in better understanding of the client's

health status and aid in planning strategies to improve their health.

Uses of HWT in Healthcare

Besides personal health and fitness purposes, these multi-parameter physiological sensing systems can be used to determine and measure vital signs to aid in medical interventions.[6] For example, a patient discharged after surgery or a patient prone to heart attack are at a higher risk, hence monitoring their vital signs remotely, by HWTs, is very critical. Disabled, paralyzed, deaf, blind and patients whose memory has been compromised also benefit from special HWTs that involve controllable electrical and wave pulse adjusted according to their needs. HWTs can function as a preventative healthcare tool and telemedicine by tracking and monitoring data.[7] Furthermore, HWTs are elaborately used in the research field. Researchers have been using them to understand the physiology of uncommon diseases. For instance, a study has been examining the ability of wearable sensor in assessing walking quality and the balancing rate of patients with frailty syndrome, which is characterized with physical weakness. With the help of wearable sensors and in-home monitoring, researchers were able to distinguish between three frailty levels.[8] Another study was conducted to examine the sensors ability to predict falling rhythm of patients with dementia.[9]

Multi-parameter physiological sensing systems can assist clinicians when engaged with patients in remote areas. In China, a project called *"wireless heart health program"* utilized wireless health among eleven thousand patients in a far-flung rural areas of the country. In perspective, smartphones operating heart beat sensors were utilized and were being connected to the 96 numbers of local doctors, who could text and call them as well as review and send feedback. Subsequently, physicians announced that the 11,000 patients from the experimental group checked by health sensors, turned out to have serious cardiovascular problems, enough to investigate further treatment at the clinic.[10]

Another critical application of wearable technologies is the automated drug infusion pump. It controls the amount and the duration of injecting drugs or nutrients into a patient's body. These pumps have been used widely for a number of chronic diseases like diabetes (insulin pump) and acute infections (antibiotic pump).[11] Similarly, transdermal drug delivery (TDD) devices or patches are advancement in wearable technology. The devices use heat, electric current and sound waves to improve the delivery of drugs into the systemic circulation. Although TDD is still in the development stages, it aims to enhance patient comfort and life quality.[12]

Advantages of Integrating HWT into Electronic Medical Records (EMR)

In the recent past, translational bioinformatics methods have made an important progress in implementing genomic medicine at the highest point of care along with seamless integration with electronic medical records (EMRs). The integration of patient-generated fitness or medical data with big data such as prevailing health data into the EMR along with other biological and genetic data is very powerful and robust. This integration can serve as a valuable, comprehensive and reliable source of data for clinical diagnosis and medical research. Data mining of all the integrated data will aid clinicians in making more informed decisions by assessing how patients progress from their normal health state to a clinically significant pathological state to a reanimate state.[13]

Cohort studies are applicable for this same purpose; however, user-generated data through HWTs is more promising because of the following reasons. First, HWTs collect data automatically with zero effort required from patients, whereas in research studies, patients are required to visit the clinic several times, spend some hours for measuring, recording, studying parameters, blood withdrawal, etc. Second, data of health wearable devices (HWD) are more systematic and accurate in timing as it records all the details and analyzes them directly, unlike in research studies, where manual reporting is usually used. Manual reporting is prone to mistakes and it can be biased by individuals conducting the study. Third, enhancing eHealth literacy among patients by informing them on how to use the monitoring devices to determine their healthy-being, which will influence them to be more engaged and involved in self-management and push them to reach a very good level in providing reliable information to the healthcare providers.[14] Moreover, patients will be more motivated in taking preventative actions and addressing their concerns to their physician. This step is critical for health in general and is cost-effective too.[15]

Challenges of Integrating HWT

There is no doubt that HWTs are beneficial in tracking and monitoring health and daily activities. However, there are a number of concerns related to the integration of these technologies to the healthcare system such as its cost, weight, discomfort in some circumstances, insecurity issues, reliability and validity.

HWTs are considered costly to an ordinary person because they are one of the most cultured pieces of technology in the contemporary world. For all intents and purposes, HWTs are expensive because of the

sophistication they entail, where high levels of technology are required to come up with wearable computers. For patients with chronic diseases, they are required to wear the HWTs associated to their disease on a daily basis for their entire life. This requires a frequent maintenance of the HWTs and if these devices have a short life, replacement will be required. Equally, HWTs are costly because of the high costs associated with the establishment of local area networks to aid in the synchronization of the data to the healthcare system.[16] Cost is an issue for users as well the provider for adapting HWTs as a part of the healthcare system. More data being collected means more storage area that means more servers and backup systems are required.

