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Reimagining the Future of Healthcare Industry through Internet of Medical Things (IoMT), Artificial Intelligence (AI), Machine Learning (ML), Big Data, Mobile Apps and Advanced Sensors

A.Narasima Venkatesh

Abstract: ***From Bluetooth enabled hearing aids to robotic caretakers, wearable and smart devices industries are immensely contributing to the development of the healthcare industry with the help of Internet of Things (IoT). Latest technologies like Artificial Intelligence, 3D Printing, Big data, Machine Learning, Advanced Sensors, Mobile Applications and other technologies will continue to generate lot of opportunities for Medtech organizations. Some of the latest healthcare innovations practiced at present might have been seen or read by some of us only in science fiction movies or science fiction stories a long ago. Presently, IoT and Artificial Intelligence is creating a revolution in healthcare industry when it comes to diagnosis and treatment of varied diseases. From smartphones to robots, artificial intelligence is already making its presence felt in healthcare industry and as such it is progressively recognizing the transformative nature of IoT technologies which drives innovation in the development of connected medical devices. Gradual increase in the number of connected medical devices with the advent of technology advancements helps to capture and transmit medical related data wherever and whenever required to the concerned people and thus, it gave birth to the Internet of Medical Things (IoMT), where the Internet of Things (IoT) and healthcare meet. The IoMT helps to constantly monitor and alter (if required) the behvaiour of the patient and his/her health status in real time and also supports healthcare organizations to effectively streamline clinical processes, patient information and related work flows to enhance its operational productivity. The IoMT has made and continues to make the delivery of P4 Medicine (Predictive, Preventive, Personalized and Participatory) even for remote locations with the help of connected sensors and devices helping in real-time patient care. IoMT helps doctors and caregivers to provide patient care and support by constantly monitoring data related to patients through mobile apps and connected medical devices even when patient(s) or doctor(s) are located at remote locations. This research paper discusses about six use cases explaining how IoMT is applied in healthcare industry.***

Keywords: Healthcare, Artificial Intelligence (AI), Internet of Things (IoT), Internet of Medical Things (IoMT), Machine Learning.

I. INTRODUCTION

The Internet of Things (IoT) has paved way for infinite possibilities in the healthcare industry like when normal medical devices are connected to the internet; those connected devices will be able to gather invaluable additional data to provide additional insights into symptoms so that the doctors and caregivers can deliver remote care to the needy patients. IoMT helps the patients not only to gain more control over their treatments but in turn control over their lives too. IoMT offers exciting benefits to both doctors and patients with faster and increased accuracy in the diagnoses, effective healthcare service delivery at the reduced costs. With the help of IoMT, doctors can collect patient health data in real time using his/her smartphone without the need to make a visit to the patient's room nor to call and enquire a nurse about a patient's health status. On the other hand, IoMT also help insurers to analyze the patient data swiftly and can initiate the claim process more quickly and accurately. Undoubtedly, the development of various smart devices and wearables help both doctors and patients immensely in the healthcare industry. Doctors can use various healthcare apps to constantly track their patients' health status. In turn, patients can receive suitable advice from doctors related to their treatment through smart medical devices. AI Software will be able to wisely classify through a flow of data from IoMT devices to provide only the required data related to patients to doctors in a timely manner that needs their attention as the capability to process all that gathered data is very important to the success of the technology. It should be noted that, in IoMT, most of the smart medical devices will be able to make the patients' life easier primarily during their prolonged illness and at times, some of the smart medical devices may literally be a patients' lifesaver.

