Smart Health – Potential and Pathways: A Survey

To cite this article: C Arulananthan and Sabibullah Mohamed Hanifa 2017 *IOP Conf. Ser.: Mater. Sci. Eng.* **225** 012065

Smart Health – Potential and Pathways: A Survey

Arulananthan C[1]
Research Scholar, PG & Research Department of Computer Science, Sudharsan College of Arts & Science, Pudukkottai – 622 104.Tamilnadu-India
E-mail Id: asgokula@gmail.com Mobile: +91-9943742532

Sabibullah Mohamed Hanifa[2]
Associate Professor & Dean, PG & Research Department of Computer Science,
Sudharsan College of Arts & Science, Pudukkottai – 622 104.Tamilnadu-India
E-mail Id: manavaisafi@yahoo.com, Mobile: +91-9443592702

Abstract: Healthcare is an imperative key field of research, where individuals or groups can be engaged in the self-tracking of any kind of biological, physical, behavioral, or environmental information. In a massive health care data, the valuable information is hidden. The quantity of the available unstructured data has been expanding on an exponential scale. The newly developing Disruptive Technologies can handle many challenges that face data analysis and ability to extract valuable information via data analytics. *Connected Wellness* in Healthcare would retrieve patient's physiological, pathological and behavioral parameters through sensors to perform inner workings of human body analysis. Disruptive technologies can take us from a *reactive illness-driven* to a *proactive wellness-driven* system in health care. It is need to be strive and create a smart health system towards wellness-driven instead of being illness-driven, today's biggest problem in health care. *Wellness-driven-analytics* application help to promote healthiest living environment called "*Smart Health"*, deliver empower based quality of living. The contributions of this survey reveals and opens (touches uncovered areas) the possible doors in the line of research on smart health and its computing technologies.

Keywords: Smart Health, Smart World, IoT, Cloud Computing, Sensing Technologies, Big Data Analytics, Disruptive Technologies

1. Introduction

Medicine is an industry that pays great attention to the accumulation and renewal of knowledge. Connected Wellness in Healthcare is all about retrieving people's physiological parameters through sensors and performing analysis. Disruptive technologies like; IoT, Cloud, Big Data Analytics and Sensing can take us from a *reactive illness-driven* HealthCare System (HCS) to a *proactive wellness-driven* system. It is expected that the healthcare costs will account for 20-30% of GDP in some countries by 2050 [1, 2]. In order to ensure quality of life for the elderly citizens specialized in HC systems need to be designed that will minimize human wellness centered support systems [3]. In HCS, stakeholders like doctors, care givers, hospitals, pharmaceutical companies, medical device

manufacturers, all benefit when the patient becomes *ill,* should keep patients *healthy. B*usiness models are in force towards the HC stakeholders of medical eco-system, when people are not *well.* There is a need to strive towards a system that is wellness-driven instead of being illness-driven, today's biggest problem in health care. It will help to promote healthiest living environment called "*Smart Health"* (Collaborative disease management and care coordination) *art of diagnostics* to *science of prognostics*, deliver empower based quality of living. This survey reveals and insights the possible doors in the research line of Smart Health and its computing technologies.

2. Impact on Digital Data in Patient era

The healthcare industry today generates large amount of (both unstructured and structured) data from record keeping of patient related data, health and medical devices related data, drug research data, health insurance data, clinical outcome data, laboratory data, images with graphic, audio, video data, health policy data[4]. The use of health big data (Electronic Health Records (EHRs) already been proven to be effective for a wide range of healthcare challenges, such as disease management support [5], building models for predicting health risk assessment [6], enhancing knowledge about survival rates, discovering co morbidities, and building support systems for the recruitment of patients for new clinical trials [7].

