

Summer Training Report

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Abbreviations

HTI	Healthcare Technology Innovation
AI	Artificial Intelligence
MI	Machine Learning
BD	Big Data
EHR	Electronic Health Records
EMR	Electronic Medical Records
IT	Information Technology
IOT	Internet of Things
IPHS	Indian Public Health Standards
PHC	Primary Health Care
MOHFW	Ministry of Health & Family Welfare
CTQ	Critical to Quality
CDF	Cumulative Distribution Function

PART- 1

Assigned by faculty Mentor

WORK FROM HOME PROJECT- REPORT

The changing landscape of Indian Hospitals- *Implementation of Technology innovations and challenges associated with them*

INTRODUCTION

Technology has impacted human lives in myriad ways. Its expanse today, stretches from the hitherto “conventional” sectors like “brick and mortar” businesses, to even the most advanced of financial markets. By essentially blurring the line between human capabilities and that of its limitations, it has played a pivotal role in development and advancement of the whole of human race. Healthcare sector is no different, and the rapidly evolving technology innovations, have thrown up huge opportunities which until now didn’t exist. Among many other factors, the primary ones fueling the technology adoption are viz. change in life style, climate change, increase in life expectancy and demographic transitions.

Technological innovations and its adoption by the healthcare industry has evolved over the years. It has helped in easier collection and archiving of critical patient information (data). “Data is the new oil” - as the saying goes, the availability of such macros to healthcare professionals, has revised the whole perspective and approach towards understanding of critical illness and the quality of treatment meted out to their patients.

Private institutes in general, have been much more perceptive of the opportunities that these technology measures offer and their adoption rate is higher when compared to the public ones. Many private hospitals, especially in tier 1 and tier 2 cities, have been at the forefront of driving such innovations, with a few of them viz. Max healthcare, Fortis Healthcare, Apollo Hospital having already implemented EHR (Srivastava, 2016).

Despite all the hullabaloo around the potential of such innovations and its adoption in the healthcare sector, unfortunately, India has been relatively slow on this front, when compared

to its peers in other developing countries. The reasons underpinning this anomaly can be figured out by taking a closer look at the challenges plaguing the adoption of such measures.

This report aims to do just that and will review the current challenges encountered by Indian hospitals in the implementation of technology innovations. It would further analyze the possible solutions to overcome these challenges and mitigate the anomaly.

OBJECTIVES

- To lay down the importance of implementing technology innovation for the future evolution of healthcare.
- Describe the various types of technological innovations presently being used in the hospitals.
- To understand the Existing Challenges that hinder the adoption of technology innovation in Indian Hospitals.
- To analyze the existing challenges and provide the suitable suggestions for the same

METHODOLOGY

This study is based on review of past studies, reports, and other refereed articles. The primary information on which the researched report is premised is sourced from numerous studies, blogs, articles and newspaper periodicals. The information from such sources have been assessed, structured and analyzed to device possible solutions that may prove useful in tackling the primary challenges.

In order to plug the gaps in information needed to base this study upon, a comprehensive survey literature was done using tools like – pub med, google scholar, Research Gate, etc.

1.REASONS FOR ADOPTION BY INDIAN HOSPITALS

According to recent UN projections, India is set to surpass China as the world's most populous country. The present population of India is approximately 1.37 billion. Providing quality healthcare to millions spread across the geography is a difficult task, especially when the doctor to population ratio and hospital beds to population ratio is not adequate in India. Hence, healthcare innovation technologies can help improve healthcare delivery by working on Affordable, accessible and effective healthcare.

Innovation could be a way out for achieving affordability in healthcare delivery for populous countries like India. Hospitals use a slew of systems to store various internal data such as the patient vitals, reports, administrative data etc. Trying to access the needed data and its analysis consumes a lot of time as well as man power, leading to higher costs. The introduction of Big Data and Analytical tools to hospitals has made storage and analysis of vast data better and easy thereby making it affordable. We can safely say that affordability is a precursor to availability and accessibility.

Artificial Intelligence (AI) and Machine learning (ML) has the potential to provide real time wisdom to the front-line workers in every decision that needs to be made. Along with Decision support, image analysis and patient triage AI and ML help physicians in making smarter choices. Machine learning can graphically represent data to further analyze problems and illness, much faster than any physician. This may help healthcare workers to have a better understanding of illness and its treatment. Robotics in the domain of surgery (Ahmed, 2019) (Andonian S, 2018) help surgeons to perform high precision surgeries, and help serve better outcome to patients (Tabor, 2007). This may further reduce cost due to post- operative complications. Improving outcomes with the help of technology can help make "Smart hospitals" more patient centric.

The Healthcare environment keeps changing and is very volatile. There are external forces that has the potential to drive changes in the healthcare system. Factors such as customer behavior patterns, where almost every other person with a smart phone today has access to knowledge and therefore a burning desire to receive the best possible services. This constant desire to have

the best of healthcare services, makes the Indian Hospitals adopt and implement advanced techniques and innovate medical practices for customer satisfaction. This approach is called the consumerist approach where healthcare is seen as a marketplace in which patient (consumers) are involved by making choices about the services, and healthcare market responds to their preferences (Catherine Foot, 2014).