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II. STATE OF IOT IN HEALTHCARE INDUSTRY

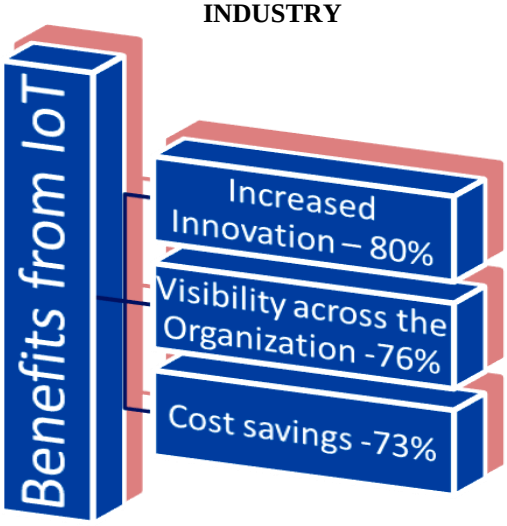

Fig. 1. Benefits from IoT

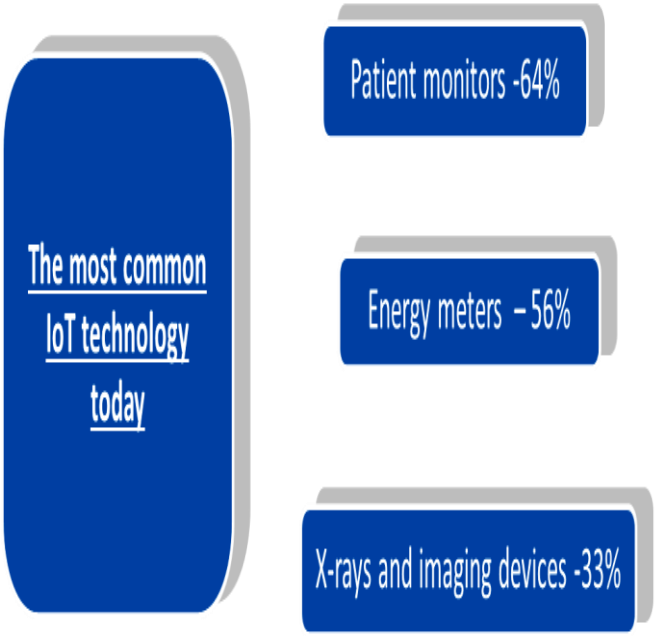

Fig. 2. The Most Common IoT Technology Today

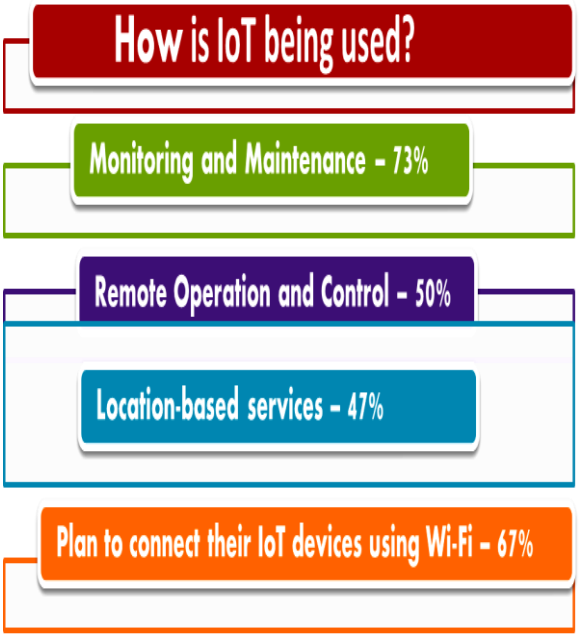

Fig. 3. How is IoT being Used?

