International Journal of Scientific & Engineering Research Volume 12, Issue 4, April-2021
ISSN 2229-5518

Internet of Things in Healthcare and Medical Science

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***Abstract* - In the current era, there is a requirement of a system with connected devices, persons, time, places and networks, which is completely incorporated in what is called as Internet of Things (IoT). IoT has been implemented in various domains such as agriculture, healthcare, industries, home automation, environment monitoring, smart tourism, etc. IoT has been implemented in the field of healthcare with various applications leading to the introduction of new technologies like Radio Frequency Identification (RFID), sensors, Nano-technology and many more. Internet of Things has become the ultimate building blocks in the development of healthcare monitoring system. The aim of an efficient IoT healthcare system is to provide real time remote monitoring of patient health condition, to prevent the critical patient conditions and to improve the quality of life through smart IoT surroundings. New challenges have been introduced with IoT for the security of systems and processes and also with the privacy issues of person's medical data. There are some of the challenges that IoT can help to solve: break geographic barriers, providing rapid clinical responses, medical consultation and communication links of medical images and video data. A unique ontology for all things among IoT-based healthcare. There are a lot of applications in the healthcare field, including the possibility of using smartphone capabilities as a platform for monitoring of medical parameters that advise patients of medical issues. Moreover, it would lead to a great development in the field of healthcare. In this project report, we have proposed a methodology to track the intake of medicine for Tuberculosis (Tb) patients using an IoT device.**

***Keywords* –'Internet of Things (IoT)', 'RFID', 'Healthcare', 'Nano-technology', '99DOTS', 'Tuberculosis'.**

I. INTRODUCTION

In current situation, understanding checking takes delayed time. Consolidation of IoT framework in medical care makes proficient for quiet checking. Use of IoT empowered patient observing framework makes more intelligent and tedious.

Presently days, IoT empowered sensors makes checking simpler and unavoidable. This prompts sound, safe observing and it are regularly accomplished effectively with the help of IoT empowered gadget. Both consistent and far off checking framework are regularly acted in patient medical care observing framework. such a network is performed with the help of actuators, portable specialized gadgets and sensors are alluded to as Internet of Things and clinical gadgets (IoT-MD) is on the change field in the medical services space. This availability makes dynamic support of specialist and patients which brings about speedy data for diagnosing the wellbeing related issues inside the brilliant method of preparing the further treatment.
For instance, during this we may additionally look at 99DOTS (Directly Observed Treatment, Short course) which might be a minimal effort, cell phone-based innovation that licenses continuous distant checking of every day admission of treatment, first presented by the Revised National Tuberculosis Program under the public program in 2015 in high-trouble antiretroviral treatment (ART) focuses. This undertaking was dispatched for the essential time in 2016 in Rajkot area, Gujarat, India, and henceforth this was an endeavor to guage 99DOTS.

II. LITERATURE SURVEY

Internet of Things (IoT) and cloud computing plays a vital role in today's Tele-monitoring health system. Advanced technologies in IoT such us cloud computing, big data, grid computing, soft computing, etc., can be used in handling connected devices for monitoring and guiding patients health. Blood pressure and body temperature monitoring, electrocardiogram monitoring, wheel chair management, glucose level sensing, emergency healthcare can be provided through connected devices anywhere in the world. In 2013, Andrews Cross and William Thies of Microsoft Research India proposed a model named as "99DOTS". The main aim of 99DOTS model was to ensure that the patients take their medication regularly without missing any doses. The project 99DOTS has been started by the RNTCP especially for Human Immunodeficiency Virus (HIV) associated TB patients. The patients especially the HIV associated TB patients because of their weak immunity cannot travel to long distances for taking their medication so an initiative was taken for them. The initiative ensured that the patients would be able to take their medication sitting at their homes only without travelling to long distances.