Analytical tools such as AI and Big data are the tailwind to future healthcare delivery. As cited by Rajesh Shewan (Head – Technology and Solution Architecture, Teradata India) in an interview in 2017 - Big Data can help in marketing by understanding the current customer needs. Analyzing the available data may help organizations become more efficient in providing healthcare services that are tailored to specific needs of a patient. Innovation is critical to future healthcare.

The revenue cycle of a hospital is an area that is labor intensive. AI and automation present an opportunity to the hospitals to cut costs by streamlining and optimizing manual processes, since automation is an affordable way to reduce labor cost. Hospitals with AI implementation can be more strategic towards the work they outsource. In house work dealings can reduce the amount paid to a third party. Revenue from AI application is most likely to have a tremendous growth over the coming years (Figure 1).

Enterprise artificial intelligence market revenue worldwide 2016-2025

Revenues from the artificial intelligence for enterprise applications market worldwide, from 2016 to 2025 (in million U.S. dollars)

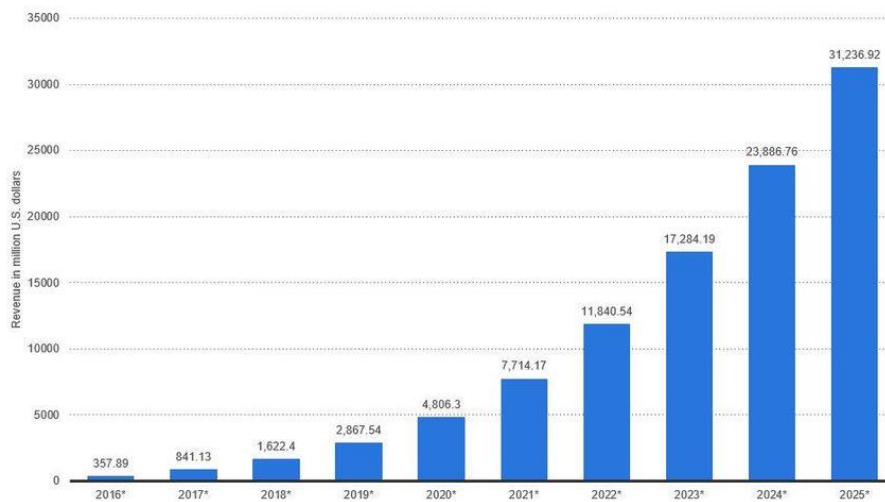


Figure 1: Source- Statista

Global revenues from AI application is projected to grow from 1.62B\$ in 2018 to 31.2B\$ by 2025- attaining a 52.59% CAGR in the forecast period. According to this survey report the projected AI growth in enterprise is fueled with these few applications of AI in Image Recognition and tagging, Patient data processing, predictive maintenance, localization and mapping, use of algorithms and machine learning to predict and prevent security threats, HR systems, and intelligent recruitment.

Reasons for adopting AI worldwide 2017

Business organizations' reasons for adopting artificial intelligence (AI) worldwide, as of 2017

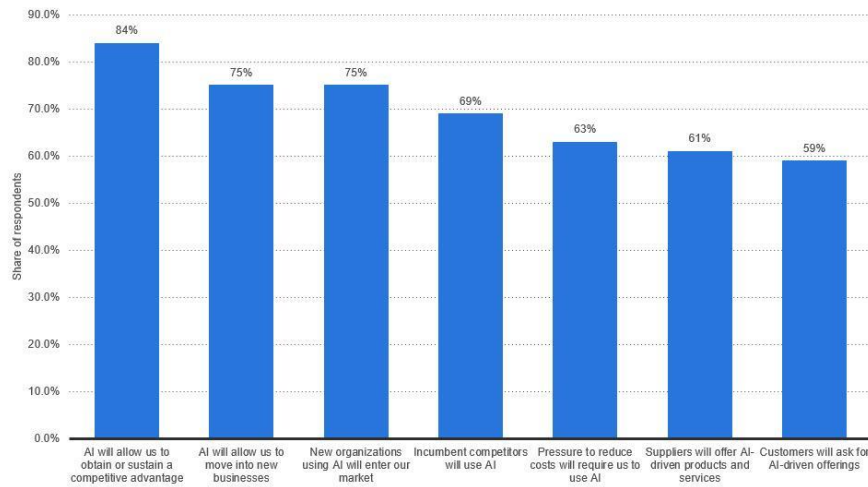


Figure 2 : Source: Statista

According to this survey, 84% of enterprises believe that investing in AI will lead to a greater competitive advantage. 75% believe that AI will open up opportunities for new projects and businesses while also providing competitors new ways to gain access to their markets. And, 65% of enterprises believe the pressure to reduce cost will require the use of AI.