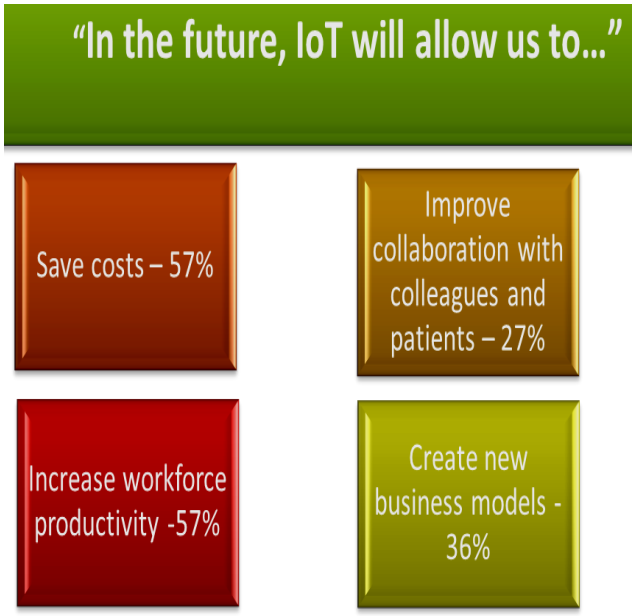

Fig. 4. "In the future, IoT will allow us to…"

Reimagining the Future of Healthcare Industry through Internet of Medical Things (IoMT), Artificial Intelligence (AI), Machine Learning (ML), Big Data, Mobile Apps and Advanced Sensors: SIX USE CASES

In this research paper, six Medtech organization's /universities [ihealth labs, widex, Augmedics, Crycadia Health Inc, Mediate (MIT-spinoff AI Startup), Rice University, Texas & IBM Research] healthcare products/services are concisely discussed in the ensuing paragraphs. Hospital executives/doctors/decision makers should plan to integrate these healthcare products/services depending upon their requirements in hospitals while providing healthcare services to patients.

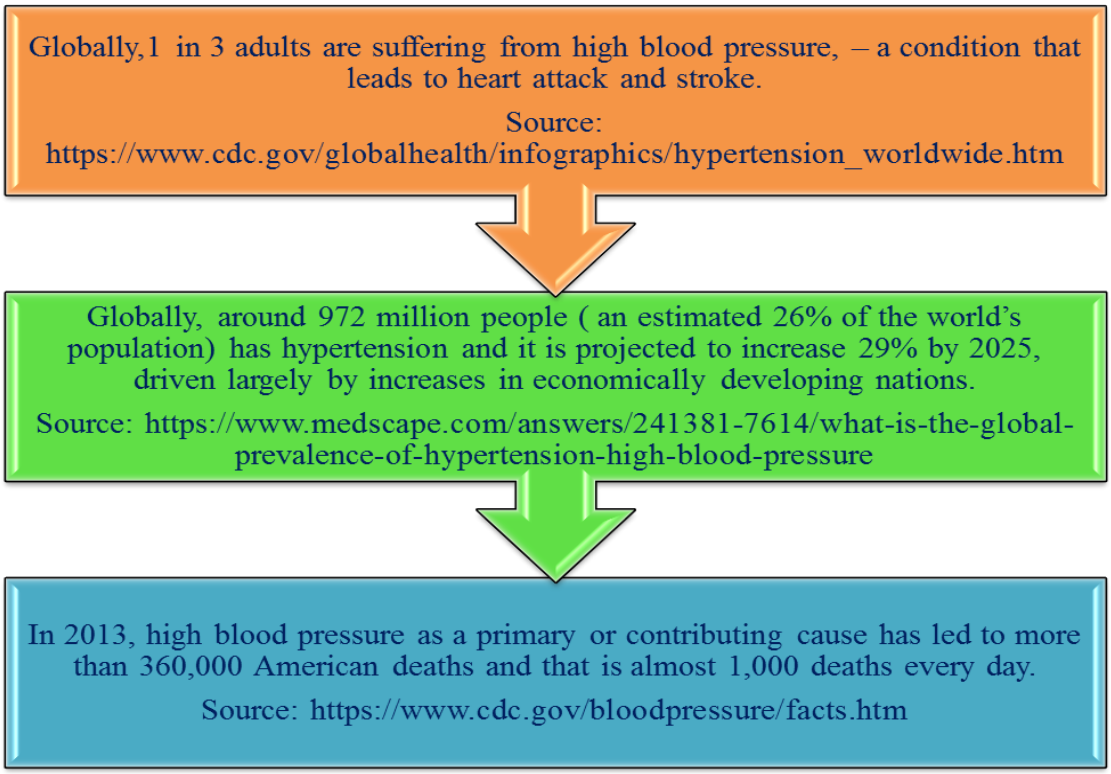

***Fig. 5.* Research Statistics on High Blood Pressure**

1)