The specialized healthcare monitoring system for elderly people is a growing need in the aging population world. Owing to costlier healthcare and long waiting time in hospitals, the concept of in-home patient monitoring system have been emerging in the recent years. This system collects data of various body parameters through Biosensors, wearable devices and smart textiles and it transmits the data to central node server securely through Cipher text Policy Attribute Based Encryption (CP-ABE) method. In turn, the server shares the collected data to the hospitals for further treatment. The server rings alarm to the ambulance [3] during emergency situation. It is very beneficial for elders and chronic patients who require continuous monitoring.

From the reviews, devices like Warfarin, Wearables, automated wheel chair, wireless transmitters and receivers, Kit, Etc., can be highlighted. This paper proposes the IoT technologies used for remote monitoring healthcare, challenges and obstacles faced by IoT.

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III. PROBLEM FORMULATION

The Internet of Things (IoT) has substantially changed health care in a relatively short time. For example, connected devices allow older people to age in place safely for as long as possible. They help doctors confer with specialists across the world about complex cases, and they monitor patients' chronic diseases between office visits.

Nonetheless, any advance in technology brings with it challenges to be overcome. However, 2017 research from Cisco, painted a less-than-glamorous picture of IoT transformation efforts. The research involved getting feedback from more than 1,800 people across the US, UK, and India, who were stakeholders in past or ongoing IoT initiatives. Cisco's survey revealed that finished projects were only considered successful 26 percent of the time. Additionally, about one-third of respondents deemed their finished projects unsuccessful. Most projects—60 percent—encounter trouble at the proof-of-concept stage or shortly thereafter. The advancements are indeed impressive, but one of many challenges associated with all of them is the amount of data generated. The vast possibilities for using IoT devices in health care also present concerning vulnerabilities. As device use rises, so does the number of ways hackers could infiltrate the system and mine for the most valuable data.

According to research from Aruba Networks, the most common use of IoT technology in health care is to apply it to patient monitoring systems. It's undoubtedly handy to take that approach, but something health organizations often forget is that unlike websites, for example, those devices typically cannot go through planned periods of downtime. Instead, updates have to occur continuously as people use the monitoring devices.

IV. METHODS

Ethics committees at the National Institute for Research in TB, the Brigham and Women's Hospital, and Tufts University approved this protocol. To enroll a geographically diverse cohort, from August 2017 to February 2019, we sequentially enrolled and visited patients with drug-susceptible TB from 11 clinics in Mumbai (none of whom were PLHIV) and 5 clinics in Chennai and Vellore (all of whom were PLHIV). Patients were enrolled at different times in the treatment course, during treatment initiation or medication refill visits. We aimed to achieve representation of home visits across the first 2 months (intensive phase) and last 4 or more months (continuation phase) of therapy, since adherence and 99DOTS engagement may wane with clinical improvement. At enrollment, we collected informed consent for a baseline questionnaire and future unannounced home visit. Patients became eligible for a home visit 3 weeks after enrollment to minimize short-term changes in 99DOTS engagement (i.e., calling) or adherence from anticipation of the visit. The exact day of the visit was selected using a random number generator. During home visits, researchers administered a questionnaire and collected the patient's urine sample for testing using the IsoScreen test (Supplementary Appendix). Mixing urine with IsoScreen reagents results in a color change if isoniazid is in the sample; we classified such patients as "adherent per urine testing." Samples without color change were classified as "nonadherent per urine testing." Isoniazid is detectable in urine in nearly all patients 6–48 hours after ingestion and undetectable in nearly all patients > 72 hours after ingestion [5, 6]. However, urine isoniazid test results < 6 hours and 48–72 hours after ingestion are variable (the "gray zone") [5, 6]. We excluded from analysis test results for patients whose 99DOTS record only reported doses taken within "gray zone" timings, without doses reported 6–48 hours before the home visit. This resulted in exclusion of 8% of test results. Patients whose 99DOTS record reported at least 1 dose taken 6–48 hours before the home visit were classified as "adherent per 99DOTS." Patients whose 99DOTS record reported that the last dose was taken > 72 hours before the visit were classified as "nonadherent per 99DOTS." In addition to patient-reported doses (via phone calls), 99DOTS allows HCPs to report doses, which they do after calling patients to assess their adherence. We analyzed 99DOTS' operating characteristics using only patient-reported doses and including both patient- and HCP-reported doses. We estimated 99DOTS' sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy for measuring adherence by comparing the 99DOTS record to urine isoniazid test results as the more rigorous biomarker-based comparator. We stratified findings by specific subgroups (e.g., PLHIV vs non-PLHIV). We used the χ 2 test to assess differences in prevalence of medication adherence and 99DOTS operating characteristics between subgroups. We used McNemar test to assess differences in 99DOTS accuracy using patient-reported doses alone vs patient- and HCP-reported doses.

