

# Smart IoT based Wearables and Care-Kit as enhancers for Effective Remote Care Service Delivery: A Case-based study in post COVID-19 Perspective of Healthcare 4.0

Samyadip Chakraborty

Department of Operation & IT

ICFAI Business School (IBS), ICFAI Foundation For Higher Education (IFHE) University

Hyderabad, India

samyadip@ibsindia.org

## Abstract –

Covid-19 pandemic has completely transformed the way care service delivery front works making a 360 degree operational change from under traditional norms. The advent and adoption of cloud technology with IoT-enabled smart platform devices have largely changed the remote care delivery regime, which has evolved into an effective and efficient digitized platform under new normal constraints. This study in the backdrop of Covid-19 digital care transformation era, using primary case based analysis approach proposes and establishes a working model of remote care delivery and patient analytics; highlighting how the IoT-enabled devices adoption and care-kit devices application, entangled through a cloud-based digital integration platform. This study through simplistic analysis of extant literature, complemented by real-time case-lets in Indian healthcare context proposes a model with a set of propositions, which waits to be converted into testable hypotheses and validated through large scale empirical analysis. The model proposes and highlights that adoption of Internet of things (IoT)- enabled wearables/devices and application of non-IoT digital care-kits fosters the integration in the digital platform which is complemented by cloud-enabled platforms and effectively leads to efficient remote care service delivery, monitoring and patient care analytics; aimed at better care service delivery promises.

**Keywords:** IoT wearables, Cloud platform, Remote monitoring, Healthcare, Patient Care Analytics.

## I. INTRODUCTION

The World Health Organization (WHO) announced the Novel Coronavirus-19 (COVID - 19) as a pandemic on March 11, 2020[1]. The abrupt dawn of the new year of 2020 turned out to be a difficult moment in the global health market. As time

progressed, the dread and fear of SARS-COV-19 did grow. COVID-19 fear and pandemic crisis spread through the general public like wild fire, via print media, electronic media, social networks, journals, tweets and awareness drives, both propagating apprehension among people. With almost regular rising number of COVID patients, the overwhelming task was falling on health institutions from one corner of the world to the other. Throughout South Asian Association for Regional Cooperation (SAARC) nations have vowed to take all cooperative steps appropriate for tackling the situation with regards to covid-19 and other different types of communicable diseases.

As an immediate effect of covid-19, health systems' capacity has been decreased as hospitals are flooded with patients and medical; staffs including doctors, nurses, ward boys, administrative staffs were working day and night and restlessly to treat the patients infected with virus. with the observation of higher loads on healthcare system and unavailability of beds in hospitals, government decided to treat the covid patients while they are quarantined at their home by using modernized healthcare technologies like IoT devices, mHealth devices and other measurement devices. It is not advisable for patients to visit the hospital for just a consultation purposes as hospital became the big bed of covid-19 infections. Some of the giant hospitals has started the practices of online appointment booking with the consultant physicians for the daily healthcare needs of patients and some hospital launched online preventive healthcare program [2].

The issue was overloaded patients infected with covid-19 to the hospitals and to take care of them. For present healthcare infrastructure, it was not possible to take care of all the covid-19 positive patients in hospitals and they needed to be taken care while they are in home quarantine[3]. Some of the hospitals have launched covid-19 packages, in which during the registration itself, hospital ensures that patients will get pulmo-oximeter, electronic spigmo manometer and electronic thermometers along with the crucial medicines to the patients'

home [4]. Everyday, doctor connects to the patients on video call and take the notes of the vital and describe the patients about their health conditions[5]. These initiatives have decreased burden on healthcare system.

#### A. Objective of the study

With the help of case-based methodology the research tries to study the IoT enabled, smart healthcare products and other systems which are given to the patient as their covid-19 kit, and how these instruments help the healthcare provider to take care of patient effectively.

## II. LITERATURE STUDY

### A. Temporal Displacement of Care

Effective and vital data can be obtained from patients, which can be analyzed and converted into the decision by involving the state-of-the-art technology in healthcare (e. g. IoT, Digi tech and wearable devices). This replaces the time spent by medical practitioners and patients and controls the associated delays in healthcare provision called "temporary displacement of care." Better patient conditions can be accomplished with lower prices by the temporal changing of treatment [6]. An company may generate value in real time by evaluating data when action is taken [7]. The theoretical perspective is used by care providers treating chronic diseases (diabetes, CKDs, hypertension and other cardiac disorders).