ORGANIZATION NAME	**healthlabs**
PRODUCT NAME	**Health Feel**

Health Feel is a wireless blood pressure monitor which works like the blood pressure monitor which a patient can find in the doctor's hospital. It is validated by BHS and dabl for accuracy and also approved by FDA to be a medical-grade device. All the information from a patient's blood pressure monitor
can be accessed only by the patient and hence it is protected and secured. Moreover the patient can share the data from the iHealth app to the doctor/care giver in various formats like pdf, csv or excel file. Charts and visual trends will enable the doctor to easily analyze lifetime progress and various statistics related to a particular patient's blood pressure.

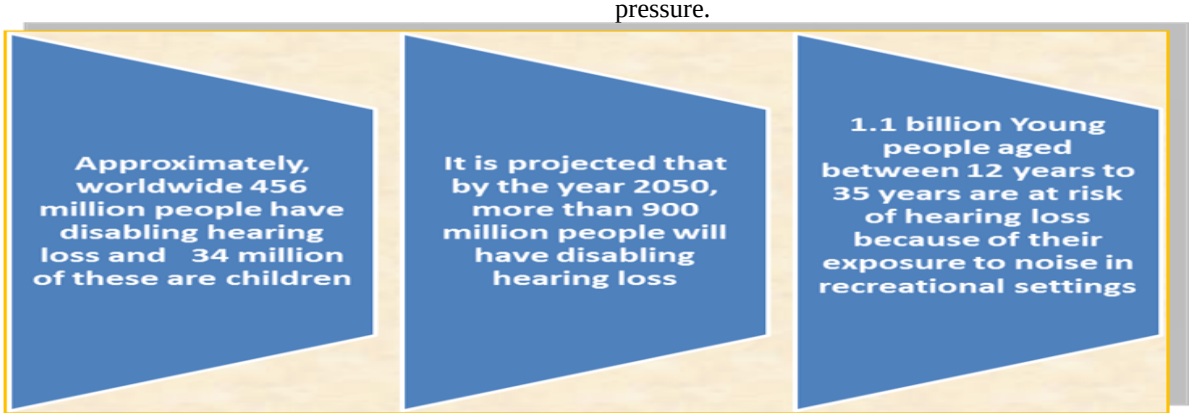

***Fig. 6.* Research Statistics on Hearing Loss**

2)

ORGANIZATION NAME	**Widex**
PRODUCT NAME	**COM-DEX**

Widex, based in Denmark is a leading manufacturer in hearing solutions has come up with COM-DEX solution which is capable of streaming high quality sound from any Bluetooth device to a Widex hearing aid. One who uses it can continue the conversation with their conversation partner even in noisy environments or at a distance. The hearing aid user will be able to take calls or listen to music when the connection is established with the user's phone.

Fig. 7. **Research Statistics on Spinal Cord Surgery (SCI)**

3)

ORGANIZATION NAME	**Augmedics**
PRODUCT NAME	**xvision**

Augmedics based in Israel has developed augmented reality headset called xvision for surgical procedures which will help neurosurgeons to have X-ray like visualization. It is a light weight device and helps neurosurgeons with powerful visualization of patient's anatomy easily switching between 2-D and 3-D image. Neurosurgeons can have accurate and constant tracking of surgical instruments. Spine surgeons can have safer outcomes and shorter surgeries with the help of xvision's software navigation system and it is compatible with all leading imaging systems like Siemen's Cios, O-Arm Ziehm Imaging RFD 3D and so on.