3. MOTIVATION

Smart Health provides healthiest living environment by way of empowering the quality of life. In massive health care data sets, the valuable information is hidden. Despite some advances, many people yet to have access to affordable and effective healthcare. Significant challenges remain for many patient populations, including the elderly with chronic conditions or diseases. To address these needs*,* evaluation of models of wellness applications in disease etiology, customize care shift will focus disease treatment to prevention. *Connected Wellness* in Smart Health is a major uncovered area towards health care system. It is to be harnessed by using big data processing technologies to deliver the *right health big data analytics* to *right living (people)* for getting *right care (wellness-driven).*

4. SMART HEALTH (SH)

Smart Health provides healthiest living environment by way of empowering the quality of life. Collaborating the disruptive technologies (Internet of Things (*IoT) + Cloud Computing + Smart Sensing + Big Data technologies*), a paradigm shift in the field of ICT to promote and render right solution, right care coordination in the collaborative management called "*smart health"*. The sensors, devices (mobile phones, surgical devices that measure our blood chemistry and brainwaves), computers, fit bit smart bands, applications, human actors are all *Intelligent Agents*, might be connected in the *Smart Health System (SHS),* provide health related services using a network. Simply, SH will connect multiple agents like; patients, devices, networks, providers. SH will integrate various nearby big health care data sources of patient data like, Electronic Health Records (EHR) - stores patient's demo-graphics, medical history, medication and allergies, radiology related information, immunization status, vital organ status, lab test results and personal details on age, weight, height etc.) (e.g. Hospital Information Systems (HIS), Radiology Information Systems (RIS), Laboratory Information Systems (LIS), picture archiving and communication systems (PACS), Computerized Physician Order Entry (CPOE), Point of Care Information Systems, Wearable/ Implantable Health IT Systems, E-Prescribing, Health Information Exchange (HIE) Networks, Personal Health Records

(PHRs), and Mobile Health in an adequate environment for applying various powerful analytics functions.

4.1 Smart World

The concept of [8] *smart world* (comprising smart environment (smart health [health tracking-RFID, smart pharmacy], smart people, smart homes and offices, smart plant, smart water supply), smart sensing, smart police, smart transportation (smart cars, smart traffic, smart parking, 3D assisted driving), smart cities, smart homes, smart grids, and smart lights etc.,) is one of the emerging research areas of the 21st century. Smart Robot taxis and City Information Model (CIM) are the futuristic application domains. Concept of smart cities is one of the major areas that is getting promoted and focused is the "Healthiest living environment or smart health" [9].

5. IMPACT ON ANALYTICS SYSTEM, BIG DATA AND BD ANALYTICS IN HEALTHCARE (BDAH)

In the current age of smart phones, wearable devices and IoT, large amounts of health data files forming "Big Data" are being placed into databases where they can be accessed by multiple users including doctors, caregivers and patients. Big Data Analytics in Healthcare (BDAH) is envisioned to offer big scientific insights that eventually helpful in alleviating the human life and community at large [10]. *Diagnosis, Treatment* of diseases, and *Readmission* of patients into hospitals are some of the applications of analytics of BD. Analytics techniques can be categorized into four levels as detailed in Table.1

Table 1: Categories of Analytics Techniques

Analytics techniques	Description	Techniques used
Descriptive analysis	To explain what is happening in a given situation	Histograms, charts, box and whisker plots, or Data clustering.
Diagnostic Analysis	Why certain things happened and what are the key drivers. E.g., why is disease infection increasing? Or why some patients readmitting every month?	Clustering, classification, Decision Trees (DT), or content analysis
Predictive analysis (Like Patient profile analytics)	To predict the probability of an uncertain outcome. (For *Proactive care* or Lifestyle changes thro' Prediction Models [30-34]).	Statistics and machine learning
Prescriptive analysis	To optimize the decision outcomes	DT, linear & non-linear promg. Monte-carlo simulation

Analytics system can provide the necessary data and *evidence-driven prognosis* addressing the migration from illness to wellness. India spends around 4.2 % of its GDP on healthcare. It insists that use of big data analytics to bestow better healthcare facilities to its citizen [11]. BDA helps in understanding the data patterns and its relationship with the help of clustering, classification, decision tree, association, sequence analysis, segmentation, regression and data mining, and image processing algorithms.