In this scenario, the idea is to change the time and place of patient-physician interaction from a physical space to a virtual mode. When patient and physicians are interacting through digital technology, patient does not have to go to the hospital. However, with the modernized instruments like IoT band / wearables, oximeter and spigmo manometer all the important vitals can be shared with the doctor and automatically or manually stored on the cloud through mHealth apps.

### B. Adoption of wearable devices

Due to the usefulness of wireless technologies, healthcare value of wireless technologies has been recognized, and research on IoT and wearable devices are on the rise. Several research studies have been carried out using TAP, TAM, TPB and UTAUT. In the models and research papers about health monitoring by means of wearable electronic gadgets, the reasons for adoption has been shown [8]–[11]. Further, in line with developments, the idea of wearable medical devices has taken the so-called paradigm shift. Wearables and care devices adoption in the modern context has lost its focus on convenience of usage as well as its relevance in care delivery and accessibility. Wearables, such as *temperature sensors, oxygen levels, and sensors are* IoMT (Internet of Medical Things) driven, connected diagnosis platform, enabling enhanced focus towards utility driven acceptance and adoption. An extensive literature exists on trust and committed literature of key healthcare users (provider, technology platform, and physician) as crucial and essential[12].

### C. Adoption of non-IoT enabled electronic devices

Apart from the adoption of sensor enabled IoT based wearable devices, covid-19 enhanced adoption of non IoT enable devices also like electronic thermometer, electronic sphigmo-manometer and pulse-oximeter [2], [4]. As hospital cannot provide sensor enabled devices to all for the operational and

financial reasons, hospital provided the non IoT enabled devices to the patient. These devices come with ease of use, in which patient does not have to take the help of any medical professionals or any other person. Patient can measure the vital signs directly and upload the same in to the m-Health app, provided by hospital. As m-Health app is integrated with cloud, physician can also observe the patients' condition in real-time as quick as patient updated it. This practice creates the discipline in patients as time for uploading the data is also recorded and seen by physician. In a way, m-Health app helps the patient to creating a virtual journal for their vital signs.

### D. Cloud enabled Platforms

Cloud-enabled m-Health applications may have massive tools for data collection and data processing in their Personal Digital Assistants. With the login keys, patients can have access to their health records. A doctor could have access to all the patients that is currently being researched. With internet-based technologies, the patient will still be held linked to a specialist at all hours. M-Health applications allow doctors and patients to connect in various environments, including regular treatment or emergency care[13].

### E. Remote Patient Monitoring

With the help of digital technologies, it is possible to monitor the patient remotely [14]. IoT enabled devices helps patients as well as physician to record and share every vital activity in real time, where patient and physician both can interact.

IoT enabled m-Health triad opens up a space for graphical representation of vital signs, whereby, patient or physician can monitor the change in vital signs with the time[15], [16]. On the other end, non – IoT enabled healthcare trackers enables certain degree of discipline in patients, as patient perceives that physician is looking for the data at regular interval, patient also measures and upload vital data on m-Health application.

### F. Patient care analytics

When the provider has vital data of patients, analytics team from provider end can run various number of analytical operations on received and stored patient data for the betterment of healthcare systems. Some of the predictive analytics helps physicians to intervene early, in such cases, with the early intervention by medical professional, fatal situation can be managed and handled.

With the high-quality data received from sensor enabled IoT supported wearable devices, analytics can be performed with higher degree of accuracy. With the help of supervised learning on data collected from heart sensor, predictive analytics can alert the patient and doctor well in advance.

## III. RESEARCH METHODOLOGY

The case-based approach has been used to identify the relationships between above mentioned constructs and to create the proposition. We contacted with physicians, infectious disease specialists and critical illness specialists who were treating the patients of covid-19, online IoT platform enabled technology and also using the modernized care technology.

### A. Case 1

During the telephonic conversation with infectious disease specialist, we got to know that, physician is treating the patient online using Skype and WhatsApp videocall. Physician is

treating 90 percent of his patient using this online mode with technology integration. Physician has ordered electronic thermometer and oximeter in a bulk and provided these instruments to the patients who were found positive in RTPCR test and under home quarantine as per the government regulations and guidelines. Physician used to connect to patient twice a day and was giving the advice on the health and disease related situation. On the other side, he made a small system on which patient uploads the reading of oximeter and thermometer at every 3 hours during the day.