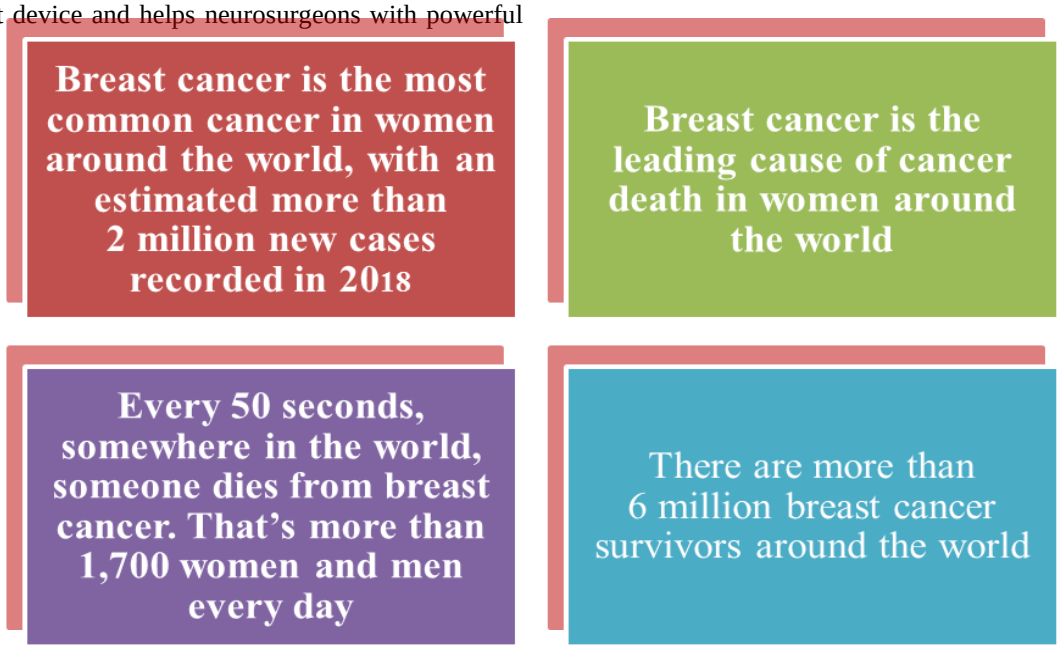

Fig. 8. **Research Statistics on Breast Cancer**

4)

ORGANIZATION NAME	**Crycadia Health Inc**
PRODUCT NAME	**iTbra**

Research studies indicate that a dense breasted woman has the probability of six times more to develop breast cancer. Crycadia Health Inc based in US is working on a wearable bra prototype called iTbra which can detect breast cancer at an early stage and can be used as a cancer screening tool at home itself without the necessity to visit a doctor or a hospital. iTbra is easy to wear anywhere anytime, with no pain, no pressing, no uncomfortable examinations and no radiation. iTbra can be worn underneath garments for 2 to 24 hours to assess breast wellness and it can detect abnormal circadian temperature changes (which can lead to breast cancer) within breast tissue. The data collected will be communicated anonymously from the user's mobile or pc to the Cyrcadia Health Core Lab for analysis. After the data submission, using its predictive analytic software, Crycadia Health will send accurate, reproducible and automated results to doctors and reports can be shared with family members too.