5.1 BD Analytics Technologies / Tools

Many methodologies that can drive and solve IoT data processing and analytics issues through Apache Hadoop and Apache Spark eco-system. Apache Hadoop ecosystem consists of; (Hadoop [HDFS], MapReduce [Programming model], Hive, Hbase, Pig [Database model], NoSQL (to support key-value, graph based, *column based and document based databases are most suitable for HC datasets*] and Mahout (rely on ML mission [Classification, clustering, collaborative filtering and categorization].

5.2 Role of BD and Data Analytics in Health Care (HC)

Big data and its analytics can help in following areas [11]:

Clinical Treatments: It allows efficient storage of both structured and unstructured healthcare data and by performing analytics. Comparative Effectiveness Research can be used to provide optimal treatment to specific patients.

Administration: Helps to maintain all the transactional records, financials and will keep the track of EHRs data of patients, feedback and schedule of doctors and nurses to make decisions.

Health Policy: Helps to allow governments to make health policy and decide health budget according to the obtained results from large data sets.

Clinical research and development: BDA will assist medical students to do research in treatment, genomics, semantic and drug analysis research.

Public health: Benefit in tracking infectious diseases outbreak, its pattern analysis and transmission for improving public health surveillance and response.

Patient Profile Analytics: To identify individuals who would benefit from proactive care or lifestyle changes.

Device/Remote monitoring: Capability of capturing and analyzing the real-time large volumes of fast moving data such as of in-hospital and in-home devices, for safety monitoring [12].

Clinical outcome and safety: In case of emergency & safety, helps in easy access of health record.

Fraud Detection: Insurance claim related fraud can be detected and eliminated using big data analytics.

5.3 Health Care (HC) Services: Predictive / Proactive

The healthcare services need to be *predictive* and *proactive* to limit the occurrence of expensive acute health episodes [13]. HC services need to be individualized, rather than population-based in order to guarantee the delivery of the right treatment. The delivery process of care services need to be decentralized from hospitals to the community and the home. In practice, Information and Communication Technologies (ICT) can play a main role in providing an effective solution to deliver manageable models of patient services in home and community locations.

5.4 Levels of HC in India

The rural public health care system in India has three different levels of health care access called primary, secondary and tertiary health care. At the lowest level, Primary Health Center (PHC) which is basic units having minimum facilities serving the rural India, each PHC supervises sub-centers, are most basic units of health in villages and first point for treatment between villagers and public health care. Secondary HC is the second tier of health system where patients from primary health care are referred for specialized treatment [14]. The health

centres for secondary health care are District hospitals and Community Health Centre. Tertiary health care is the third level of health system, where in specialized consultation is provided on referral from primary and secondary health care. Specialized Intensive Care Units, advanced diagnostic support services and specialized doctors are the key features of it. In India, tertiary care is provided by either medical colleges or advanced medical research centers [14].

5.5 Patient Monitoring

In Healthcare, the most impacted domain is ***Patient Monitoring***, where the taxonomy of IoT based services, detailed in Table 2.

Table 2: Taxonomy of IoT based services

Patient Monitoring	Vital Parameter Monitoring	BP, Blood Glucose, Heart rate, Temperature, EKG, Weight and Walking pace
	Body Monitoring	Intelligent sensors attached to the body
	Activity Monitoring	Steps taken, Speed, Calories burned, Rest time
	Ambient Monitoring	Healthcare services delivered via ambient intelligence consisting of *ambient sensors* and objects interconnected into an integrated IoT represent a promising and supportive solution for the "ageing society". Supports people in their daily lives.