V. COMPARATIVE ANALYSIS

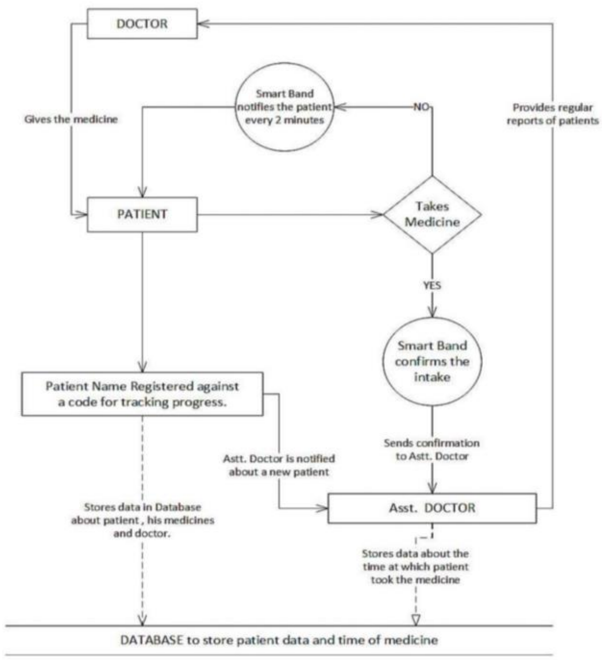
In this study, medication adherence was relatively high, including among previously treated patients and in the continuation phase—subgroups for whom adherence is often assumed to be suboptimal. However, we likely overestimate daily adherence, given that the urine test is positive for most doses taken in the prior 48 hours. Also, posttreatment disease recurrence may increase even with mild nonadherence (≥ 10% of doses missed) .Our findings therefore highlight the need to further improve adherence in this population, especially for PLHIV.99DOTS engagement was consistently lower than adherence measured by the urine test—reflected in 99DOTS' suboptimal sensitivity—particularly for PLHIV and in the continuation phase. As such, HCPs may face major challenges in using 99DOTS to identify nonadherence. 99DOTS' low NPV suggests that HCPs have to reach out to about 10 patients reported as being nonadherent by 99DOTS to identify 2 patients who are actually not taking medications. Levels of patient engagement with 99DOTS in our study are similar to findings from the broader 99DOTS rollout to > 20 000 patients in Mumbai. Higher 99DOTS engagement has been reported elsewhere; however, lack of an objective adherence measure and methodological differences make comparison with our study difficult. Prior studies suggest that suboptimal engagement with DATs is context dependent. For example, TB patients monitored using 2-way text messaging (SMS) in Pakistan and individuals taking human immunodeficiency virus (HIV) preexposure prophylaxis monitored using electronic pillboxes in the United States . both underreported adherence for different reasons, such as technology fatigue or concern about the pillbox's conspicuous appearance, respectively. 99DOTS' low specificity also indicates suboptimal benefits for identifying nonadherent patients. When using only patient reported doses, 99DOTS missed identifying about 4 of 10 patients who were not taking medications, presumably because these patients called 99DOTS without ingesting doses. While other operating characteristics improved when HCP-reported doses were included, specificity decreased further, such that 99DOTS missed identifying 6 of 10 patients who were not taking medications. This finding may reflect patient hesitation to admit nonadherence when contacted by HCPs (i.e., socially desirable responses).