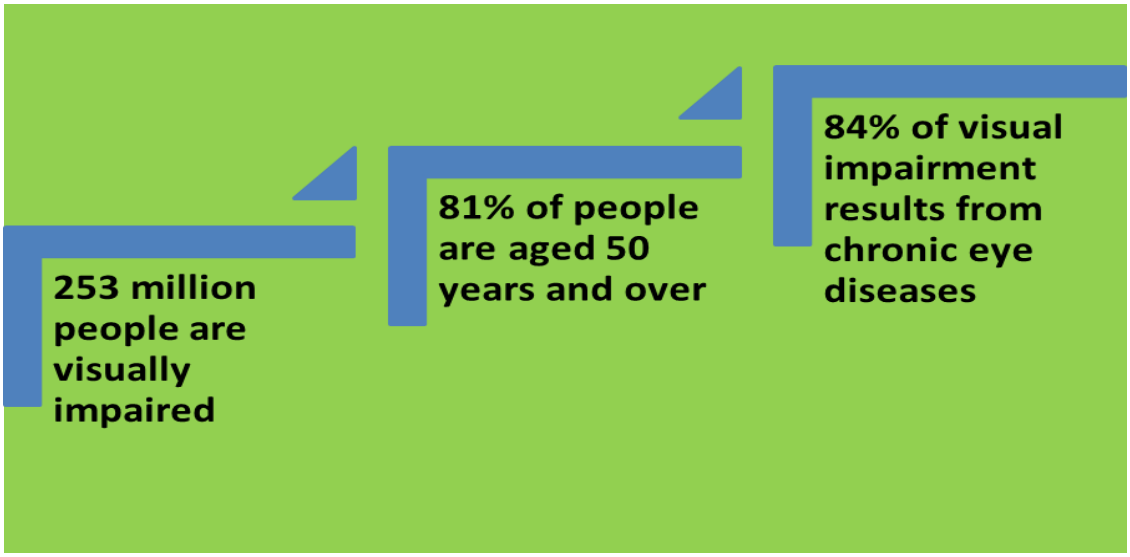

Fig. 9. **Research Statistics on Blindness**

5)

ORGANIZATION NAME	**Mediate (MIT-spinoff AI Startup)**
PRODUCT NAME	**Supersense**

Mediate (MIT-spinoff AI Startup) has developed an AI app called Supersense to help blind and visually impaired to find the empty chairs, stairs, doors or any other objects. Mediate is led by a team of entrepreneurs, researchers in the AI, designers from MIT, Harvard and McKinsey and generously supported by National Science Foundation. The AI app is supported by Android 6.0 and above and for the first week subscription is free and users of this app can cancel it during the first week without making any payment.

This AI app can also be used to explore a new room or an environment. The user need to choose what he/she is looking for and scan the environment with his/her smartphone. Supersense will be able to find it without an internet connection.