Physician told that before talking to the patient he was checking the instruments reading uploaded by patient and based on that he planned his conversation with patient. He also tied up with laboratories, as when he feels that, patient need some tests, he used to connect to the path lab and a person from path lab and a person from path lab goes to the patients' home for sample collection in the morning and give the report in electronic form to physician and patient both. Physician was happy with these modern technologies as he can visit a greater number of patients by saving time to travel to OPD to OPD and was able to provide ample amount of attention to the patients who are admitted due to complications and comorbidities and are in critical condition.

#### B. Case Study 2

In a chat over the smart-phone with a medical professional we got to know that, a young individual in Hyderabad used the m-Health software to eliminate the confusion of covid-19. Physician added, after watching some reports on Youtube about the pandemic of corona-virus, patient demonstrated that he might be infected with covid-19 and patient was really concerned for his welfare. His symptoms have been checked and identified. He opened the m-Health application he signed himself and he noticed that m-Health providers made a special section for coronavirus details. He tapped on it and demanded to be consulted. Within 5 minutes the form was submitted to him about the symptoms like cough (dry and/or mucus), body temperature (measured in the home with the thermometer), and so on. The investigation was given to me, and I called to him and we debated the symptoms. Since the affirmation patient, he just noticed the breathing difficulties and feeling like fever after he watched the television and learned about the signs(which was not there, while checked with the thermometer as well as Rapid Antigen Test). For more tests, the doctor recommended him to visit the lab report section and inform him once again if he started to experience the same.

From the above-mentioned case studies, we have made the theoretical model explained in figure 1 below with the propositions that:

*P1: IoT enabled wearable device adoption fosters growth/expansion of cloud enabled platforms.*

*P2: Non-IoT enabled wearable device adoption fosters growth/expansion of cloud enabled platforms.*

*P3: Growth/ expansion of cloud enabled platforms foster remote patient monitoring.*

*P4: Growth/ expansion of cloud enabled platforms foster patient care analytics.*

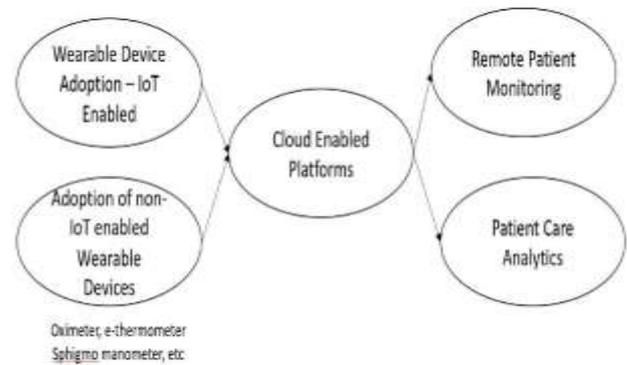


Fig. 1. Theoretical Model

#### IV. DISCUSSION AND IMPLICATION

Wearable devices have become the trend and need of the hour as most patients and their related physicians find it easy to get a trend in the vital daily physical activity statistics and body parameters, in a synchronous mode, about their patients when treating for lifestyle ailments. It became more meaningful especially in the last one year, in which context this study paper is developed, i.e. especially for contagious yet severe diseases like Covid-19 [17]. The usage of IoT-sensor enabled devices connected to the cloud platform helped largely to extend care to quarantined patients, yet keep a close tab and observation on their vital health parameters on a regular basis. The usage of IoT-enabled fit-bits or activity trackers on one hand helped in constant real-time tracking, on the other hand enabled updation of non-IoT data through their interfaces to the cloud platform. Unlike the regular care situations where physical diagnosis, testing and reporting was preferred in face-2-face mode, Covid-19 crisis has ushered in the situation where sensor enabled contact-less diagnosis, reporting and care delivery has become priority for the physicians and also the new code of standard care protocol prescribed by medical bodies and government. Although there are some issues related to the patient data privacy, it is of less concern with the advanced technology implementation which can easily deal with the privacy [18]. In course of the study it was observed and it emerged while case development and interaction with the stakeholders that IoT enabled devices helped updating the data across the cloud platform in a standardized manner, which largely helped in the remote video-enabled care surveillance and care monitoring easier, affordable and efficient. In traditional diagnostic setup while diagnosis, identification of affected patient, screening and reporting all acted as separate silos, the IoT enabled devices, cloud technology platform largely helped in easier statistics maintenance trend-analysis, clustering analysis and algorithmic prognosis and diagnosis as aide to physicians with predicted course of treatment trajectory. This model is a nascent working model of the antecedent -consequence linkage established between technology and outcome process front designed and elaborated in the covid-19 scenario.