2.TYPES OF HEALTHCARE TECHNOLOGY INNOVATIONS IMPLEMENTED IN INDIAN HOSPITALS

2.1. ROBOTIC SURGERY

Robotic surgery is one of the most promising innovative technology in healthcare industry. Surgical robotics has revolutionized conventional surgical method and set a new “gold standard” in healthcare. Robotic surgeries cover wide spectrum of medical procedures like the Minimally invasive surgeries which were adopted to avoid all complications that resulted from open surgery as it depends on small incisions (Haggag, 2005). The most common types of Robotics used in medicine are- Da Vinci Robotic system, Veebot, Hanako etc. The advantages of Robotic surgeries are as enumerated below:

- Used for minimally invasive surgeries
- High precision - which helps the surgeon in minimizing errors and post-operative complications eventually resulting in better healing/quicker recovery of the patients.
- Minimal chances of infection.
- Less pain and blood loss of the patient, during and after surgery (Jeelani S, 2015).

LIMITATION

A major limitation of Surgical Robots is its cost (Jain S, 2015). Though, the global Robotic surgical market is growing at a rate of 10 percent, the Indian market is still small due to the high cost associated with the procedure.

To set some context, the third and fourth generation da Vinci robotic surgical system used in India cost \$1 million and \$2 million respectively (Ahmed, 2019). Meeting up with such high prices is not only challenging for the patient but also for the hospitals.

2.2. ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

Artificial intelligence (AI) is the property of computer programs, machines and systems, which has the capability to perform certain functions with intellect, creativity and with independence just like a human being does. Most artificial systems have the ability to think and learn while giving possible solutions and making decisions for a given problem. AI has the potential to work with 90-96 percent accuracy and reliability (Jahanzaib Shabbir, 2018).

AI technology is being used widely across the world in different industries for its known capabilities and potential. Healthcare industry has also adopted this technology to provide high quality services and to use its tools to figure out solutions to healthcare problems/ issues, with speed and accuracy, and to come up with possible solutions for the same.

According to an analysis done by “PWC”, AI can be extremely beneficial to Indian healthcare system and probably is the only possible solution to India’s present situation, where we have only 1.1 Hospital beds, 0.7 doctors and 1.3 nurses per 1000 population (which is much below the acceptable levels prescribed by WHO, of having 1 doctor per 1000 population). Therefore, AI can fill in this gap, by helping doctors to treat more patients efficiently and faster.

2.3 MACHINE LEARNING

Machine learning (ML) is a statistical tool for fitting models to data and to ‘learn’ by training models with data. Machine learning is one of the most common forms of AI (Kalakota, 2019). In healthcare, ML is commonly used for predicting the treatment protocols, which is most likely to succeed on a patient based on various patient attributes and treatment context. This is commonly known as Precision medicine (Lee SI, 2018).

The potential uses of AI and Robotics is vast in Healthcare industry. **Figure 3** explains how AI and robotics together can transform the world of healthcare in eight different ways.

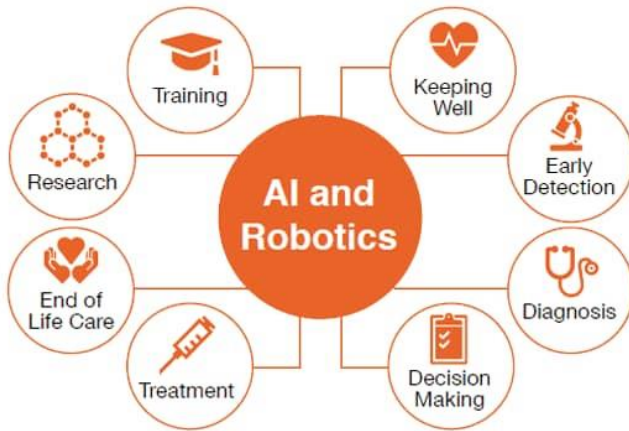


Figure 3: Source: PWC Report

LIMITATIONS

- Concern among the healthcare providers regarding the reliability of medical devices, to the lack of healthcare regulatory body in India. While, although the Medical device rules act 2017 became effective in 2018, its effectiveness is yet to be seen.
- Clinical data sharing seems to be a difficult task among clinical practitioners and among hospitals in India.
- Unaffordability is a huge challenge in the implementation of AI. A survey conducted by PWC showed, how a personal oncology consultation charges can be much affordable as compared to Oncology consultation using AI Software.
- Healthcare organizations store, maintain and transfer a huge data, it is often challenged with safety and security concerns regarding patient's personal information, due to lack of technical support (Karim abouelmehdi, 2018).

2.4. BIG DATA (DATA SCIENCE)

Big Data refers to large & varying data sets, that can be collected, stored and later analyzed to provide insights to an organization (Knight, 2018). Healthcare industry is one of the most promising industry where Big Data is used. It is most often used for healthcare analytics. Big Data helps in collection and structuring of large complex data sets collected from various departments of the hospitals, patients, devices, etc. (figure 4) and is analyzed for improving the services and efficiency of the organization. Large unstructured data sets are easily collected with the help of various digital tools from different departments of the hospital, and are converted in a structured manner to be analyzed further. A few of such data sets are :

- Nursing Diagnosis, interventions and outcomes extracted from the Electronic Medical Records (EMR) (Jane Englebright, 14 (4) (2016)).
- Medical and clinical data from Imaging and Laboratory examination.
- Also, data sets like, Electronic health records (EHR), Pharmacy Prescription, Insurance records, etc.

