

IoT Health care Monitoring and Tracking : A Survey

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Abstract—Hospitals all over the world are moving towards better and more advanced technologies. In the recent times, integration of the Internet of Things with the available medical technologies as well as with patients and their environment has given a new scope for data collection and better decisions. This survey paper focuses on various ways the IoT devices can be used to improve the health of people along with ensuring that there are no mistakes in the process of medication and medicine delivery. Here we have taken many examples of the devices that are being used and which are and can be used in the future for more advanced and secure health care.

Keywords—Internet of Things-IoT, Continuous Glucose Monitoring (CGM), Radio Frequency Identification-RFID, Health Monitoring and Tracking.

I. INTRODUCTION

In Internet of Things, a thing can be a vehicle that has various sensors attached to it in order to make the driver aware of the tire pressure as well as other factors that might affect him/her, an animal which has a transponder with a biochip attached to its body, a person with an implant in his/her heart to monitor the blood flow, or any natural or man-made device that can be assigned with an IP address and has the ability to transmit information over a network. If through a technological perspective it is seen, the Internet of Things has been defined as systems communicating and interacting with each other, resulting into huge amount of data being generated and processed to value added operation that can command as well as control various actions. This makes life quite effortless for humans as well as traditional machines. IoT has tremendous benefits in the observation, communication and application of collected data. IoT not only works in the above fields but can be used broadly in the research area of health care and medical. It is no more a dream but has turned into a huge scope of reality. With the strong evolution of technology in the Internet of Things, an intellectual, accessible, helpful and communicative system will follow the trend in future for development of medical health resources.

II. IOT DEVICES IN HEALTH CARE:

Various technologies have played huge role in the area of Internet of Things, but one of the fastest growing, value adding, easy to access field is the Radio Frequency Identification, popularly known by its abbreviation RFID, uses electromagnetic fields to identify automatically and to track tags (containing information in an electronically-stored medium) attached to objects. The following described in the

paper[1] has focused mainly on the RFID perspective of the Internet of Things along with other prospects.

Internet of Things in Medical Science

With the advancement of computers and information technology, there has been significant rise in the use and development of electronic devices in medical sciences, and with the unfolding of IoTs, the medical IoT has slowly but steadily penetrated itself into lives of individuals. The medical Internet of Things has been seen as a way in which technology has helped in embedding wireless sensors in medical equipments which then gets combined with the world wide web and interacts with patients, hospitals and medical equipments to make use of the new development in the model of modern medical.

In the area of health care and medical science, some of the main applications of the Internet of Things includes technological advancement in medical control of medications and equipments, telemedicine and mobile health care along with personal medical management, health data management, which can further be explained as:

A. Control of Medication and Medical Equipment

With the help of visualisation of the development of material management, we can monitor production, delivery, tracing and anti-counterfeit of medical equipments and medications. Some of the aspects of the application of the IoT in the scanning and management of medications and medical equipments include:

- Continuous Real-time Monitoring - In medical system round the clock monitoring can be done using RFID tags. Especially, in the case where packing of medicines are automated, readers instated in the manufacture line spontaneously recognises the data of all medicines and transfer it to the memory. These readers are able to store all relevant data in the processes and can take up all-round monitoring at any time during circulation. This can also be done for storage environment. This helps with tracing back the flawed medicines when medication quality problems occur, according to their names, origins, category, batches, delivery, processing, sales, storage and some related information.
- The Anti-counterfeit of Medication and Medical Instruments - Tags with RFID, that contain identity, attached on the products are unique and difficult to duplicate, because

of this we can easily enquire about the information of the product, in order to identify counterfeit products.

- Information Management of Medical Refuse - A hospital garbage information system can be made, that will be able to trace the medical refuse with the help of RFID tags. During the complete mechanism of transportation from medical institutions to waste processing factories, illegal dumping of hospital waste can be avoided.

B. Information Management in Hospitals

At the present scenario, the desire of medical information and the need of management from hospitals mostly includes identification details of doctors as well as patients, of medical equipment, medical records, medication or chemicals in order identify the ailment or symptoms, etc. Some specific usage involves these below mentioned features.