Cloud-enabled platform growth and IoT enabled Analytics and monitoring through devices adoption and also usage of treatment kit providing digital data for easy updation through the smart-phone interfaces, helped cater to large set of patients by relatively minimal number of physicians from remote care service location efficiently. In course of the study several anecdotal evidences helped fine tune the working proposed model which remains awaited for being tested with large scale data empirically.

Major implications of this model-driven case analysis are aimed at two fronts. From the business front, the industrial and clinical implications of this model is immensely important as it provides a holistic understanding about closing the loop of remote efficient care in healthcare context using technology interfaces. Clinically it offers the best possible way of delivering constant real-time care assurance to patients maintaining the prescribed social distancing norms in the new normal era. From the academic viewpoint, it may be one of the first approaches to creating a study model on the way to large-scale empirical validation. It adds to the research body of knowledge and may prompt many further in-depth researches in the near future. This study provides the holistic overarching model for the physicians and hospital network ecosystem to get motivated and adapt as per convenience; aiming at superior care delivery in the remote setups through tele-medicine and online cloud enabled internet platforms.

## V. LIMITATION AND FUTURE SCOPE

The limitations of this study were magnified by the context and timeline of its implementation. The context and the background being in the Covid-19 pandemic backdrop, the initial planning and basic model proposition took place with the case based analysis rather than a large scale empirical data-driven validation. The study cases were mostly confined to a single Indian due to the movement restrictions and policies regarding limited access and discussion in face-2-face manner. The study cases were portrayed in the context and backdrop where with every passing month the standard protocols and practices were being changes and managed as per the phases of the biggest lockdown India ever experienced. The last but not the least was, this study conceptualization occurred in the pre-vaccination stage of Covid-19, which may in the later years need scenario and context analysis before generalizability.

Future refinement of the study working model will be carried out through pilot and final large scale survey driven empirical data including suitable scale development for standardization.

## VI. CONCLUSION

Remote care-service delivery concept has been championed by many stalwarts in the context of healthcare. This innovative and futuristic practice have been highlighted to be of specific importance in the context of India where last mile reach happened to play a major barrier for most quality care to reach

the extended grass-root level people in the rural areas. However the advent of Covid-19 pandemic created a mighty leveler in the context of reach and affordability, where due to the distancing norms and contagious virulence the physician-patient distancing became a part of necessity in even urban setups.

This study conceptualization, case-driven outcomes and discussion establishes the imminent need and importance of digital IoT-enabled smart cloud platforms as standardized avenues of care delivery. The case enabled analysis reveals that the IoT and care-kit devices enabled data capture, fosters and prompts the use of updating and analysis on the cloud enabled platform which in turn results into superior preparedness and effectiveness of not only remote care service delivery and monitoring services to home-quarantined and also isolated ward quarantined patients, but also provides the much needed platform for detailed patient care analytics using the trend and large-scale data from the device fronts; enabling superior care process planning and visualization. The mobile internet penetration, reach and affordability, emboldened through availability of digital devices, technology and smart-phones have largely helped the cause of not just remote care service, but effective and efficient remote care delivery.

This study model creates the first stepping stone towards affordable remote care efficiency study investigation complemented through cloud and IoT technology platforms. This creates a mental map for motivating the physicians and healthcare stakeholders to take nuanced look at the promises in store towards using technology enabled remote care delivery in Indian healthcare context.

## REFERENCE

- [1] "WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020." <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020> (accessed Feb. 09, 2021).
- [2] "Top Doctors at Apollo Hospitals. Book Appointment Now | AskApollo." [https://www.askapollo.com/book-health-check/apollo-pro-health?utm\\_source=referral&utm\\_medium=apollohyderabad&utm\\_campaign=homepagebanner](https://www.askapollo.com/book-health-check/apollo-pro-health?utm_source=referral&utm_medium=apollohyderabad&utm_campaign=homepagebanner) (accessed Feb. 09, 2021).
- [3] M. Javaid and I. H. Khan, "Internet of Things (IoT) enabled healthcare helps to take the challenges of COVID-19 Pandemic," *J. Oral Biol. Craniofacial Res.*, vol. 11, no. 2, pp. 209–214, Jan. 2021, doi: 10.1016/j.jobcr.2021.01.015.
- [4] "Online Doctor Consultation in Hyderabad | Telemedicine Consultation in Hyderabad." [https://www.yashodahospitals.com/packages/product/online-doctor-opinion/?utm\\_source=website&utm\\_medium=homepage&utm\\_campaign=online-doctor-consultation](https://www.yashodahospitals.com/packages/product/online-doctor-opinion/?utm_source=website&utm_medium=homepage&utm_campaign=online-doctor-consultation) (accessed Feb. 09, 2021).
- [5] V. Bhatt, S. Chakraborty, and T. Chakravorty, "Importance of Digitech Adoption for Providing Efficient Healthcare Services during COVID-19," *Int. J. Emerg. Technol.*, vol. 11, no. 3, pp. 1–13, 2020.