5.6 Sources of Healthcare Data for Big Data

- Clinical Data (Structured EHR Data, Unstructured Clinical Notes, and Medical Imaging Data)
- Genetic Data (DNA Sequences)
- Other Data (Epidemiology & Behavioral (Social network data, Mobility sensor data)

6. GENESIS OF SH – DISRUPTIVE TECHNOLOGIES (SH= IOT+WSN+CC+BDA)

SH is defined as well-thought-out blend of WSNs-CC-IoT, empowers the quality of living to the fullest extent and could be termed as "Smart Health" [15]. Advances in medicine and clinical care are increasingly tied to computing technologies. It explores emerging trends in smart health and the benefits they bring to individual patients and society as a whole. The rapid expansion of big data analytics and cloud computing technologies has led to the creation of powerful new tools including virtualized tissue banks and disease-specific clinical-trials recruiting and selection databases. Such tools let researchers more nimbly leverage our growing knowledge of human biology to directly improve patients' health outcomes and quality of life. Despite these advances, many people still do not have access to affordable and effective healthcare, and significant challenges remain for many patient populations, including the elderly with chronic conditions or diseases. To address these needs, researchers are designing, implementing, and evaluating novel smart-health and wellness applications to better understand disease etiology and pathogenesis, reduce medical costs, customize care, and shift the focus from disease treatment to prevention. Key ongoing research activities include analyzing physiological and behavioral data from mobile and environmental sensors, improving telemedicine services, and exploiting emerging information sources such as social media and health data aggregators [16].

6.1 Role of Internet of Things (IoT)

IoT is defined as"*the interconnection of uniquely identifiable computing devices via Internet connectivity* among devices, services and system, enable automation in many areas of health care application. IoT is also expected to generate large amounts of data from *diverse locations* and from *heterogeneous sources*. When multiple sensors are used together and interact, they are referred to as a Wireless Sensor Networks (WSN). Advances in sensor, wireless communication, and data processing technologies are the driving force for implementing IoT in healthcare systems. The emerging Wearable Body Sensor Networks (WBSNs) were developed to monitor patient activities or medical parameters continuously[17].

"Internet of Things" connected devices to almost triple to over 38 billion unites by 2020 [18].

6.2 Role of Medical IoT (mIoT)

Devices that constantly monitor health indicators and auto-administer therapies, these devices and mobile apps are now increasingly used and integrated with telemedicine and telehealth via the medical Internet of Things (mIoT). Sensing-based technologies are projected to participate as one of the fundamental contributors to the big data era especially as the Internet of Things (IOT) has started to gain attention in our daily activities [19].

6.2.1 Dynamic capabilities of IoT in Healthcare system [20] (Refer Table 3)

Table 3: Capabilities of IoT in HCS

D2M	Device-to-Machine,	O2O	Object-to-Object	P2D	Patient-to-Doctor
P2M	Patient-to-Machine	D2M	Doctor-to-Machine	S2M	Sensor-to-Machine
M2H	Mobile-to-Human	T2R	Tag-to-Reader		

6.3 Role of Sensing Technologies (Wireless Sensor Networks [WSN])

Sensors Technologies can take a main role in developing healthcare services with smart software capabilities. Sensing is a pervasively used technology in nearly every aspect of hospital-based service starting from the simplest digital thermometer to complex laser-guided surgical tools [21]. Sensors are defined as a devices that converts a physical measure into a signal that is read by an observer or by an instrument and "sense" the state of an environment or object, have a significant role in the medical treatment process. Sensors can monitor the characteristics of the environment or objects like temperature, humidity, movement, and quantity. Actuators can affect the environment by emitting sound, light, radio waves or even smells. Sensor Data, exhibits three characteristics of BD: Volume, Variety and Velocity. Sensing technology [21] can play a main role on monitoring the main health status indicators of an individual via ambient monitoring of day-to-day patterns, where in-house healthcare has become a main component of the IOT [22]. Advanced sensing devices are utilized by pathologists in hospital laboratories to perform hematology, immunology, biochemistry, histopathology and microbiology functions.

6.3.1 Role of RFID sensor networks (RSN)

RSN are the possibility of supporting sensing, computing, and communication capabilities in a passive system. RFID systems are the very small size, very low cost and its lifetime is not limited by the battery duration. Implantable sensors [23] address the challenges of both acute and chronic disease monitoring by providing a means of capturing critical events and

continuous streamlining of health information. Ambient sensorsand objects interconnected into an integrated IoT represent a promising and supportive solution for the "ageing society".