Despite advancements in engineering technology, HWTs are relatively heavy because they are assembled with multiple components of the wearable technology, which must be attached to the body. This implies that it requires a Central Processing Unit (CPU) and other peripheral devices as well as a monitor to ensure that the computer captures data input. These components are heavy and difficult to wear for users. Thus, users are likely to face discomfort because they have to carry them daily. Far and beyond heaviness, discomfort and irritation are also likely to be experienced by users, especially during hot and humid weather conditions. In addition, the components of HWTs are likely to emit heat, even though they possess an inbuilt cooling technology, resulting in health hazards such as headaches and dizziness.[16] According to Shih *et al.* on the use and implementation barriers of wearable activity monitors, participants claimed that these trackers were uncomfortable to wear even when exercising because they were cumbersome and intrusive when worn during daily activities.[5]

Privacy and security of personal data generated by the users are a major concern of HWTs and devices. Users of these devices have privacy concerns because they do not own their data. On the contrary, the manufacturers collect this data and keep it. There are claims that some manufacturers are willing to share the users' private information such as age, email address, social media accounts and profiles, sex, and location as well as other GPS-tracked activities. In addition to this, there are also concerns about the sophisticated algorithms, which are said to have the capacity to cross-reference biometric data generated by wearable technologies with other digital traces of users' behavior. In this way, the personal identity can be revealed to a third party, increasing chances of identity fraud.[17] Furthermore, HWTs can enhance security concerns by being hacked easily when they are left unattended. This is because they are connected to the

company's server to make the flow of communication possible between the users and the office in which they are based.[16] The benefit of integrating personal, health and activity data in one system is taken for granted, with no proper bio-security system, which can lead to exposing this information by others either inside or outside of the healthcare provider crew. Consequently, users will think twice before using HWTs and reject the idea of using it.

Reliability and validity of wearable are two potential concerns. HWTs are generally marketed based on the premise that they will play an imperative role in improving the wellbeing – health and fitness – of the people. However, most manufacturers are not in a position to offer "tangible" evidence to prove the effectiveness of these devices. Comparative studies that have been carried recently on the effectiveness of various HWTs designed for tracking physical activity have illustrated significant variations in terms of accuracy between different devices. The error margin demonstrated by these devices is stated to be up to 25 per cent.[17] This discrepancy is of the highest magnitude hence this reflects the problems wearable medical apps may create. For example, a study evaluated several HWTs applications used for melanoma detection, by processing and analyzing skin lesion images. The study showed that these applications did not meet the standards required in terms of being reliable. Essentially, this device had a 30 per cent failure rate.[18] Hence, before releasing any HWD to the market as health or medical application, its reliability should carefully address.

Exposure to electromagnetic radiation and microtrauma has been raised in the literature as potential concerns.[19,20] When it comes to HWD, most healthcare practitioners believe that they emit very low levels of radiation and produce minimal microtrauma posing no health risks at all. Additional work to make the technology safer and more efficient will likely always be a goal. As HWT become increasingly popular, creating the best and safest devices to improve healthcare will continue to be a challenge.

Future Applications of HWT

In the future, HWTs must include certain features to meet the need of this integration. One of these features is system interoperability. Several commercial companies have been manufacturing HWTs using different computational algorithms with a range of characteristics and features, which makes it hard for the EMR to be compatible with all. Having HWTs with a single and standard computational algorithm will facilitate its integration to the EMR. In addition, these computational algorithms should be created by both computer and data scientists. The aim is to co-operate with clinicians in order to improve different health

conditions accurately. What is more, data reliability and other usability issues illustrated by HWTs need to be addressed to enhance their operations. Improving interactivity of HWTs is another future possibility. HWTs could be integrated with established interactive computing systems, such as those that already exist in smartphones such as Google Now and Microsoft Cortana.[17] Likewise, HWTs interactive interface will provide an educational environment where clinicians can send notifications and education messages to patients.

Right now, most HWTs are designed and manufactured to operate as a one-point solution especially the medical ones. Future HWTs should be able to handle multiple measurable data. This will reduce the number of HWTs that the patient will have to wear in order to cover, trace and monitor data. For example, cardiac patients require constant tracking of their blood pressure, cortisol levels and cholesterol.[15] Multiple point HWTs lead to increasing the concerns pointed earlier, regarding costs, weight and discomfort. Therefore, they must be designed smartly keeping these facts in mind.

Developing comprehensive, accurate and manageable HWTs will also influence insurance companies to adopt these technologies and reimburse for wearable technologies that are employed in clinical practice.[2] Subsequently, there will be more FDA regulations and standards to control the use of HWTs and insure their safe and accurate use.

Conclusion

In conclusion, HWTs are small electronic devices embedded into wearable items with high computational processing capability. These technologies have different features including accessibility, portability, multi-functionality and practicability among others. Most importantly, HWTs have several benefits on tracking and monitoring fitness and medical daily activities independently. Gathering these functions in a single device and integrating the collected data to the EMR, will definitely have a huge potential in promoting the meaningful use of EMR. This integration will provide a long-term view of a patient's overall health, filling in data gaps to enable evidence-based care. Over all, smart HWTs will increase both patient engagement and preventive care, and that ultimately will save time and money.

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