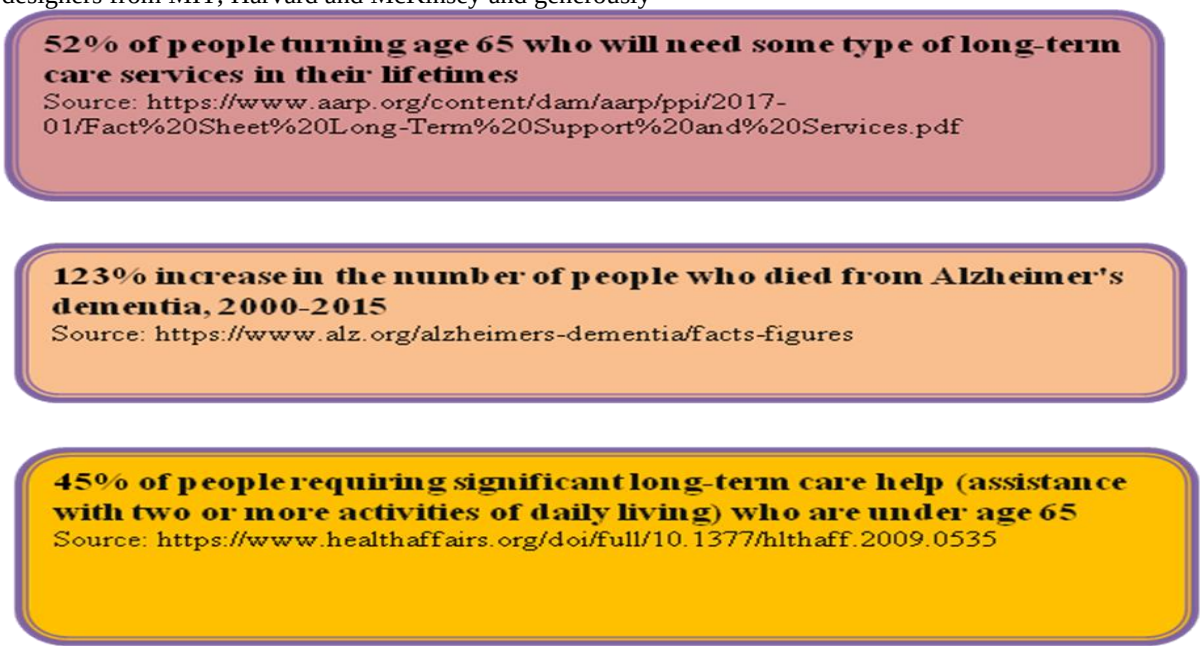

Fig. 10. Research Statistics on long-term care services

6)

ORGANIZATION NAME	**Rice University, Texas & IBM Research**
PRODUCT NAME	**IBM MERA**

In association with Rice University, Texas IBM Research is working on a prototype called IBM Multi-purpose Eldercare Robot Assistant (IBM MERA (pronounced as mee-rah)). IBM MERA can be a personal assistant to elderly people like helping them to get up when they fall down, can answer the health related questions posed by elderly people like symptoms of a heart stroke etc.,. Further, IBM MERA can also scan and read heart rate, variability in heart rate and breathing rate of elderly. With the help of cognitive technology, sensors are connected with walls, floors, ceilings and other wearables, this cognitive agent will be able to learn different patterns of day to day activities of elderly like wake-up time, breakfast time, exercise time and time of medicines taken by elderly and to verbally remind elderly when they forget to take prescribed medicine on time.

IBM Research is using "Embedded Cognition" technology which will combine real-time data generated by sensors with the help of cognitive computing and provide more meaningful insights to doctors/care givers to make better and informed decisions with regard to elderly patients.

III. CONCLUSION

The growth of IoMT is due to rapid digitization in healthcare and the development of mobile health care apps which in turn helps to deliver effective patient care especially for the ageing population and patients who are long suffering from chronic diseases. The IoMT in health care industry is radically shifting from reactive and largely sporadic models of health care that are considered to be costly and unproductive to operate, to health care models that are proactive, digitally connected which makes possible to deliver better value for patients. Thus, undoubtedly, with the application of Internet of Medical Things (IoMT) in healthcare industry will certainly help healthcare providers to deliver efficient and cost-effective healthcare delivery to patients with a meaningful and positive impact.

IV. FUTURE IMPLICATIONS

The growth of IoMT arrives at a time when healthcare delivery seems to be increasingly expensive. Therefore, Medtech organizations either they are start-ups or established organizations, there is a need to reinvent themselves to sustain in the competitive healthcare industry. They need to formulate appropriate strategies to effectively utilize BIG Data gathered from digitally connected healthcare devices so that their respective healthcare business and operating models can be more relevant and sustainable. Thus, ever changing regulations in healthcare industry, rise of new technologies like Artificial Intelligence, Big Data, Machine Learning, 3-D Printers, Mobile Apps, Advanced Sensors will certainly pose several challenges (like data security, data privacy etc.,) as well as opportunities to the healthcare industry. Though it is obvious that robots and automation will certainly replace some of the repetitive jobs, they will also create new types of jobs wherein specific and specialized employee skill sets need to be necessarily utilized.

Furthermore, some organizations will be using IoMT technologies to aggregate data thereby offering healthcare consultative services by the way of predictive analytics. Thus the rise of connected healthcare devices and increase in the adoption of smartphones usage will fuel the rapid growth of IoMT in the healthcare industry for an efficient and better patient care delivery at an affordable cost.

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