6.4 *Role of Imaging Sensing Technologies – Diagnostic Medicine*

Evolution of radiology in the use of digital imaging systems, particularly in radiology, where digital management of images has allowed the healthcare department to be more efficient, reduce operating costs, and improve the communication between radiologists and the referring physician. Examples are electronic and Imaging (e.g., Magnetic Resonance Image (MRI), X-rays), Positron Emission Tomography (PET), Computed Tomography (CT), Wave analysis (EEG, ECG), Laparoscopic surgery and ultrasound are commonly used imaging technologies for providing medical insights into the health status of every patient.

6.5 *Role of Wearable Sensing Technology (Remote, Digital and Mobile Technologies)*

Wearable devices are being developed at breathtaking speed [24]. The growing wearable technology can keep track on our bodies' inner workings.These are remote, digital and mobile technologies that integrate with other systems so as to collect, access, and mange patient information (generate smart EHRs). Wearables and mobile apps today support fitness, health education, symptom tracking, and collaborative disease management and care coordination. A new category of "personalized preventative health coaches" (Digital Health Advisors) will emerge. Wearable applications are emerging that could extend the quality and length of life in ways never before thought possible.
E.g., of Wearable Devices, e.g., smart shoes, smart watch, smart bracelet, etc.,
E.g., of Wearable (Medical) Devices, e.g., ECG and respiration, motion sensors, etc.,

6.5.1 *Wearable based Physiological Sensing*

Wearable devices are expected to lead the next device revolution. These are more capable not only to sense Photoplethysmogram (PPG - signals sense the heart rate, respiratory rate and BP can be measured), signal from a wrist wearable (www.shimmersensing.com) but also get ECG waveforms from it. **(**www.empatica.com**).**

6.5.2 *Wearable Pathological Sensing*

Current pathology systems are invasive in the sense that blood or other *in-body* fluid samples need to be collected. Future generation pathological sensing either uses easily available outer body fluid like sweat or teardrops. Reports on measuring blood glucose from tear drops [25]. Google announces to build a *smart diabetic sensing contactlens* using this technology. Another study reported that doing body nutrient analysis using tear drops (www.superiorideas,org/projects/infant-teardrop). Startup organizations aim to build wearable sensors that can sense and analyze body sweat for measuring hydration, fluid loss and electrolytic imbalance and (www.wired.com/2014/11/sweat-sensors) Smart ingestiblepills(www.marsdd.com/news-and-insights/ingestibles-smart-pills-revolutionize-healthcare). Scientists reported that measurement of ethnol, drug, ion and metal content from body sweat [26].

6.6 *Nearable Devices*

It means that camera and RF sensing devices which can be placed near a person to gather information about physiology. No external device or internal implant need to be placed on a person's body. Recent work by MIT which can sense heart rate from normal optical camera signals using 3D image processing tracking micro movements in our face due to blood

pumping[3]. Once mature this technology, it would be a low-cost and monitor health of multiple patients without putting anything on patient's body.

6.6.1*IoT Smart Health Opportunities and Challenges*

Kind of things we can get from IoT are remote monitoring, self-management of chronic conditions, performance improvement, behavior modification, detection & diagnosis and treatment etc., these are platform & data heterogeneity, data integrity & accuracy, privacy, security and trust based challenges.

6.7 *Bluetooth Technology*

Most of the devices use mobile phones as a gateway for transmission using low power protocols like Bluetooth Low Energy (BLE) instead of connecting to the internet directly via a cellular connection. BLE (Bluetooth LE) marketed as *Bluetooth Smart,* is a wireless personal data network technology marketed by the Bluetooth Special Interest Group aimed at novel applications in HC, fitness, beacons, security, and home entertainment industries. E.g., Classic Bluetooth and Bluetooth Smart.