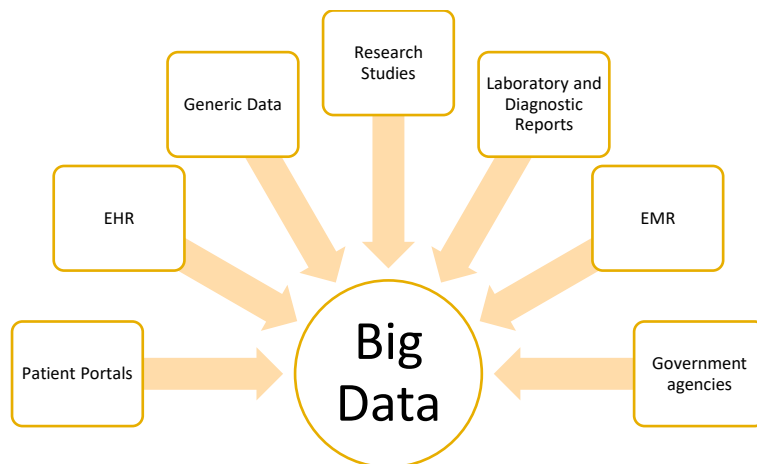


Figure 4. *Role of Big Data in Healthcare*

Big Data in collaboration with deep learning and the use of HER, can help in the making of prediction models at hospitals, for diagnosing many health problems (Maragatham G, 2019).

LIMITATIONS

- One of the major concerns faced in the implementation of Big Data, is the privacy disclosure of underlying data. Big Data technology exposes personal medical data of patients to a greater risk and it is quite evident, that it is now more difficult than ever, to protect such information (LIANG HONG, 2018). Medical data sets are huge and contain information from every department and functioning sections of a hospital. The transfer and analysis of these large data sets are expensive.
- Information Barrier- A large amount of data set is scattered in different information pools, and there is only a minimal interconnection between these data set. Also, data sharing mechanism is imperfect, due to the information barriers between hospitals and other institutes (Kruse, 2016).

2.5. ELECTRONIC HEALTH RECORD SYSTEM (EHR)

EHR is the real time record of a patient charted digitally. It is a technology innovation that has led to a reliable and safer storage of patient records. It safely maintains information of the patient health data and makes it available only to the authorized person. EHR is useful for the storage of data. This stored data can be used by the healthcare practitioners to analyze (Figure 5), by leveraging other technological tools like AI & Big Data, and understand the disease patterns, improve efficiency and effectiveness of the care delivered to their patients (Electronic Health Record, 2019 updated). EHR standards were first notified in 2013 in India by MoHFW, and its revised version in 2016. Most of the corporate hospitals in India like Max Hospitals, Apollo Hospital, Shankara Netralaya Hospital , Fortis Hospital, etc. has implemented EHR (Srivastava, 2016).

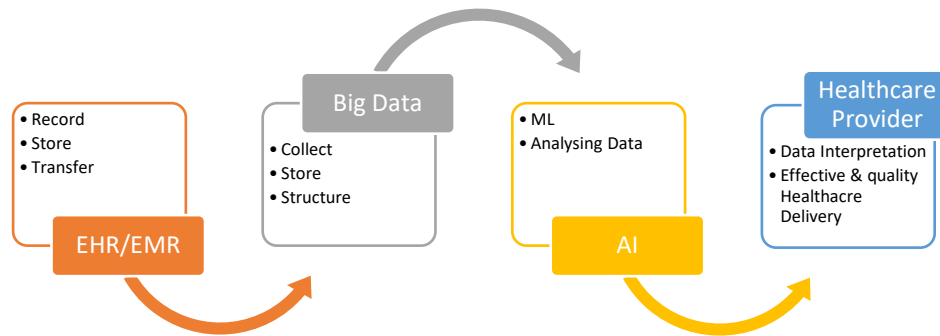


Figure 5. *Process of an effective Health care delivery system using HTI*

LIMITATIONS & CHALLENGES

(Mukul, 2018)

Introducing change in any organization culture takes time to be accepted. Success of EHR relies first on the acceptance by the clinicians who should use them to record clinical patient data. Hence their attitude plays a key role in the implementation of EHR in the organization.

Lack of knowledge and training of the clinicians to operate digital and computerized methods. EHR's lack of "ease to operate" design is a major impediment along with the lack of awareness amongst clinicians on the safety protocols of the EHR.

- The practice of 'data hugging' by many health care practitioners which leads to inadequate and incomplete data sharing via EHR.
- Lack of awareness among the clinicians about the safety protocols of the EHR.
- Insufficient investment towards hardware and software in the public health sector makes the implementation of such technologies next to impossible.
- Minimal to no backup, in case of mechanical failure or damage.

3. IMPLEMENTATION CHALLENGES OF HEALTHCARE TECHNOLOGY IN HOSPITALS IN INDIA

Technology slows down many physicians. Introduction of EHR has changed the conventional charting system, from where the patient's information used to be hand written. On the hand, patient's information charting and recording has to be keyed in manually, which is seen by many as more time consuming viz. a viz. scribbling by the physicians, since most of them are new to technology (Robert Pearl, 2014), thereby leading to decline in their productivity.