- Management of Data of Patients - A patient's medical examination, medical history, treatment record and drug allergy, etc., may help doctors to work out therapy proposals; at the same time, physicians and nurses can constantly monitor a patient's vital symptoms and tests and treatments to avoid any use of wrong medications and injections.
- Emergency Management - Efficient and reliable data storage and examination processes of technology involving RFID, under a circumstance in which too many wounded patients are present, or patients currently in serious conditions, helps doctors to quickly identify a patient, along with phone number, blood type, medical history, their relatives and finish the initial work by saving precious time during emergency treatment.
- Management of Storage - The examination and storage of medication can make use of RFID technology, by simplifying manual records, prevent scarce supplies of medicines, and also to stay away from the confusions of synonymous medicine names, portion to be taken with dosages, strengthening management of medication and safeguarding in-time provision of medication.
- Blood Statistics Management - The technology involving RFID used in applications to manage blood, that can help in avoiding the shortcomings of the use of bar codes and increases untouched evaluation to decrease contamination of blood and will make it possible for multiple target recognition and efficiency of collection of data.
- Preventing of Error in Pharmaceuticals - With the construction of preventing error procedure in the processes involved in dispensing medications we can confirm the type of the medications along with dosage which the patients have taken. We can collect its batch number and the flow of the medicines etc. to ensure the patient's good health.
- Anti-theft in Neonatal System - In this system there is a combination of the neonatal anti-theft management, identity management and access of passageway for protection for babies.

C. Movable Medical Supervision and Telemedicine

A service with the name of Telemedicine in medical, with the help of combination of technology involving computers, medical and communications is aimed at improving the diagnosis and reducing health care cost, meeting with the need

of people's health simultaneously constructing a patient centred system for carrying out consultation remotely and monitoring continuously critical patients. With time Monitoring of Telemedicine has gradually improved from only focusing on upgrading people's life- style to issuing life-saving knowledge and on-time acquisition of medical programs.

D. Management of Health

It is a process where the main aim is preventing and controlling the appearance and spread of diseases, reducing hospital costs, and improving quality of life.

Remote patient monitoring nodes are implantable sensory nodes that transmits signals regarding an abnormal readout by tracking biometrics for a patient. If a patient is not taking timely medications, the nodes can place an emergency call to contacts from a list or can communicate with a monitoring station or speedily provides other assistance in situation of emergence.

III. FORMS OF E-HEALTH USED CURRENTLY:

- Electronic Health Record (EHR)-electronically comprehensive report of patient's health on an overall basis, making available the required information to the patient [2]
 - Electronic Medical Record (EMR)-digitally created report from a particular practice [3]
 - Personal Health Record (PHR)-private, secured, and confidential environment to keep the patient's health related information [4]
 - Virtual decision support and healthcare teams-corroborating, exchanging and working teams of healthcare professionals who with the help of digital equipment gather information on patient aiming to make better decisions with the enhancement of knowledge[5, 6]
 - E-prescribing-with the help of this technological framework the health care institution can directly write and send prescription electronically to the pharmacy [2]
 - E-appointments-scheduling and fixing appointments for any health care institution can be made faster and easier as well as reducing waiting time for the patients in this online service [7]
 - M-health (mobile health)—health practices through mobile devices and other wire- less devices[4, 8]
 - Telemedicine and Telehealth — the ICT(Information and Communication Technology) based delivering of healthcare data and services remotely to various diseased persons[9, 10, 11, 12,13]
- These are some vital digital health technologies that make data encompassing, storage, transfer, retrieval and processing the health-related data easier. It improves interaction between healthcare professionals and patients and helps in monitoring various biological and physiological parameters, and ensures distant medical timely treatments.[14]

IV. DEVICES IN THE MARKET

- Marketing and business industries move towards the direction where maximum profit can be gained. As more and more people are becoming conscious about their own well being the devices being used for health monitoring and care

are becoming prominent at a rapid pace. In the research work detailed in [15] some of the following devices has been mentioned.

- **HEARTFAID** is aimed at developing an innovative platform of service for improving initial detection of diseases and effectively manage heart diseases in elderly population. Its creative computerised system helps in improving the processes like diagnosis, prognosis and therapy provision, providing the following services like EHR, tele-monitoring, signal and image processing, clinically supporting in making decision in the domain of heart disease, which is focused on pattern recognition in previously collected data, its analysis and determining interference in it.