6.8 *Wireless Telemedicine & Applications*

HC at a distance (Telemedicine [Tele-cardiology, Tele-radiology, Tele-psychology]) relies on the use of telecommunication and ICT. It is essential for HC institutions to invest more into telemedicine. It helps in saving lives during critical situations through technology. Moreover, the worldwide HC services in rural areas still remain as a major challenge [27]. One of the characteristics of "Validity" in Big data can play an important role by making available reports or results using big data analytics in seconds. Since, it refers to time dependent data in healthcare like in telemedicine patient's information of each second is important during treatment. If data reaches late patient's life is at stake. (For example there are certain tests which are locally not possible to detect, than samples are sent to big cities and their reports takes three to seven days in India to give results)

6.9 Role of Cloud Computing

Cloud Computing (CC) has been acknowledged on the top of Gartner's list of the ten most disruptive technologies of the next years [28]. CC consists of a *front-end* (users' computers and software required to access the cloud network) and *back-end (*various computers, servers and database systems that create the cloud).

6.9.1 Cloud computing in Healthcare

Use of CC in healthcare is emerging [29]. CC enables the use of computing resources and standard mechanisms supported by heterogeneous thin or fat client platforms (e.g., laptops, mobile phones, and PDAs). Cloud is able to provide at-rest analytics (i.e., retrospective analysis) for stored data thro' its delivery models like SaaS (end users to utilize outsourced software) , IaaS (physical environment is outsourced), PaaS (platform is provided) and DaaS (data can be housed within a cloud). Cloud Computing could improve health care services and research [27]. Since, high speed physiological data is an untouched resource in healthcare. BSaaS, PTaaS and BioAaaS are the examples of healthcare related cloud services.

6.9.2 Role of cloud computing for big data

CC and BD paradigm is emerged to address the data-oriented challenges. Communication between the cloud environment and external world is facilitated by the interfaces (like either by GUI or APIs) made available by the service providers. Interfaces provide the users not only

rich-set of operations (like; collection, aggregation, visualization and data mining) but also the platforms to perform them, directly by click-based selection or via programming implementations. CC credited (applicability, usability and acceptability potentials) to bring the analysis of big data to the users of various level of scientific and technological understanding ranging from naïve to elite experts.

6.9.3 Cloud-assisted Big Data Models and Technology Big Players (http://stevenimmons.org)

It provides efficient and most accurate solutions of complex big data problems. Some of the available *cloud based models* are; Cloudra**,** Cloudant, CloudKit, Cloud Datastore, Datameer - Provides HDaaS,Azure DocumentDB, Amazon DynamoDB, Google's BigQuery, Dydra. *Amazon, Microsoft's HealthVault, Google, IBM*'s [PureData Solution-*Diagnosis*, Watson Health-Super computer, Watson Care Manager (WCM)-*Treatment*], Piedmont Healthcare's Patient First-CVD-*Readmission* are the big players in health care applications of BDA.

7. CONCLUSION

This is a content & computing-rich domain and complex research area that has to be well-positioned to investigate in the health care perspectives. This summarized survey on potentials to smart health, and pathways to disruptive technologies would definitely open eye to inspire and extend the interests in naïve and elite researchers, since upward health care analytics are shaping up the current research efforts in emerging disruptive technologies. This research attempt may survive in 2050.

REFERENCES

[1] Jean P Drouin, Viktor Hediger, and Nicolaus Henke. "Health care costs: A market-based view". *The McKinsey Quarterly*, September, 2008.

[2] ChristianHagist and Laurence J Kotlikoff. Health care spending: What the future will look like, 2006.

[3] Arpan Pal, Arijit Mukherjee and SwaranaDey, "Future of Healthcare – Sensor Data Driven Prognosis", *Springer International Publishing*, Switzerland, 2016.

[4] J.Archenaa and E.A. Mary Anita, "A Survey Of Big Data Analytics in Healthcare and Government", *2nd International Symposium on Big Data and Cloud Computing (ISBCC"15), Procedia in Computer Science* 50, 408 – 413, 2015.