Data interoperability is also a major concern for all healthcare organizations. There is no specific industry standard for data sharing. Hence, lack of interoperability makes it difficult to share patient's data between organizations. This denies access of physicians to certain disease or information, which could have been analyzed to make better medical decisions resulting in duplication of medical tests thereby making the overall treatment process slow and adding to its cost (Siddhartha, 2018).

Common barriers seen while using Health information systems such as EHR in Indian Hospitals are enlightened in a survey in 2018 (**Figure 6**). Most common barrier is the resistance to implementation from physicians, lack of interoperability, and inadequate IT infrastructure (staffs).

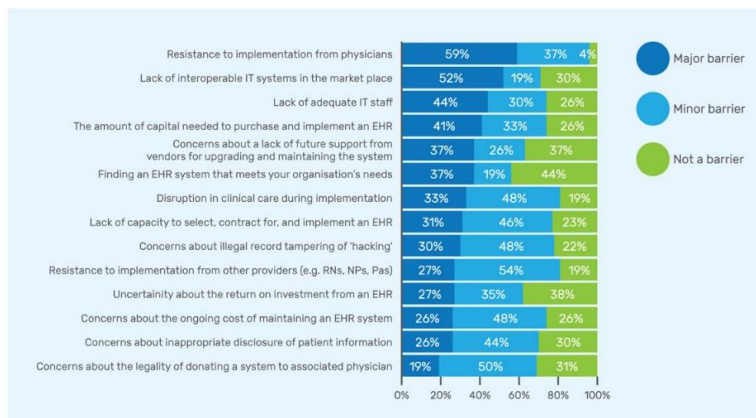


Figure 6: Barriers to health information systems use [source: (Adam C. Powell, 2018)]

Consumer awareness and demand plays a very important role in the adoption of Healthcare Technology Innovations . (DAVIS, BAGOZZI, & WARSHAW, 1989) Mentioned that external attitudes and internal intensions play a huge role in the acceptance and adoption of a new technology to any field. Using the same theory, we can infer that the acceptance of new technology in the healthcare system by the patients can take time. This can further lead to a delay in its implementation by hospitals. Behavioral factors that affect technology adoption may not only be limited to consumers but also to the healthcare providers as well (Devendra Dhagarra, 2020). A study conducted by (Raj Vaithamanithi, 2016) based on theoretical review of existing model such as Theory of Reasoned action (TRA), the Technology Acceptance Model (TAM), the Motivation Model (MM), the Theory of Planned Behavior (TPB), etc., unveils the perceived relationship between Clinicians and technology adoption by them. Based on this study the most intervening factor for technology adoption could be ease associated with using technology, the willingness of clinicians to try out new technology, and their individual performance expectancy related to the use of new technology.

Industry conservatism is a challenge. Convincing industry stakeholders of the positive return on their investments with AI adoption can be difficult. Whilst healthcare institutions are inclined towards adopting technology and digitalization, Private and government Investors do not find such investments worth it. They would rather invest in improving medical facilities in hospital i.e. increasing the strength of staffs and beds, etc. (Korgaonkar, February 2014) than investing in technology and digitization. The initial high cost and uncertain financial benefits are potential barriers for the adoption of any new technology in the form of hardware or software in a healthcare organization. For example, the high upfront cost of EHR initial installment is its primary barrier (Robert H. Miller, 2004).

(B Reshmi, 2010) carried out a study aimed at finding out the awareness of healthcare professionals and their perceptions of using Electronic Medical Record (EMR). The study showed that a major challenge in the implementation of EMR, is the concern of physicians regarding confidentiality and privacy of patient records (87%). Another significant percentage of physicians had concerns regarding unwillingness of physicians to devote time for EMR

training. This may have a huge impact in the effectiveness and productivity using EMR systems. EHR has a huge storing capacity and features that can be utilized for capturing all kinds of data generated in an organization. However, these features are underutilized by physicians from in healthcare institutions in India. A survey ([Figure 7](#)) throws light on the usage of EHR/EMR by physicians in Indian Hospitals. The most commonly used feature is patient demographics, whereas every other feature is the least used and thus has the lowest data stored in such categories. For example, the number of immunizations record was the least recorded in EHR in the given survey.

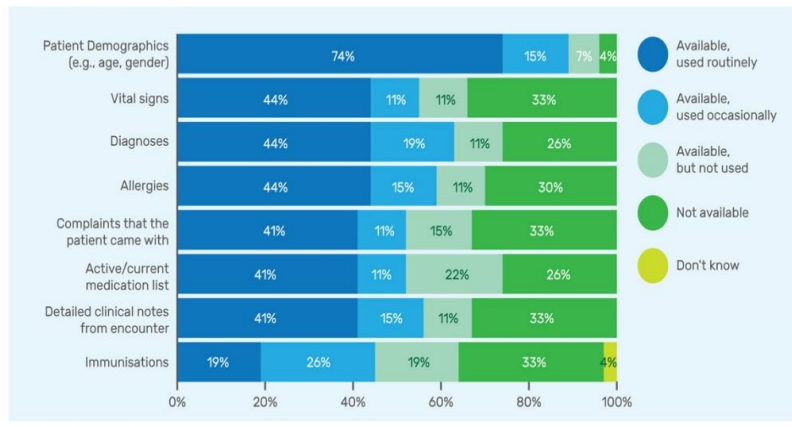


Figure 7: Reported clinical data on EHR within the organizations [Source: (Adam C. Powell, 2018)]

