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Health Monitoring Through Microchip Implants and Wearable Devices.

Abstract – **Health monitoring is the supervision of an individual's health in order to recognize abnormalities through the use of data measurement and analysis. As a part of the healthcare system, the cost of the usual health monitoring is high and stressful for the daily life of individuals. The use of implants and wearable devices provide the possibility of tracking a patient's conditions, a quick response, cost-effectivity, and without the constraints of hospitalization. This paper aims to examine the current state of health monitoring through the use of implants and wearable devices, their development in consideration to their profitability, and benefits.**

I. INTRODUCTION

The continuous ageing of population due to life expectancy and evolution of illnesses have progressively increased the costs of treatments and medicine [1]. As of 2017 18.2% of the population in the UK (United Kingdom) is comprised of people of age 65 or above and there is an expectation of a 20.1% growth in 2027 [2]. With the increase in life expectancy it comes the increase of chronic and physiological illnesses and a direct effect can be observed in the costs and workload of the healthcare system [1]. In 2017, in the UK, the expenses in healthcare were of 197.4 billion pounds. This equates to a 9.6% of the GBP (Gross Domestic Product) in the same year [3]. Due to this many organizations are already planning for the future, as it can be observed with the NHS (National Health Service). With the implementation of wearable devices and implants, the NHS aspires to prevent more severe situations that may require hospitalization of an individual [4]. One example of a possible future wearable device is the "Glucosense" a device developed by Professor Gin Jose [5]. The Glucosense is composed of a new medical sensor capable of reading the level of glucose in blood through a non-invasive method by the use of a photonic chip. This device utilizes disposable paper, make it more cost efficient than regular readers [6]. Hence why the development of such technologies is already restructuring the way health monitoring works in healthcare and will continue to do so if their development and cost effectiveness is explored further.

II. IMPLANTS AND WEARABLE DEVICES

While implants and wearable devices both focus overall in the wellbeing of the patient, they are utilized in different circumstances and have different premises.

a. IMPLANTS

Implantable devices are mostly utilized for the purpose of replacing a function that the body can not realize by itself anymore and in the most recent years with the capability of storing data and responding accordingly [7]. Two examples of such devices are: pacemakers and implantable cardioverter defibrillators.

Another factor that differentiates implants from wearable devices is cost and methodology. Implants are mostly implanted through a clinical process such as surgery, therefore they are considered invasive devices. The benefit this brings is accuracy and response time, and long cost-effectiveness [7].

Implants are by no means perfect, the level they are in today is due to various decades of research. The key difficulties found in implants are:

- Material bio-compatibility, which gold has been found to be one of the most effective materials as well as certain structures of SUS and polymers [8].
- Size.
- Power consumption.

A study by Yoon, H. et al. [8] demonstrated that Continuous Glucose Monitoring (CGM) is feasible and biocompatible, their data acquired through the MiniMed CGM Sensor was found to be more than acceptable within the error spectrum.

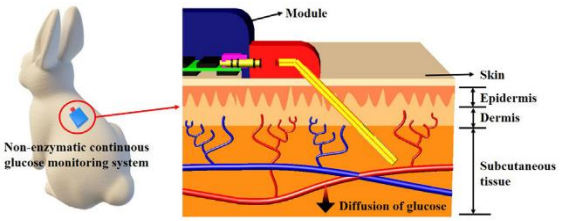

Figure 1 - Continuous Glucose Monitoring System from Wearable, robust, non-enzymatic continuous glucose monitoring system and its in vivo investigation [8].

This is clearly a great advancement for the healthcare field as the information provided by implants through monitoring has become more reliable and the risks taken by patients has diminished.

b. WEARABLE DEVICES

Wearable devices are those with the capability of monitoring physiological signals in real-time while being considered modular o non-invasive to the human body. Similar to implants the monitor glucose, heart rate, or oxygen in blood among many other

signals. The negative aspect of this sensors is that currently there are no wearable in the market capable of reading various physiological signals simultaneously [9]. While it is not recommended due to crosstalking, it's still valuable in specific circumstances.

III. REMOTE HEALTH MONITORING

Health monitoring has many aspects to take into consideration other than how the technology works, it has to consider its user and their right for the information that it's been procured.

a. Controllability and Patients

The ability to self-monitor is important to certain people and this varies in accordance to culture and even the type of disease [10]. Only one factor which seems to agree for patients, caretakes, and doctors is to facilitate the understanding and access of the data to the patient its pertinent to.

Devices such as the "FreeStyle Libre" or "Glucowise" have launched the first steps into addressing these problems. A study by Landau et al. utilizing the FreeStyle Libre showed a more controlled and manageable state of diabetic patients' glucose levels due to the monitoring and response of the device [11]. Although the results demonstrate the value of this technology and self-monitoring devices, practically 17% of their patients stopped utilizing the device due to lack of knowledge of these technologies. This provides a significant better understanding of the relationship between devices, with the same purpose as implants and wearables, and their patients. A better understanding of how their health monitoring functions and the capability of self-monitoring is an important factor for a patient's quality of life.

b. Cost-Effectiveness

Great strides are being done towards lowering the costs of health monitoring technologies. This is reflected in the study done by Harada et al.

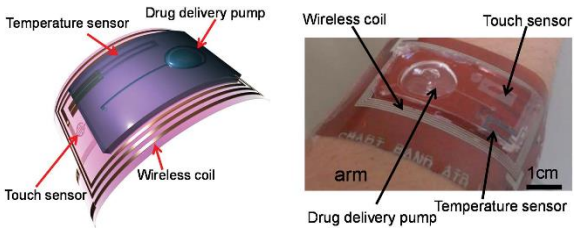

Figure 2 - Smart Bandage concept from Toward Flexible and Wearable Human-Interactive [12]

The Smart Bandage is made out of printable composite for low cost, while being capable of maintaining a temperature sensitivity for it not to affect the readings [12].

With the raising of the Internet of Things (IoT) and the focus shifting into lower cost technologies it was but a matter of time for smart biosensors and IoT to encounter each other and being a flexible material [9].

c. Security and Data Privacy

Laws and regulations are already being considered and implemented by different governmental associations. These rules are modifications and improvements of regulations such as CEN/ISO EN13606-Part IV, which are about patient's records and their rights for disclosure [13].

IV. DISCUSSION AND CONCLUSION

While many improvements are constantly being made for the lowering of costs and compatibility for the devices in health monitoring, there's still a clear conflict between the controllability of users and their protection and use of data. As future situations arise and form a precedence many governmental bodies are improving the data protection of patients in the most ethical manner. Another upcoming factor in the future of health monitoring is the IoT, this can be observed in the most recent terminology in medical care when it comes to networking:

- Wearable and Implanted Body Sensor Network (WIBSN) and
- Wireless Body Area Networks (WBAN) [14].

These networks are the result of the IoT integrating to medical care and health monitoring, as these networks transmit physiological signals in real time for health monitoring.

It can be concluded that the possibility of self-medicating through health monitoring is closer to becoming into a reality [12] and the implementation into the IoT that a market for biosensors and health monitoring devices will be impactful in the future of medical care.

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