[5] J. Sun, C. D. McNaughton, P. Zhang, A. Perer, A. Gkoulalas-Divanis,J. C. Denny, J. Kirby, T. Lasko, A. Saip, and B. A. Malin, "Predicting changes in hypertension control using electronic health records from a chronic disease management program," *J. Amer. Med. Informat. Assoc.*, vol. 21, pp. 337–344, 2014.

[6] D. W. Bates, S. Saria, L. Ohno-Machado, A. Shah, and G. Escobar, "Big data in health care: Using analytics to identify and manage high risk and high-cost patients," *Health Affairs*, vol. 33, pp. 1123–1131, 2014.

[7] M. Marcos, J. A. Maldonado, B. Martınez-Salvador, D. Bosca, and M. Robles, "Interoperability of CDSS & HER using archetypes: A case study in clinical trial eligibility," *J. Biomed. Informat.*, Vol. 46, pp. 676–689, 2013.

[8] Heba Aly, Mohammed Elmogy, ShereifBarakat, "Big Data on IoT : Applications, Arch, Technologies, Techniques and Future Directions", *Intl. Jr. CSE (IJCSE)*, Vol.4(6): 300-313, 2015.

[9] "National telecom m2m roadmap," Ministry of Communication and Information Technology, Department of Telecommunications, Government of India, Tech. Rep., May 2015. [Online]. Available: http://www.dot.gov.in/sites/default/files/National/20Telecom/20M2M/20Roadmap.pdf)

[10] Shankar Krishnan, "Application of Analytics to Big Data in Healthcare", *32nd Southern Biomedical Engineering Conference, IEEE,*pp: 156-157, 2016.

[11] MimohOjha, KirtiMathur, "Proposed Application of Big Data Analytics in Healthcare at Maharaja Yeshwantrao Hospital", *2016 3rd MEC International Conference on Big Data and Smart City, IEEE*, 2016.
[12] SherifSakr, Amal Elgammal "Towards a Comprehensive Data Analytics Framework for Smart Healthcare Services", *Big Data Research,2016*, http://dx.doi.org/10.1016/j.bdr.2016.05.002.
[13] James Manyika, Michael Chui, Brad Brown, Jacques Bughin, Richard Dobbs, Charles Roxburgh, Angela Hung Byers, and McKinsey Global Institute. "Big data: The next frontier for innovation, competition, and productivity", 2011.
[14] Muni Kumar and Manjula R, "Big Data Analytics in Rural Health Care - A Step Towards SwasthBharath", *Intl., Jr.,of Computer Science and Information Technologies*, Vol. 5 (6) , 2014, 7172-7178, ISDN 0975-6946, 2014.
[15] Yash Mehta, ManoharaPai M.M., SanoopMallissery, Shwetanshu Singh, "Cloud enabled Air Quality Detection, Analysis and Prediction - A Smart City Application for Smart Health", *2016 3rd MEC Int. Conf. on Big Data and Smart City, IEEE*, 2016.
[16] UpkarVarshney, Carl K. Chang, "Smart Health and Well-Being ", *November 2016, www.computer.org/computer*
[17] Miorandi, D., Sicari, S., De Pellegrini, F., &Chlamtac, I., "IoT: Vision, applications and research challenges",*Ad Hoc Networks*, 10(7), 1497–1516, 2012.
[18] http://www.juniperresearch.com/press/press-releases/iot-connecteddevices-to-triple-to-38-bn-by-2020.
[19] Rolf H Weber and Romana Weber. "Internet of Things".*Springer*, 2010.
[20] M.S.H Talpur, "The Appliance Pervasive of IoT in HCS", *Intl. Jr. of C.S* Issues, Vol.10 (1), pp: 419 – 424, 2013.
[21] Michael J. McGrath and Cliodhna Ni Scanaill, "Sensor Technologies: HC, Wellness and Envtl. Applns".,*Apress, 2013*.
[22] Hermann Kopetz, "Internet of things", *In Real-time systems*, pages 307–323. 2011.
[23] P. Rashidi and A. Mihailidis, "A survey on ambient-assisted living tools for older adults," *IEEE J. Biomed. Health Informat*, vol. 17, no. 3, pp. 579–590, May 2013.
[24] Dimiter V. Dimitrov, "Medical IoT and BD in Healthcare", *Health Inform Res., July*; 22(3):156-163, 2016.
[25] Yan Q, Peng B, Su G, Cohan BE, Major TC, Meyerhoff ME, "Measurement of tear glucose levels with amperometric glucose biosensor/ capillary tube configuration", *Anal Chem*, 83(21): 8341-8346, 2011.
[26] Jadoon S, Karim S, Akram MR, Kalsoom Khan A, Zia MA, Siddiqi AR, Murtaza G(2015), " Recent development in sweat analysis and its application", *Intl. Jr, Anal Chem.,2015*, Article ID 164974.
[27] Nikunj Agarwal, M.P.Sebastian, "Use of Cloud Computing and Smart Devices in Healthcare", *WASET*, *Intl. Jr. Computer, Electrical, Automation, Control and Information Engineering*, Vol.10(1): 156-159, 2016.
[28] Gartner top ten Disruptive Technologies for 2008 to 2012. Emerging trends and technologies road show.*Technical report, Gartner*, 2008.
[29] D.B. Hoang and L.Chen,"Mobilecloud for assistive health care", *IEEE Asia-Pacific Services Computing Conference (APSCC)*, pp: 325-332, 2010.
[30] SabibullahM , "Prognostic Neural Network model for diabetic risks prediction", *In Proc. of IEEE International Conference on Emerging Trends in Science, Engineering and Technology*, pp.392-395, 2012.
[31] Sabibullah M, Shanmugasundaram V, Raja Priya K, "Diabetes Patient's Risk through Soft Computing Model", *Int. Jr. of Emerging Trends & Tech. in Comp. Sci.(IJETTS)*, Vol. 2, No.6, 61-65, Nov-Dec, 2013.