Interoperability of Data is the need of the hour in Healthcare industry. Plenty of data such as patient records and reports are stored in Health Information Systems (HIS) such as Electronic Health records (EHR) in hospitals. This stored data is only useful if it is being analyzed to learn the current state and predict future disease patterns to deliver the best healthcare service. Thus, for analysis and predictions, these stored data must be protected and shared. Government's initiatives like Information Technology (Reasonable Security practices and procedures and sensitive personal data or information) Rules of 2011 ('The Data protection rules'), a set of rules prescribed under the Information technology Act 2000 and the revised Electronic Health Record standard in 2006, are all focused on safe data protection and sharing, but unfortunately the plan couldn't pass muster.

Implementation of any new technique or adoption of technology is associated with a learning curve (Bach C, 2014) , which not only makes the practitioner more skilled and proficient but is also beneficial in terms of patient safety. Robotic surgical system being a mechanical one, is more prone to have mechanical damage and malfunctions. In an article published by (Sundaram, 2017), he talks about - how with the evolving technology implementation in hospitals, the risk of surgical failures and complications would increase, and thus the staffs and practitioners have to be trained and updated with the evolving technology to trouble shoot any problem that may arise. (Andonian S, 2018) in his article has reviewed a study, where the rate of decline in robotic surgery complications were seen over a period of time with relation to increase in trained staff.

Technology Implementation in any healthcare institution/organization in the form of hardware or software requires a backbone for its support, i.e., a well-built infrastructure is also very crucial for the adoption of technology. Massive amount of data collection, storage of data from different devices and outputs, implementation of various software and tools requires a strong IT infrastructure in every organization. Internet of Things (IOT) is required for using every such tools and software for collection, transfer and for the application of machine learning. Many healthcare organizations and institutions lack a stronger internet connection and network support especially the ones situated in outskirts of the country where the availability of such technology is limited or not accessible and almost all government aided hospitals that lack proper infrastructure. In spite of IPHS guidelines for PHC in India, mandating the implementation and provision for computers and internet connectivity, many PHCs still lack these facilities. And the ones that have the availability of resources such as computers, are underutilized.

A survey conducted by Mckinsey & Company (**figure 8**), shows that the concerns regarding AI implementation in Healthcare Organizations by different stakeholders. Top concerns are lack of interoperability/systems for data sharing. And the major concern of healthcare professionals is lack of skills in data analytics/understanding of AI. This data also reflects concerns regarding inadequate funding and lack of interoperability and quality of data as potential barriers in the initial implementation of AI in healthcare.

WHAT ARE THE MAJOR BARRIERS FOR INTRODUCING OR SCALING AI IN HEALTHCARE ORGANISATIONS?

Startup executive, investor and healthcare professional responses

percent

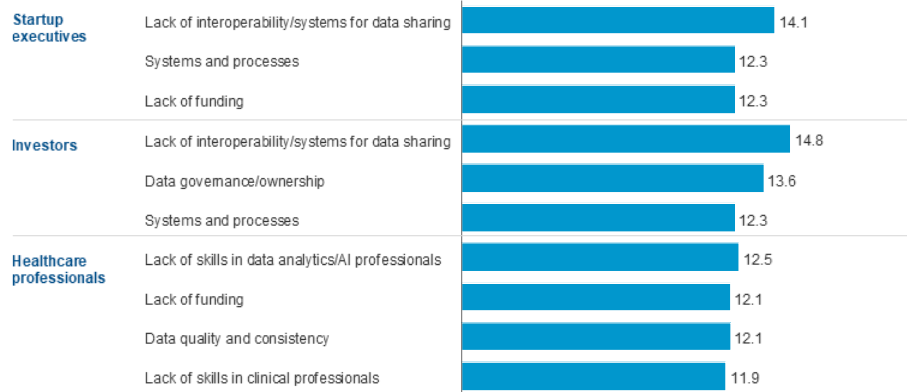


Figure 8: Source: Mckinsey & Company (Transforming Healthcare with AI, March 2020)

4. GOVERNMENT'S INITIATIVE FOR TECHNOLOGY ADOPTION IN INDIAN HEALTHCARE SYSTEM

Indian Govt. believes Technology is the new vanguard of health. And is looking forward to and is presently working on new policies and framework for technology adoption for efficient, affordable and accessible healthcare delivery all across India.

MOHFW in 2013 first notified Electronic Health Records (EHR) standards for India with an objective to introduce a uniform standard-based system for creation and maintenance of EHR by Healthcare providers. These standards were revised over time and the MOHFW notified new standards for EHR in 2016 which encouraged its adoption in the IT systems by healthcare institutions/ providers across the country.

MOHFW in 2015 proposed an authority “National eHealth Authority (NeHA)”, which is to be responsible for development of an integrated health information system in India (NHP India).