- **ALARM-NET** - It sees through the integration of heterogeneous devices, wearables as well as devices placed inside the living space. Collecting, combining, pre-processing, storing, and acting upon data is done according to a set of system requirements.

- **CAALYX** - Complete Ambient Assisted Living Experiment, is a wearable device that is light weight and helps to detect whether an old person has fallen down and if so their location. It then automatically communicates in real-time with their care taker immediately and informs about his/her location, thus increasing self-confidence in the older people.

- **TeleCARE** - It is a framework of solutions for tele-supervision and tele-assistance for the elderly. The technological approach is based on integrations of the multi-agents and the federated information management paradigms, giving rise to a distributed cooperative network support infrastructure.

- **CHRONIC** - Integration of the advancement in information and technology for the treatment of diseases that are chronic.

- **MyHeart** - Acts as a way for handling cardiovascular diseases services offered by smart electronics. It has been designed for educating professionals theoretically with the use of multiple components regarding hypertension and self-management (e.g. BP monitoring) in young adults. It also can be used for studying by other young adults.

- **OLDES** - Based on virtual health provision for the elderly by the use of internet and digital technology. The intervention relishes on the concept of 'co-production', using an innovative low-cost technology.

- **SAPHIRE** - A clinical decision support system that helps with the monitoring of patients based on clinical data and principles. It is carried out by two pilot application: first is monitoring hospitalised patients at their bedside and second is monitoring them at home for those who have been rehabilitated after a revascularization therapy.

- **MobiHEALTH** - Continuous online monitoring of crucial symptoms via Universal Mobile Telecommunications System) and GPRS (General Packet Radio Service) technologies and on a BAN (body area network) and utilising next generation public wireless sensory networks that helps in providing tele-monitoring and tele-treatment. This system has developed manifold to provide incorporation of various

medically used sensors via wireless connections. It transmits measured symptoms to doctors and real-time feedback to the patients.

- **SAPHE** - Growth of market for sensors has given scope for developing small wireless body sensors and sensors that can be integrated inside homes. These allow for unobtrusive and intelligent continuous health monitoring via tele-care networks

- **DITIS** - It is a mechanism that provides help to dynamic Virtual Collaborative HealthCare Teams that handles healthcare remotely from home. Virtual medical teams make use of its dynamic creation, co-ordination and management, for continuously treating patients at home, and visits at certain intervals to the hospital for treatments.

- **AXARM - Multiple Sclerosis (MS)** is a neurodegenerative disease (ND) that can create visible exhaustion in sufferer by just going to the clinic for rehabilitation or timely check ups. This tool allows the staff of the hospital to remotely carry on patient consultations and actions from their suitable location, minimising the displacements to hospitals. AXARM consists of a hybrid P2P architecture and has a cross-platform videoconference system, having audio/video recording abilities.

- **VirtualECare** - This can be enabled to monitor, interact and serve the patients, who are, frequently, in need of care services, and therefore is considered to be an intellectual multi-agent device.

- **Sen.se Mother** - Mother is composed of incredibly smart sensors that can act as drones over whatever you care about. It is like one solution for tens of device driven functionality. These sensors are called Motion Cookies which are slick and small so that they can be affixed to almost anything. Using Smart Motion Technology™ they detect and analyse the movements done in every activity. It helps in keeping track of the count of steps taken by a person during his/her daily schedule-going for a walk, going to work, running, shopping and hiking. Displays your coffee consumption data at all times. Based on the reception or loss of the Cookie's signal Mother will get alerts of each person's incomings and outgoings. Detects real teeth brushings and measures their duration and sends an optional notifications when someone forgets to brush. Monitors any unusual activity in the accessibility of home/door. Monitors regularity of medicine intake. It not only can monitor sleep cycle but also the temperature, activity habits, drinking habits etc.[16]

Some other examples of IoT devising use of IoT health care devices that includes personal health, fitness management and care for babies and the old people[17].