Our study has important limitations. Because we achieved representation of home visits across the treatment course, our reported prevalence of adherence is roughly representative of adherence throughout therapy in the overall patient population. However, because we conducted a single home visit for each patient, our study was not designed to evaluate adherence throughout therapy for individual patients. Also, 22% of eligible patients did not enroll in our study or were not found despite multiple home visits. Enrolled participants may have been more motivated to engage with TB care. 99DOTS engagement and adherence may therefore be higher in our participants than in the broader patient population. Forthcoming qualitative study findings will shed further light on patient engagement with 99DOTS. Future analyses should explore patient characteristics associated with adherence and 99DOTS engagement. Despite its suboptimal accuracy, 99DOTS may still improve adherence or treatment outcomes via other pathways, such as facilitating habit formation in pill taking, Rigorous trials are needed to assess 99DOTS' impact on these outcomes.

In summary, we found suboptimal accuracy of 99DOTS for measuring TB medication adherence in a multisite cohort study. Our study highlights benefits of urine isoniazid testing for understanding adherence and assessing the accuracy of DATs, especially given growing interest in these technologies [2, 3]. Our findings raise concerns about India's large-scale 99DOTS deployment and highlight urgent need for high-quality studies regarding its impact on treatment outcomes, especially given that a recent study found that HIV clinics implementing 99DOTS had higher unsuccessful TB treatment outcomes than clinics that had not [11]. Our findings highlight a need to strengthen 99DOTS' implementation, with ongoing evaluation of whether its accuracy—and value for monitoring adherence—can be improved, or whether alternative strategies such as testing for urine isoniazid or other biomarkers should be studied for routine monitoring of medication adherence.

VI. METHODOLOGY PROPOSED

In the 99DOTS project the number was revealed only if the pill was dispensed but it does not give any assurance whether the pill was taken by the patient or not. What if the patient dispenses the pill and threw it off. This problem can be solved by a neck band which can sense the shape and the weight of pill. If it is swallowed by the patient, it can notify it to the nearest health center to make sure that the patient has taken the pill. The neck bands can be given to the patients along with the medicines and they could be asked to wear it around their neck while taking the medicine. These neck bands will be solar powered and will contain amicro X Ray emitter and a digital chromatographic film on the other side, so as to identify the shape and size of the medicine taken. The image captured by the film would be compared with the shape and size of the original medicine as already stored in the memory of the IoT device. Global Positioning System (GPS) technology connected to the internet can be used to send the confirmation to the doctor confirming the intake of medicine by the patient.



From this figure, we could clearly identify that according to the proposed methodology, Doctor gives the medicine to the patient. The patient is then registered against a code for tracking purpose. After the patient is registered the assistant doctor is notified about a new patient and all the details of the patient are stored in the database. If the patient intakes the medicine the smart band confirms the intake of medicine and sends confirmation to the assistant doctor. The assistant doctor is then notified and the details of intake are stored in the database. If the patient has not taken the medicine the smart band sends a notification to the patient after every 2 minutes. The assistant doctor provides regular reports of the patients to the doctor. The use of neck band will not only confirm the medicine being taken but also confirm the true time of the medicine being taken by the patient. Whereas, in earlier case we just knew the time at which the patient dispensed the medicine from the envelope.

VII. CONCLUSION

By going through various research papers we found that an initiative was taken for HIV associated TB patients in 2013 named as "99DOTS". In this technique medication for one month is given to the patients and each time they have to call on a number when they dispense the pill. Also we came to know that the model has a high success rate of about 99%. But we identified that this model does not give any assurance whether the pill was taken by the patient or not. Patients can even throw the pill after dispensing it off. For this problem, we found that a neck band can be made which will sense the shape and weight of the medicine. A notification would be sent to the nearest health center if it is swallowed by the patient. Further many researchers have estimated that IoT in the field of healthcare will rise exponentially in the next 5 years. Moreover, each organization would be using IoT devices to treat their patients and maintain information about the patients as well as the diseases. Also, many research

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scholars have estimated that IoT will develop healthcare to an extent that there would be no disease that cannot be cured.

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