- [6] S. Thompson, J. Whitaker, R. Kohli, and C. Jones, "Chronic Disease Management: How IT and Analytics Create Healthcare Value Through the Temporal Displacement of Care," *MIS Q.*, vol. 44, no. 1, pp. 227–256, 2020, doi: 10.25300/misq/2020/15085.
- [7] S. Chakraborty and V. Bhatt, "Interactional Resource Adoption: A Bridging Solution to Healthcare Service Divide in India," *Handb. Res. Eng. Innov. Technol. Manag. Organ.*, pp. 253–268, 2020, doi: 10.4018/978-1-7998-2772-6.ch014.
- [8] M. Mital, V. Chang, P. Choudhary, A. Papa, and A. K. Pani, "Adoption of Internet of Things in India: A test of competing models using a structured equation modeling approach," *Technol. Forecast. Soc. Change*, vol. 136, pp. 339–346, 2018, doi: 10.1016/j.techfore.2017.03.001.
- [9] M. S. Talukder, G. Sorwar, Y. Bao, J. U. Ahmed, and M. A. S. Palash, "Predicting antecedents of wearable healthcare technology acceptance by elderly: A combined SEM-Neural Network approach," *Technol. Forecast. Soc. Change*, vol. 150, no. June 2019, p. 119793, 2020, doi: 10.1016/j.techfore.2019.119793.
- [10] A. Papa, M. Mital, P. Pisano, and M. Del Giudice, "E-health and wellbeing monitoring using smart healthcare devices: An empirical investigation," *Technol. Forecast. Soc. Change*, 2020, doi: 10.1016/j.techfore.2018.02.018.
- [11] S. Y. Lee and K. Lee, "Factors that influence an individual's intention to adopt a wearable healthcare device: The case of a wearable fitness tracker," *Technol. Forecast. Soc. Change*, vol. 129, no. January, pp. 154–163, 2018, doi: 10.1016/j.techfore.2018.01.002.
- [12] V. Bhatt and S. Chakraborty, "Importance of Trust in IoT based Wearable Device Adoption by Patient : An Empirical Investigation," in *Proceedings, Fourth International conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)*, 2020, pp. 1226–1231, doi: 10.1109/I-SMAC49090.2020.9243533.
- [13] S. Chakraborty, V. Bhatt, and T. Chakravorty, "Big-Data, IoT Wearable and mHealth Cloud Platform Integration Triads - a Logical Way to Patient-Health Monitoring," *Int. J. Eng. Adv. Technol.*, vol. 9, no. 3, pp. 388–394, 2020, doi: 10.35940/ijeat.c5241.029320.
- [14] S. Chakraborty, V. Bhatt, and T. Chakravorty, "Is telemedicine best alternative to reaching last mile: Investigation in the context of rural india," *Indian J. Public Heal. Res. Dev.*, 2018, doi: 10.5958/0976-5506.2018.01341.4.
- [15] K. T. Chui, R. W. Liu, M. D. Lytras, and M. Zhao, "Big data and IoT solution for patient behaviour monitoring," *Behav. Inf. Technol.*, 2019, doi: 10.1080/0144929X.2019.1584245.
- [16] A. Zamanifar, "Remote Patient Monitoring: Health Status Detection and Prediction in IoT-Based Health Care," in *IoT in healthcare and Ambient Assisted living*, Springer, Singapore, 2021, pp. 89–102.
- [17] S. Mohapatra and S. Parija, "IoT-Based Modeling of Electronic Healthcare System Through Connected Environment," in *Advances in Intelligent Systems and Computing*, 2021, vol. 1199, pp. 423–431, doi: 10.1007/978-981-15-6353-9\_38.
- [18] S. Nandan, A. Radhika, V. Dahiya, and C. Ranjan, "An Efficient Amalgamation of Computational Models to Ensure a Secure IoT Environment," vol. 13, no. 2, pp. 235–243, 2020.