Ministry of Commerce and Industry set up the “Task Force on AI for India’s Economic Transformation” in 2017. It is set up to leverage AI for development in various fields. This Task force advices and implements recommendations to various research institutions, industry and government. The Ministry of electronics and information Technology formed a ‘Policy Group’ to study AI and build a policy framework for its’ adoption.

NITI Aayog is currently working on strategies on implementing Electronic Health Records (EHR) across India “to help create a longitudinal medical record for every individual and enable sharing of the same across health facilities”. The project aims to: looking at IT requirements, ensuring interoperability, defining data privacy and security guidelines, establishing the institutional framework and measures to increase adoption of EHR systems. (Mishra, 2020).

ROAD MAP FOR INDIAN HEALTHCARE

- There has to be greater emphasis on the quality of the available clinical data without errors, which is critical to enable its widespread adoption.
- Private and public healthcare sector should work together to form a reliable functional cloud system which can allow data storing. This will help not just in the ease of getting required data, but it will also make it less expensive.
- Implementation of a stronger functioning regulatory body in India for medical devices, to ensure data privacy, security and improve interoperability of data while also making the use of medical devices more affordable.
- ‘Made in India’ goods and services will not just help encourage employment opportunities but will eventually lead to affordability and accessibility of services such as healthcare. Affordability is a huge factor that is responsible for the adoption of Healthcare Technology in Indian Hospitals. Therefore, Government should start investing more and motivate Indian entrepreneurs in coming up with innovative healthcare technologies, that can help in reducing cost and increase affordability. Startups are revolutionizing healthcare delivery in India, by bridging the Gap between healthcare providers and end users through applications, robots, networking, etc. Government’s encouragement and initiative towards such technologies will incentivize the sector and eventually lead to flow of private investments.
- Increasing the budget allocation in healthcare sector can help in increasing the adoption of such innovations and technologies in Public (Govt.) Hospitals in India.
- Regularizing and mandating the use of computers and uninterrupted availability of internet connection is a prerequisite for the adoption and use of technology like EHR, etc., in rural India.

- Understanding of Behavioral models from various disciplines is important. Adapting to new change is always difficult in any organization, especially in Indian hospitals where traditional methods are still widely used in health service delivery. Extensive Training must be given to every healthcare provider of the organization before implementation of any new healthcare technology. This will boost confidence, which can further encourage healthcare practitioners to adopt and implement such technologies to their practice.
- Healthcare technology innovation should be designed and used in such a way that they abolish or eliminate iniquity and help build equity.
- Motivating the healthcare workers is highly important for the adoption and implementation of new changes being introduced in the system. Incorporating Incentive programs, in the form of financial and other rewards on multiple clinical indices may encourage the use of full-fledged technology in hospitals by the healthcare providers.

CONCLUSION

Implementation of HTI is the new road map for Indian healthcare system to provide highly efficient and quality driven healthcare service with equity. Addressing the existing challenges in Indian Hospitals regarding the implementation of Healthcare technology is a complex proposition. It requires a thorough understanding of the problems pertaining to these challenges to come up with the right solution.

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Part 2

Assigned by faculty Mentor

Online Course- REPORT

Title	:	Data Analytics for Lean Six Sigma
Mode	:	Online learning; Self-paced
Learning Platform:		Coursera
Duration	:	16 hours
Submitted By	:	Malini Nair

Data Analytics for Lean Six Sigma

COURSE OVERVIEW

This course is designed by the University of Amsterdam in collaboration with Coursera for teaching data analytics techniques which are useful for Lean Six sigma improvement projects. The learners of this course are trained by Dr Inez Zwetsloot, Professor of Data Analytics of University of Amsterdam.

The entire course is laid out in segments for the duration of 16 hours, where each segment consists of modules that cover topics on Lean Six Sigma projects, various analytical tools and hands on training in the analytical software Minitab.

Various actual Lean Six Sigma projects have been used as examples to illustrate all tools. The settings chosen for data examples during the course are Lean Six Sigma improvement project.

OBJECTIVES

This course aims to teach the learners how to analyze and interpret data gathered within lean six sigma projects. It is emphasized on learning the use of data analytics tools using analytical software such as Minitab, and the interpretation of the outcomes.

The course objectives are:

- Introduction to Lean Six Sigma improvement projects and its steps.

- Introduction to Minitab and its application.
- Deep understanding of various Analytical tools specific to Lean Six Sigma improvement Projects.
- Application of analytical tools in analyzing actual lean six sigma improvement project example by hand on training using Analytical software Minitab.
- Training the learners to interpret the analyzed data.
- Towards the end of each module learners should be able to solve Lean Six Sigma improvement projects by themselves using their learnings and understanding of the application of analytical tools and be self-capable in interpreting the outcomes to come up with the right solution.

COURSE CONTENTS

The Course contents are laid out into several topics as headings and subheading focusing on teaching various key concepts in each. Each topic is taught using reading material and Video Lectures. The topics are as follows:

1.Introduction to Data Analytics and Lean Six Sigma.