[32] Sabibullah M and Kashmir Raja S V, "Prediction of stoke risk through stacked topology of ANN model". *Intl. Jr. of Advanced Research in Computer Science*, Vol.1, No.4, 170-177, Nov-Dec, 2010.
[33] Sabibullah M and Kashmir Raja S V, (Sep-Oct'2010), "Stroke risk prediction through Non-linear Support Vector Classification Models", *Intl .Jr. of Advanced Research in Computer Science*, Vol.1, No.3, 47-53.
[34] Sabibullah M and Kashmir Raja S V, "Aneuralprognostic modelforpredicting strokeriskfactors", *Bio-Science Research Bulletin*, Vol. 23 (1), 95-102, July-Dec, 2007.

Author's:

Mr. C.ARULANANTHAN received his postgraduate MCA degree from Anna University, Chennai in 2008 and completed M.Phil (Computer Science) in the year 2011 from PRIST University, Thanjavur. He attended many National conferences, workshops, and seminars. His area of interest includes Computer Networks, Image Processing, Cloud computing, and Big Data. Currently, he is a full-time research scholar in Computer Science at Bharathidasan University, Tiruchirappalli.

Dr. M. SABIBULLAH, currently working as Associate Professor & Dean in PG & Research Department of Computer Scienceand has 18+ years of academic experience and 9+ years of research experience specializing in Machine Learning, Biomedical big data, Cloud computing and Health care applications. He published many research papers; participated in International Conferences, Seminars, Workshops, FDP & Staff Development Programme (SDP); delivered Radio Talks in All India Radio, Tiruchirappalli. Acting as a reviewer in the International Conferences and chaired many National level computing related conferences. Delivered invited lectures on "Soft Computing" and "Self-learning Machines" in reputed engineering colleges. Now, he is very keen on harnessing research interests towards hot areas of Computer Science domain like IoT, Big Data, Cloud Computing, Health Care Predictive Analytics and Data Classification algorithms. He is a life member in various professional bodies.