A. IOT Medical Devices

Timely medication is a necessity to get rid of or control any kinds of diseases. We sometimes forget to take/give pills being busy in our hectic schedules. Some of the Internet of things medical and healthcare devices which aims at better health and sets a reminder for our medications with their smart and connected technology.

- **AdhereTech** smart wireless pill bottles

Pharmaceuticals and research engagements use smart bottles that can collect and send all the data related to patient health in real time automatically with the help of a system which analyses and populates the information sent and stores it in a secured database. With these smart bottles patients can get connected with doses, treatment etc and gets notifications via text messages or calls in case he/she forgets.

- **GlowCaps–Vitality** GlowCaps medication adherence solutions

GlowCaps frees people from tracking scheduled medications. GLOWCaps are smart IoT devices in health care that fits within all prescribed bottles and notifies when it's time to take medication with its light and sound system.

B. Wearable Healthcare Gadgets

Wearable device not only tracks daily work out but works like a medication device which sets a reminder to take medications, trace blood pressure, go for a walk or any other activity to improve health care. Some of the wearable health care IoT devices are:

- **Smart Watch** - Lets us compute accurately the heart beat safely with its smart pulse technology and built-in optical sensors. It gives a perfect calculation of exercises performed and number of calories burnt on a daily basis with the data that it collects from heart beats.
- **Intelligent Asthma Management** - Automated Device For Asthma Monitoring And Management or ADAMM is again a wearable technology that helps in providing a complete solution for monitoring and managing in circumstances of Asthma. Tracking and journaling of treatment plan, and information on treatments of the observed symptoms are displayed. It has an app which lets a patient get real time data of monitoring Asthma.
- **Quell Relief** - Quell Relief is a technology in medical and health care which correlates most favourable stimulation levels so that the subject receives optimum relief. It is a smart internet of things healthcare device which knows what levels of stimulations are needed during the day and delivers it to the person and it will adjust to appropriate levels at night. It can sense when the person is sleeping and automatically alters to night therapy.
- **Smart Contact Lenses by Google** - Google is hugely fascinated about the Internet of things and its smart device 'Google Smart Contact Lenses' helps detect diabetes in various kinds of patients. It is mechanised in a way that it takes a drop of tear and calculates the presence of Glucose levels. It is engineered to restore the autofocus naturally of the eyes.

Leaf Healthcare Ulcer Sensor

Leaf Health Ulcer Sensor is an addition to healthcare devices which alerts a person when it is time to move in order to eradicate no moving time. Scientists believe that constant sitting at a place for a long time may be a cause for Ulcer. With its triaxial accelerometer this IoT device can sense positions and can assist in proper turns resulting in good health.

Real time ICU monitoring type devices present themselves as huge solutions in IoT industry. There are various connected IoT devices that wirelessly monitor ultrasound and vital signs

of diseases. Wearable devices improve the emergency treatment just with a push button.

More examples that may help the upcoming decades to see an uprising in diagnosis and treatment of diseases, as the Internet of Things is being fetched to carry on the available medications[18].

- **OpenAPS(closed-loop insulin delivery)** - It makes use of continuous glucose monitor(CGM)'s data feed and a microcomputer(Raspberry Pi). The loop is completed by the software and according to requirement changes the quantity of insulin that the pump can deliver.
- **For developing connected systems** that makes use of a sensor implanted below the skin of the patient for 90 days to help diabetes sufferers with allotment rights for an implantable long-term device called continuous glucose monitoring (CGM), an initiative was taken in 2016, . The sensor's networks has a smart transmit tech. dispatches information regarding the levels of blood glucose to some app on the patient's mobile.
- **Activity trackers during cancer treatment** - The cancer centre MSK(Memorial Sloan Kettering) and Medidata's cloud research company that are working on tests that make use of action trackers to gather data regarding the lifestyle of patients who are being attended to for multiple myeloma. These patients can sport an action tracker for one week before their treatment and then consecutively in upcoming months in case of several treatments. These trackers will help in recording fatigue and action levels, along with food intake and capacity, and all these data is preserved to Patient Cloud ePRO app owned by Medidata on the patient's smartphones. By using these wholesome unstructured data gathered on a daily basis via wearables or an app is figured out to be a fair way by which the therapy and diagnosis can be boosted for different conditions. Technology involved here can work extensively for a disease like cancer, where the response to treatment plays crucial and determinant role in advising the right kind of medication and therapy.
- **Inhalers that are connected** - The basic and important use for Internet of Things technology in health care is widely to make sure that there is adherence. Adding sensors to delivery systems or medicines allows doctors and health care personals to continually keep precise tracks of whether a patient is following his/her medical plan or not. These devices interconnected to some specific mobile apps allow patients to receive reminders and also for checking adherence. A company named Novartis is undertaking inhaler research that are connected with both Propeller Health & Qualcomm, by developing inhalers of different kinds for Chronic Obstructive Pulmonary Disease (COPD). Again Propeller's Breezhaler tool tethers to a defined digital framework through sensors simultaneously passively records and transmits useful data.
- **Ingestible sensors** - The World Health Organisation conducted a study in 2003, which showed more than 50% of medications are not taken as directed by the physicians. In order to reduce this figure Proteus Digestive Health has designed pills that dissolve with acids in stomach and gives rise to a tiny signal that can be collected by a device sported on human body, that then conveys the information to a mobile app.

- Depression-fighting Apple Watch app - Takeda with a 30-patient trial, by collecting both passive and active data, is experimenting to assist patients with MDD (major depressive disorder) by using an Apple Watch app. Developed alongside Cambridge Cognition, this app monitors and evaluates cognitive functions, accompanied by the test set in order to inspect how the designed app collates with self-assessment and traditional trial by taking quizzes which analyse and report mood and cognition.

- Coagulation testing - A Bluetooth-enabled system was launched in 2016 by Roche that enabled customers to examine how steadily their blood clots occur. The coagulation determining device is one of the first-ever produced machine for anti-coagulated sufferers, helps patients to test on their own to remain within their healing span and lower the danger of bleeding or any kinds of strokes, which therefore results into less visits to the clinics.

- Arthritis (Apple's ResearchKit) - ResearchKit software platform used by GSK for its Parade app for iPhone integrates with iPhone's Health platform, collects and tracks common signs of rheumatoid, along with activities and other quality-of-life computations.

- Parkinson's - Pfizer intends to develop a system that aims to detect the progress and therapy of Parkinson's by 2019, during the entrance of one of its experimental phase III drug development.

Some more of the medical IoT systems proposed are:

- E-health systems collect ECG's signal from many different distant places where the patients reside using medically advanced sensors. The system consists principally of components like patient's path finder, ECG accession, patient's data administration and hospital's reminder governance[19].

- The Smart Chair is an IoT design that's based on telemedicine monitoring device. The Smart Chair consists of hardware and sensors that need to detect the crucial medical features of a human body attached to it. It allows the person to sit with a relaxing position while the accession of physiological waves extracted from different sensors fastened to their body. Basic signals obtained from these sensors has to be collected and operated digitally with the help of an onboard micro-controller and analysed for any aberration in the fitness factors of that particular patient according to medical records. As the data is sent to cloud it can be seen at any time afterwards by a doctor or patient present in any geo-location on a device connected to the Internet[20].

- An approach based on IoT for visualising relative humidity and temperature for product preservation in medical environment or pharmaceuticals along with architecture capable of automatically sensing the change in environmental conditions and giving the user with remote monitoring facility on a real-time basis[21]. Apart from all these devices there are numerous motion tracking devices like MotionNode Bus, Opal, MTw development kit, Memsense W2, STT-IBS, Colibri wireless, 12M Motion SXT, Shimmer3, Physilog and wearable smart devices like Fitbit Flex, Withings Pulse, Misfit Shine, Jawbone Up24 etc.

V.

CONCLUSION

An Internet of Things is nothing but an integration of sensors attached to various objects with the Internet in order to provide data to the Internet along with using the already available data from the Internet. This to and fro relationship can extensively be used for the betterment of human health. The various devices explained above (which are available) are helping every individual in maintaining his/her physical well being. Early detection of any issues in the human body has been made quite easy. The main aim of this work was to give a comprehensive view of IoT usage in medical health and to report the extensive range of gadgets and tools available as well as proposed. In this survey paper, we have given priority to both research works and commercial devices to study and investigate the currently available and future technologies.

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