1.1 Video Lectures on Data and Lean Six Sigma.

- 1.1.1 Introduction to Lean Six Sigma
- 1.1.2 Data and DMAIC (Define, Measure, Analyze, Improve, Control)- Distinguish between the five phases of DMAIC.
- 1.1.3 Selection of CTQ variable (Critical to Quality)
- 1.1.4 Units and operational Definition.
- 1.1.5 Sampling

1.1.6 Organizing the Data

1.2 Introduction and Installation process of Analytical Software: **Minitab**

1.2.1 What is Minitab Installation process of Minitab

1.2.2 Introduction to Minitab

1.2.3 Loading of Data into Minitab

2: Understanding and Visualizing Data

2.1 Numerical and Categorical Data

2.2. Descriptive Statistics

2.3. Visualizing Numerical Data

2.4. Visualizing Categorical Data

2.5. Pareto Analysis

2.6. Visualizing two variables

2.7. Video Exercises and Graded quiz

3: Using Probability Distribution (Video Lectures)

3.1 Population versus sampling

3.2 Estimation and confidence interval

3.3 Normal, Lognormal and Weibull Distribution

3.4 Probability Plot

3.5 Empirical CDF (Determining the probabilities and percentages using the empirical CDF)

3.6 Properties of the Normal Distribution

3.7 Video exercises using probability distribution

3.8 Practice and Graded quiz

4: Introduction to Testing

- 4.1 Introduction to data analysis
- 4.2 Hypothesis Testing
- 4.3 Causality

5: Testing: Numerical Y and Categorical X

- 5.1 Introduction to ANOVA
- 5.2 ANOVA analysis
- 5.3 ANOVA Residual Analysis
- 5.4 Kruskal- Wallis Test
- 5.5 Two sample- T test
- 5.6 Test for equality of variances

6: Testing: Numerical Y and Numerical X

- 6.1 Correlation
- 6.2 Introduction to Regression
- 6.3 Regression Analysis
- 6.4 Regression residual analysis
- 6.5 Regression prediction Interval
- 6.6 Quadratic Regression

7: Testing Categorical Y

- 7.1 Chi- square analysis
- 7.2 Logistic Regression
- 7.3 Testing categorical Y exercises

LEARNING METHODOLOGY

Data analytics on Lean Six sigma course is an online certificate course introduced by Coursera which is a worldwide online learning platform that offers massive open online courses. The program is conducted with collaboration with the University of Amsterdam. This course is an asynchronous online program i.e., self-paced and time independent. The materials for this course could be accessed 24/7.

The modules consisted of prerecorded virtual classes and online readings provided by the course professor Dr. Inez Zwetsloot herself. The learning method of this course not only consists self-paced visual lectures but also hand on training with various actual lean six sigma project examples. The data resource for the practice exercises is provided beforehand in the form of Excel sheets.

The working application of various analytical tools taught in different modules of this course are used in analyzing and interpreting actual Lean Six Sigma improvement Projects using an analytical software Minitab.

Minitab is a statistical analysis software that automates calculations and the creation of graphs, allowing the users to analyze and interpret data results.

The course learning pattern was also graded, where each learner had to achieve an a pass percentage of minimum 80% in the quiz given after completion of each module. The course can also be taken up for free (audit) but one needs to pass the test to receive a certificate of completion at the end of the course.

The program also has an inbuilt course discussion forum which enables every participant/ learner to debate their ideas and reach out to other participants and connect with those sharing the same goals.

KEY LEARNINGS

Data Analytics for Lean Six Sigma program has been challenging and rewarding. A thorough understanding of data analytics helps to build concrete skills one can apply on everyday decision making.

Lean Six Sigma is a process improvement method that removes inefficiency and eliminates problems to create a structured and efficient system. It consists of various tools and methods which are used in a staged manner in different phases of a Lean Six Sigma Improvement Project.

One can enhance productivity by adding Data Analytics to existing knowledge. Data Analytical tools taught in this program can not only be used for Lean Six Sigma projects but for various other projects and data as well. This course helps to acquire and improve the ability to think analytically to get the right approach to problem solving.

The highlight of the course was its more focus towards hands on training in Minitab. Learnings from each topic was exercised with various actual Lean Six Sigma improvement projects which boosts confidence with every task.

The teachings from this course has been very useful, especially while preparing the summer training assignment. The learnings came in handy while interpreting graphs and data sets from various literatures, studies, etc.

Specific Learnings from the course content:

Understanding of Lean Six Sigma and an elaborative learning of its stepwise phase for process improvement.

- Addition of a new skill set by understanding the application and working of analytical software Minitab to analyze Lean Six Sigma improvement projects and various other data and projects as well.
- Minitab is a sophisticated yet easy to use software for data analysis.

- Different types of Data - Numerical and Categorical Data.
- Analyze relationship between variables.
- Deep understanding of various analytical tools and their use in analyzing different types of data sets.
- Application of data analytical tools for Lean Six Sigma improvement projects.
- Data visualization using Minitab.
- Data Sampling Techniques
- Understanding the concept of making inference and to quantify uncertainty in the estimates.
- Nature of various data distribution (Probability distribution).
- Understanding of Hypothesis testing to arrive at decisions as objectively as possible while dealing with uncertainty in a rational manner.

CERTIFICATION

Course Completion Certificate:



