Summer training

at

Healthark Insights

From 10.05.2021 to 10.07.2021

A Report

by

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MBA Hospital and Health Management

2020-22

HEALTHARK

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# Whom So Ever It May Concern

This is to certify that **Ms. Sivasankari C** worked with Healthark Insights Wellness Solutions LLP as an Intern Consultant from 10th May 2021 to 10th July 2021. During her internship, she conducted market assessment involving secondary research and basic excel modelling across Latin American, Russian and Saudi Arabian markets. She supported her seniors in preparing client deliverables in form of PowerPoint presentation and excel formats.

She has always shown responsible attitude towards the tasks assigned to her and completed them within time with utmost sincerity. She has been a good team player and was supportive to her other colleagues in the organization.

We wish her a bright future and success in her future endeavours.

Purav Gandhi

Sincerely,
Dr. Purav Gandhi
Founder & CEO
Healthark Insights

**Acknowledgement**

I would like to express my special thanks of gratitude to my guide Mrs. Veena Nair Sarkar, Assistant Professor, Indian Institute of Health Management Research, Jaipur for the consistent help associated with my learnings during the entirety of the summer training period. I would like to thank my mentor Mrs. Ritu Baliya, Manager, Healthark Insights, Ahmedabad for directing me to the area that held the most promise for the future- Artificial Intelligence.

Finally, I would like to thank my mother and friends who helped me a lot in finalizing this report within the limited time frame.

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## Acronyms/ Abbreviations

| | |
|---|---|
| KOL | Key Opinion Leaders |
| COVID | Corona Virus Disease |
| AI | Artificial Intelligence |
| MHRA | Medicines and Healthcare products Regulatory Authority |
| ML | Machine Learning |
| ANN | Artificial Neural Network |
| CNN | Convolutional Neural Network |
| RNN | Recurrent Neural Network |
| CAD | Computer Aided Diagnosis |
| NLP | Natural Language Processing |
| NHS | National Health System |
| EHR | Electronic Health Record |
| GWAS | Genome Wide Association Studies |
| GPU | Graphics Processing Unit |
| CSDD | Centre for Study of Drug Development |
| GAN | Generative Antagonistic Organization |
| ICD 10 CM | International Classification of Diseases- Tenth Revision- Clinical Modification |
| MDR | Medical Device Regulation |
| IVDR | InVitro Diagnostic Regulation |
| IBEF | India Brand Equity Foundation |
| FDI | Foreign Direct Investment |
| CHW | Community Health Worker |

# 1. OBSERVATIONAL LEARNING

## 1.1. Introduction

### 1.1.1. Healthark Insights- Organization profile

Healthark insights was established in 2016, by a team of consultants from top-tier strategy firms, with a cumulative experience of 100+ years. Over the last few years, healthark has developed a team of experts from diverse fields such as consulting, pharma, medicine, medical devices and digital health as well as public health and management with a common vision to cater to the healthcare and life sciences industry, along with a relentless focus on delivering executable solutions.

Healthark is a boutique consulting firm founded with an aim of solving most complex healthcare problems through deep domain expertise, scientific rigor and diverse skills applied in most suitable manner.

The core team consists of ex-Consultants from Deloitte and ZS, pharma industry professionals, as well as people with diverse backgrounds doctors, engineers, MBAs, PhDs, biostatisticians, researchers, etc.

They have served multiple healthcare clients globally including Johnson & Johnson, Roche, Abbott, Pfizer, Gilead Sciences, Novartis, Boehringer Ingelheim and Eli Lilly. Their delivery model supports quick turnarounds with agile approach and cost efficient model ensuring value for clients. They support clients with end-to-end capabilities, starting with business problem, to data to analysis to insights to prediction.

### 1.1.2. Capabilities

***Strategy and Research***

The Healthark team provides comprehensive assessments leveraging both primary and secondary research. Healthark leverages partnerships with companies such as Atheneum, Guidepoint, GLG etc. apart from its own network to deliver primary research. Healthark has a strong desk research capability with experience in conducting assessments in multiple global markets. With this, they excel in market landscape assessments, competitive intelligence, country/ company profiling, new product launches, BD/ licensing assessments.

***Digital Health***

Healthark supports MNCs in analysing the digital health landscape and also leverages their in-house ‘digital database’.

They offer digital landscape analysis to help companies understand innovation in specific areas of focus. This is done through the development of a comprehensive list of companies operating in a specific area of interest (e.g. e-pharmacies, patient services, patient engagement etc.) They aim to understand key adoption trends among patients and key stakeholders like payers and develop high level view of the maturity and future potential of the technology and how it can alter the landscape.

Healthark has created a proprietary database of 1500+ digital health companies covering details such as company overview, digital segments, revenue and funding ratio, partenership details, product differentiator and therapeutic area focus etc.

***Modeling and Forecasting***

Healthark's capabilities across sales and marketing functions help deliver results faster at a competitive price. They perfom sales and business analytics, multi channel marketing analysis, forecasting and sizing and market research analytics.

***Real World Evidence***

Their unique approach to handle multiple sources, analyse structured and unstructured data, evaluate inconsistency, variability & complexity in a rapdily changing environment is to go through each process in depth so as to facilitate high quality real world data analysis.

They are involved in data due diligence, data abstraction, curation, analysis and finally data modelling.

***Medical writing***

Healthark also supports MNCs in sceintific writing, developing patient education materials and supporting CME meetings.

***Artificial Intelligence***

They focus on using niche data sources and advanced machine learning techniques to solve healthcare challenges. They use NLP and sentiment analytics, voice analytics, image analytics, IOT based analytics to achieve outcomes.

***Business Intelligence and Reporting***

They develop intuitive dashboards as desired by Business Unit heads or decision makers while also managing periodic updates.

***Claims Analytics***

They have experience in addressing a series of pharma use cases based on claims data analytics.

***KOL Identification***

They help their clients identify the right KOLs to maximise impact. They first identify KOLs based on various KOL activities like publications, congress presentations, clinical trials, guidelines, committees, editorial boards etc. They profile the validated KOLs as per their roles, geography, abstracts of major publication, involvement in clinical trials and create a comprehensive database after which they rank them from highest to lowest within a defined geography. This approach enables MNCs to identify, prioritize and validate KOLs, and hence refine their overall strategy.

### 1.2. Mode of Data Collection

To carry out the duties in the organisation, secondary research or desk research was extensively done, using the Boolean operators on Google Scholar and Google search engine.

### 1.3. General findings on learning

***PwC Specialization***

The initial period of training entailed an in-depth understanding of Data analysis and Presentation skills. The courses of Data driven decision making, Problem solving with Excel, Data visualization with advanced Excel and Effective business presentations with Powerpoint were completed on Coursera.

***Brief study of Healthcare systems and Health Insurance***

Healthcare systems and methods of payment, including available insurance options for the people of the United States, United Kingdom, India, Germany and Australia were briefly studied and presented.

***Market Research of Sweden***

The nature of work allotted majorly pertained to secondary market research in the geographical location of Sweden. Cardiovascular, Central Nervous system, Neurology, Dermatology, Metabolic disorders, Gastrointestinal, Hepatitis, Infectious Disease, Liver disease, Oncology, Ophthalmology and OTC market in Sweden were the broad therapeutic areas that were extensively researched to curate syndicated market research reports. It was observed that diseases of the circulatory system continue to be the leading cause of death in Sweden followed by neoplasms and mental and behavioural disorders.

Some common diseases like Alzheimer's and Diabetes were also researched for the construction of the market research reports.

The oncological market of Sweden was further researched with emphasis on Brain cancer, breast cancer, colorectal cancer, head and neck cancer, leukemia, liver cancer, lung cancer, melanoma, prostate cancer, non-hodgkins lymphoma, hodgkins lymphoma and chronic lymphocytic leukemia. It was found that Prostate cancer is the most common cancer among the new cancer cases in Sweden followed by breast cancer and lung cancer. However, lung cancer is the foremost cause of death in the country followed by prostate cancer and colon cancer.

***Market Research of AI in Healthcare Service area***

The service area of Aritifical Intelligence in Healthcare was also extensively researched for the purpose of making syndicated reports for the Global, US, EU, APAC,UK, China and Japan market. It was observed that North America held the largest market share accounting for approximately 58.9% of the global market. However, Asia Pacific market is expected to achieve the fastest growth in the years to come.

***Express Scripts- Company profiling***

Express Scripts- one of the leading pharmacy benefit management systems in the US was carefully profiled. Cigna, a global health service company acquired Express Scripts which proved to be beneficial for its growth. Cigna continues to be the third largest pharmacy in the US with a revenue of $49.9 billion in 2020.

***Venture Capital Investments in Biopharma***

Towards the end of the training period, a consultancy assignment was undertaken which entailed the trends of Venture Capital Investments in Biopharmaceuticals. In order to get a context of the topic, Venture Capital investments and funding rounds were studied extensively. The investment trend over a period of five years (2016-2020) was studied and analysed. Insights were drawn from the data pertaining to purely drug developing pharmaceutical companies, excluding health tech start-ups and digital health ventures. At the end of the assignment, a forecast for the period of 2021 to 2024 was made after meticulous secondary/desk research.

*Key Observations*

- 2016 to 2018 witnessed a steady rise in investment size, a feature attributable to the overall pharma sector growth at that period.
- 2018 to 2019 witnessed a decline in investment size, a prospect that can be attributed to the economic impact from US-China trade war and the initial impact of the COVID-19 pandemic.
- 2019 to 2020 witnessed a rise in investment size that can be attributed to the rise in crossover funding rounds and overall demand for pharma sector development because of the pandemic.
- A change in investor behaviour was observed- a shift in trend from investing small amounts of money in many companies to investing larger amounts in fewer companies.

## 1.4. Conclusion

The current business environment demand businesses to always make informed decisions in order to achieve something and be successful. The need to use relevant available information to understand global and regional markets is a dire demand now, more than ever. This lifts up the research sector to a level where it has been deemed a necessity, rather than a luxury to thrive.

The extremely dynamic nature of the healthcare industry, the rapidly evolving healthcare options available to the public, fast-paced development of the pharmaceutical sector warrants extensive market research to stay relevant to the needs of the people, at the same time complying to the governmental regulations while choosing to launch a new product or service. This makes market research in healthcare extremely critical.

The remote working experience at Healthark Insights proved to be extremely benefecial in this regard, giving ample exposure to the field of desk research.

***Limitations***

Since the nature of allotted work was mostly market research, little experience was gained with respect to data analysis and developing insights, except towards the end of the training period when the ‘Venture capital in Biopharma’ assignment was undertaken.

***Suggestions for improvement***

More assignments entailing data analysis and insights development can improve the overall quality of learning experience.

## 2. PROJECT REPORT

### 2.1. Introduction

Artificial Intelligence is defined as the capability of a computer program to perform tasks or reasoning processes that is associated with intelligence in a human being.

The idea of AI has been the wellspring of motivation for some sci-fi scholars and futurologists for longer than a hundred years. In the recent times, developments in processing and big data have turned this distant dream into reality, with machines presently being used at a huge scope across ventures. The utilization of AI innovations is encouraging the process of development at individual, business, and financial levels. Indeed, AI has started to outwork people in a scope of work exercises. Fields where cognitive capacities are expected to make a play are also benefitted by the developments in AI.

As the level of the working populace decreases in numerous nations all throughout the planet, AI gives the truly necessary mechanization to maintain and speed up productivity development at both micro and macro levels. At the micro level, organizations have started to embrace diverse AI innovations to harbour advantages, for example, lower work costs, expanded degree of output and better quality. At the macro level, mechanization is required to bring about hearty efficiency development; McKinsey gauges that it will be somewhere in the range of 0.8% and 1.4% every year. Even though this development has been assessed for every one of the nations all throughout the planet, there are a few countries that are set to witness more growth than others. As indicated by a recent report (2019) by the Global Tech Council, the top ten nations witnessing AI development are India, France, the UK, Russia, Germany, Japan, China, South Korea, Singapore, and Sweden.

Over the last few years, the development of AI has for the most part spun around the headway of etymological, numerical and logical thinking abilities. Be that as it may, the following flood of AI developments is pushing towards creating emotional intelligence. Simultaneously, sequential learning, another component of Google's DeepMind, is empowering AIs to become familiar with different skills. In the course of time, deep learning has undergone an immense growth and is now able to empower machines to gain a better understanding of the actual world and is utilized across enterprises for different errands.

The rise of AI as an apparatus for better medical services offers phenomenal freedom to further develop patient and clinical team outcomes, lessen expenses, and effect public health.

Innovation developments and financing are driven by business models like benefit, proficiency, and profit from venture. It is imperative to investigate how these will impact AI–health care advancement, assessment, and execution. This fact is additionally challenged by public and government perspectives on health and healthcare, which sway between healthcare being a social good and healthcare being an economic commodity.

AI apparatuses can be utilized to decrease cost and gain efficiencies by having the human labour focus on more unpredictable tasks; to recognize workflow enhancement techniques; to minimise clinical waste like failures in healthcare delivery, impeding quality of care, over or under treatment, fraud and problems with

administration and to automate exceptionally repetitive business and workflow processes by utilizing the structured data available for analysis.

The COVID-19 pandemic has expanded the selection of AI in practically all ventures, generally to guarantee business coherence and accelerate processes. No place is this more apparent than in the healthcare sector, where AI devices and solutions are being utilized to foster the development of an effective vaccine. The innovation made possible with AI is additionally being utilized to process data in the post immunization stage. In the UK, the Medicines and Healthcare Regulatory Authority (MHRA) has granted Genpact UK a US$2 million agreement to foster an AI controlled tool to process data entailing the side effects of the vaccine.

This report aims to explore the areas of application of Artificial Intelligence in Healthcare services around the world and to identify if the extent of application of AI in healthcare services differs between developed countries and developing countries.

## 2.2. Types of Artificial Intelligence

### 2.2.1. Machine learning

This includes planning a set of new algorithms and working on old algorithms to enable PCs to function without unequivocal programming. They permit PCs to investigate and analyse complex big data to identify patterns and make potential forecasts. Deloitte conducted a survey in the year 2018 that claimed 1,100 US managers whose organizations were at that point seeking out new ventures in Artificial Intelligence, 63% of the surveyed organizations studied were making use of machine learning to improve their businesses.

In healthcare, the most widely recognized utilization of conventional machine learning is Precision Medicine – anticipating the success of the course of treatment by taking into consideration various patient attributes and treatment context.

ML can be further categorised into:

***Supervised Learning***

This trains the PCs to react in a way corresponding to a definitive stimulus. For this, the learning algorithm is taken care of with a progression of inputs just as with the respective outputs. Following this, the algorithm uses the same arrangement of rules for programming in case of a future application for a different purpose.

***Unsupervised Learning***

This framework is not furnished with the correct answer yet is relied upon to act in the process of learning without help from anyone else. It does this by investigating the data by itself to discover a type of corelation or pattern. As such, the AI framework utilizes its experience of taking care of one issue to take care of another issue that is closely related. For instance, this kind of machine learning can be applied to recognize buyers with comparative buying practices in order to assist with customising the market practice.

***Reinforcement Learning***

In this case, the algorithm undergoes learning via an experimental interaction i.e., a trial-and-error method. This is similar to what is being done in behaviour modification where there is a reward in case of good behaviour and punishment in case of bad behaviour. The algorithm stores this memory and uses it when a similar case pops up next time. One such example of Reinforcement Learning is Google DeepMind's prevail upon the title holder in the game of Go.

### 2.2.2. Robotics

This part of innovation is concerned about creating and preparing robots to maintain an interface with individuals and the world in a safe and predictable fashion. Be that as it may, current endeavours likewise are based on deep learning in order to prepare machines to control circumstances and react with a specific level of awareness.

Surgical robots, approved in the USA in 2000, give 'superpowers' to specialists, working on their capacity to observe and visualise patients, make sharp and precise cuts that are minimally invasive, suture lacerations, etc. Nonetheless, important medical choices are still made by human specialists. Common areas to incorporate robotics in healthcare include gynaecologic, prostate and head and neck surgeries.

The different types of robotics include the following:

- Soft robotics
- Touch robotics
- Swarm robotics
- Serpentine robotics
- Humanoid robots

### 2.2.3. Artificial neural networks (ANNs)

This is used to create new algorithms which imitate the function of a human brain, especially the neocortex part. This is the part of the brain that controls reasoning. It is not an exact comparison owing to the reason that ANNs are linearly sequenced whereas neurons in the human brain are not.

The most important role of this in healthcare is the identification of possible cancer lesions. DL is progressively used in radiomics, or the identification of clinically pertinent features in radiology that cannot be appreciated by the naked eye. Radiomics and DL are most usually found in cancer-related radiology investigations. This blend seems to guarantee an improved rate of accuracy in radio-diagnosis. This fairs better than early generation of applications that used to play a role in CAD.

The three different types of ANNs are as follows:

***Deep learning***

In this case, numerous neural network layers are found in the algorithms. They process the data at numerous stages. Prior to the development of DL, ANNs regularly just had three stages or layers, not at all like deep learning networks, which ordinarily have more than ten layers. This part of machine learning is particularly significant in light of the fact that the principal group of algorithms does not need manual intervention. This utilises raw data just like the activity of a human brain, utilizing various sorts of sensory inputs. Tremendous data storages and complex computing resources are being made available by Google that are highly advanced. This serves as the portal for deep learning all around the world. The establishing of Google Brain by Andrew Ng denoted the start of DL. The principal distinction between ML and DL is that a bigger neural network will denote a better performance owing to the fact that the access to the data which is available for processing keeps increasing as the network expands. This is not the case with other machine learning techniques owing to the stagnation of data access after a point of time.

By empowering doctors to take a gander at an individual's gene sequence and molecular framework, deep learning is working with data to deliver treatments with a more personalised approach.

For example, Deep Genomics uses enormous amount of data on the cell makeup of humans to empower machines to foresee the clinical results upon alteration of a genome. Organizations that are involved in drug discovery like Atomwise utilize the method to examine and analyse available information on sub-atomic mixtures and molecular compounds to discover newer drugs for illnesses.

***Convolutional neural networks***

These are basically the same as conventional neural networks. The lone distinction is that the neural stages/layers and their association are like those found in the visual cortex of animal species. Visual cortex is where the images that one sees, get processed. These models are modified to see each input and perceive them as images. ImageNet conducted a visual recognition contest in the year 2012. In this contest, there was only entry which used a CNN, and it accomplished a score of 84%. This contrasted with 75% the prior year. From that point forward, they have won all resulting ImageNet challenges, surpassing the performance delivered by the humans in the year 2015 where the score was 90%.

***Recurrent neural networks***

RNNs are different from other neural networks in the design. The neurons here are interconnected which enables conduction of signals back and forth between them. The data travels from one layer to another in a loop-like fashion enabling all the information to be put away as memory. This is the reason that Recurrent Neural Networks are adept for NLP applications.

### 2.2.4. Natural Language Processing

Natural language processing is a branch of Artificial Intelligence that interprets and manipulates natural human language. The innovation, though in a cruder structure, started acquiring far reaching acknowledgment in the 1950s, when linguistic specialists started creating machines to automate language translations.

NLP incorporates applications like speech recognition, text analysis, translation and other related linguistic activities. There are two types of NLP- statistical NLP and semantic NLP. The former depends on neural networks based on deep learning. This has increased the rate of accurate recognitions. It is necessary to have a huge database of languages which can serve as a hub for learning.

Today, the significant advances in NLP are driven by different deep learning techniques that are intended to impersonate the working of neurons in the human cerebrum. Curiously, deep learning NLP can now ceaselessly gain from examples and experiences, in this way discovering various applications in every area including healthcare, consumer merchandise and defence.

In healthcare, the predominant uses of NLP include the creation, comprehension and classification of clinical documentation and related research that are published across various sources. NLP can help simplify and summarise unstructured patient case histories, prepare reports, decipher patient interactions and direct conversational AI.

The key applications of NLP include:

- Speech to text
- Text to speech
- Text processing
- Natural Language generation
- Chatbots
- Machine translation

Table-1: Classification of AI in Healthcare applications based on user group

| **User group** | **Application Scenario** | **Underlying AI technology** | **Examples** |
|---|---|---|---|
| Patients | Health Monitoring | • Machine learning<br>• Natural Language Processing | • Wearable devices<br>• Mobile applications |
| | Disease prevention | • Natural Language Processing | • Prevention and management of Obesity, Diabetes<br>• Mental health applications |

| | | | |
|---|---|---|---|
| | Medication management | • Home health Robotics | • Medication and habits adherence |
| | Rehabilitation | • Robotics | • Stroke rehabilitation with applications and robots |
| Clinical Practitioners | Diagnosis- Medical Imaging | • Computer vision | • Imaging for arrhythmia detection and cancer detection |
| | Surgical assistance | • Robotics<br>• Machine Learning | • AI supported surgical roadmaps<br>• Remote controlled surgery with robots |
| | Precision medicine | • Machine Learning- Supervised and Reinforced | • Personalized chemotherapy |
| | Patient safety | • Machine Learning | • Early detection of sepsis |
| Public Health Professionals | Disease risk prediction | • Machine Learning | • Population based risk assessments |
| People in Medical Administration | Record Management | • Natural Language Processing<br>• Speech recognition | • Patient medical information in the form of Electronic Health Records |
| | Fraud detection | • Machine Learning- Supervised, unsupervised and hybrid | • Billing fraud<br>• Detection of unlicensed medical practitioners |
| | Cybersecurity | • Machine Learning | • Protection of confidential |

| | | | |
|---|---|---|---|
| | | • Natural Language Processing | medical information |
| Researchers | Drug discovery | • Machine Learning | • New drug discoveries with AI |

### 2.3. Role of AI in healthcare services

#### 2.3.1. Preventive medicine

Previously, advancements in the healthcare sector were just limited to the digitization of manual tasks. This was helping professionals reduce financial burden by reducing the anount of work and effort at the same time speeding up processes. However, improvements in Artificial Intelligence and ML have helped speed up development in the business while changing the way things operate in general.

Artificial Intelligence has shifted the trend from simple treatment of infections-reactive mentality, to a treatment where it diagnoses diseases in their initial stage or prior to their occurence- preventive outlook.

The General Manager for healthcare at Wipro, Praveen Soti, urges a shift from the trend where hospitals work on filling up beds, recommending tests and performing medical procedures, to really fending patients off and keeping them away from hospitals. AI is set to bring about this shift in trend.

Table-2: Organizations incoporating AI for Preventive medicine

| | | |
|---|---|---|
| KenSci | KenSci | A start-up based out of Washington which uses AI to track disease onset and progress, and also predicts the incidence of chronic diseases in a population or a group of patients. |
| PATHWAY GENOMICS® | Pathway Genomics | Genetic lab which develops an AI-powered tool that analyses an individual's genetic makeup and other genetic factors to provide preventive medical advice. |
| IBM Watson | | A partnership to enable development of 'cognitive coaching system' , that is powered by AI, which |

| | | |
|---|---|---|
|  | IBM + Under Armour | processes huge volumes of information to create a database that will enable the provision of preventive medical advice and regularize habits like sleep, fitness and nutrition. |

### 2.3.2. Personalised medical advice

AI is additionally paving the way for new business sectors in the health care sector. A Norwegian organization, Your.MD has fostered an AI-fueled portable application that coordinates with a patient's symptoms to freely accessible data gathered from different sources, finally offering customized guidance in regards to their diseases and ailments. This primarily works by sifting through individuals who are not in dire need of primary care, thus allowing the specialists to zero in on the individuals who need immediate medical attention. This has brought about the introduction 'pre-primary care', in which the patient winds up supporting themselves. This has introduced an entirely new market in healthcare that has harvested to potential of people in bringing about a behavioural change by themselves.

### 2.3.3. Early and accurate diagnosis

As indicated by a recent report directed by the Mayo Clinic (2017), initial diagnosis made in the U.S. are modified by a second opinion which happens nearly nine out of a ten times. In the year 2015, National Academies of Medicine conducted a research study which concluded that 10% of the deaths and 17% of all medical and surgical complications that occur in the hospital were due to diagnostic errors. Progressions in AI have brought about early diagnoses of diseases using deep learning.

Table-3: Organizations incoporating AI for early and accurate diagnosis

| | | |
|---|---|---|
|  | IBM Watson | A supercomputer that analyzes patient information to identify early signs of malignancies and other circulatory diseases. |
|  | Google DeepMind | DeepMind and NHS, UK to develop an ML framework that identifies threats to an individual’s eye sight through a simple digital imaging of the eye. |

| | | |
|---|---|---|
| PATHWAY GENOMICS® | Pathway Genomics | Created a blood test that can detect cancer at its early stages by detecting the presence of cancer cells in the bloodstream. |
| lu lumiata | Lumiata | Uses ML to identify people who are in need of getting admitted to a hospital early. |
| Microsoft | Microsoft | An advanced AI system that interprets online search engine behaviours regarding symptoms of diseases long before the patient actually develops the illness, enabling them to take necessary preemptive measures. |
| UNIVERSIDAD DE MÁLAGA UNIVERSIDAD DE GRANADA | University of Malaga + University of Granada | A joint venture in developing an AI system based on deep learning to detect brain patterns that are associated with Alzheimer's. This also enables comparison of brain patterns of a diseased vs healthy individual. |
| NYU Langone MEDICAL CENTER | Langone Medical Center | An ML algorithm to detect PTSD through the analysis of speech pattern. This showed a 77% success rate. |

### 2.3.4. Augmented Intelligence

AI will change health care delivery by supporting clinicians with their work rather than by replacing them. Artificial intelligence will uphold clinicians with less experience in performing treatment and procedures that are limited to the skills of a specialist in the field. It sifts through ordinary and noncomplex cases with the goal that experts can zero in on a challenging case load. AI will uphold people in errands that make the people suffer from fatigue, carelessness and physical difficulty. Artificial intelligence will fill in for people by working with screening and evaluation in regions with restricted access to healthcare services.

### 2.3.5. Medical Information Management

EHR frameworks and administrative prerequisites have acquainted huge clinical documentation duties with suppliers, without essentially supporting patient care decisions. AI can possibly further develop the manner by which clinicians store and recover clinical data. For instance, the part where voice recognition plays a major role in clinical documentation is already well-established. Nonetheless, such frameworks have been utilized for the most part in order to help clinicians' transcription of narrative reports like clinical notes and diagnostic imaging reports.

A major reason for clinicians' disappointment with EHR frameworks is the high frequency of unessential pop-up alerts that disturb the clinical workflow and add to "alert fatigue". This is brought about by the low specificity of alerts which is in turn due to failure of consideration of the full clinical context of the paitent. Artificial intelligence can work on this aspect by considering vast amount of patient data and contextual variables.

### 2.3.6. AI robots for surgical assistance, rehabilitation and research

Healthcare robotics was a concept of sci-fi, 15 years ago. An organization called Robodoc, an IBM side project, was quick to foster a mechanical framework for orthopedic surgeries. Despite the fact that the innovation worked, the organization couldn't make business grow and in the end shut down. Nonetheless, ongoing progressions in robotics and AI have brought about a solid expansion in the field of research in the area of robotics in healthcare.

***Surgical assistance***

The ability of healthcare robotics to assist in surgeries has gotten the greatest consideration over a period of time. One of the principal organizations to acquire significant market foothold was Intuitive Surgical. This was responsible for the launch of 'da Vinci' framework, an innovation at first intended to help in minimally invasive heart bypass surgery, which also found its use in treating prostate cancer. The fourth generation of the ‘da Vinci’ system is being used now which assists laparoscopic procedures. Surgical assistance here happens through two platforms- physical and data, which enables the user to study the entire surgical process. Organizations like Verb Surgical which is a start-up by Google and Johnson & Johnson and Dublin-based Medtronic are now in the market for manufacturing surgical robots.

***Recovery and Rehabilitation***

Someone experiencing neuromuscular aftermaths of a stroke required sensory motor therapy. This therapy is now assisted by robots. Healthcare robotics also play a role in assisting people with ASD and ADHD.

AI robots can help neuroscientists gain a better understanding of the functions of human brain. They can analyse the impact of external mechanical forces on neural plasticity. MIT-Manus rehabilitation robot has assisted with recovery of stroke- both acute and chronic.

***Research***

Robotics technology is unique through its offering of conducting research for the benefit of general health and wellbeing. Researchers are trying to develop robotic framework which serves as a replica of human biology. This helps create a simulation of existing human bilogy in an artificial setting. Robots can help in the delivery of personalised medicine by gathering information on patient behaviour, like individuals with neurodevelopmental diseases.

Robotics Business Review cites the following segments in Healthcare Robotics in one of its reports- Direct, Indirect and Home healthcare robots. Direct patient care robots include Surgical robots, exoskeletons and prosthetics. Indirect patient care robots include pharmacy, delivery and disinfection robots. Home healthcare robots include robots like Pillo that assists the geriatric population and people who have chronic disorders.

### 2.3.7. Precision Medicine

Precision Medicine has been accessible for quite a while as low-tech treatments like hypersensitivity treatment and blood transfusion. Indeed, even genetic targetting of tumors has become more ordinary currently. For instance, the pharmaceutical drug Herceptin targets HER2 protein that is associated with aggressive and malignant breast cancer.

In any case, AI advances, for example, DL and NLP analyse data from customer devices and differentiates mutation patterns in individuals which enables them to offer precision medicine at the familial as well as individual level. AI is being used to understand the biological disposition of the individual and then deliver medical care based on the individual's genetic needs.

A phenotype alludes to a detectable trait of a living being, as a result of its genetic code and the pertaining environment. Cohorts are created, grouped by triat and utilised for genomic and clinical research. EHR phenotyping utilizes the data in a patient's clinical records to deduce if the patient has the disease or not. Phenotypes are derived by applying a set of algorithms to the patient EHR data, machine learning and other statistical methods supported by AI. The idea behind this is to utilise raw EHR data and make some useful information out of it which is then used to deliver precision medcine. For instance, eMerge uses GWASs and phenotyping algorithms, to define the gold standard cohort in a population sharing the same phenotype.

Despite the fact that a large part of the exploration in this field is needed, there are a few promising projects. Some of them are listed here.

Table-4: Organizations incoporating AI for Precision medicine

| | | |
|---|---|---|
| FLOWHEALTH | Flow Health | Collects clinical data from nearly 22 million veterans and builds a database conbtaining 30 million gigabytes of data regarding genomics and medicine. It works on determining how each gene variant in |

| | | |
|---|---|---|
| | | the genome brings a change to the phenotype. |
|  | Human Longevity | Aims to sequence atleast one million genomes to use the data for delivery of precision medicine to treat malignancies and cardiovascular disorders. |
|  | Deep Genomics | Start-up based out of Toronto, that uses deep learning to understand the effect genetic variants on RNA splicing. |
|  | University of Toronto | Aims to develop a GPU powered tool to detect the mutations responsible for causing cancer in the patient. |
|  | Editas Medicine | Specialised in altering the faulty genes responsible for causing diseases.<br>Aims to treat eye diseases, malignancies, anaemia (sickle-cell), muscular dystrophy caused due to genetic reasons. |

### 2.3.8. Drug discovery

A study by CSDD reveals that the average funding required to develop a drug that has the potential to acquire market approval is US$2.6 billion, and the process requires more than ten years. That being said, Jackie Hunter, CEO of BenevolentBio agrees that less than 10% of potential drugs get market approval. Aside from being tedious and costly, this process additionally restricts the quantity of illnesses researchers can work with.

ML frameworks play vital part in minimising the effort, cost and time through utilization of relevant data from the past to arrive at the type of experiments needed to be carried out. Different frameworks can likewise be utilized to anticipate the side effects of some compounds on people, in this way accelerating the market approval process.

Key developments in this space include:

***Coronavirus immunization***

Researchers in Australia's Flinders University alongside Oracle created a COVID-19 vaccine. AI and cloud computing were use to keep the Spike protein from binding to the ACE2 receptors on human cells. Additionally, in the UK, the Medicines and Healthcare Regulatory Authority (MHRA) has granted Genpact UK a US$2 million agreement to foster an AI powered tool to deal with data pertaining to vaccine side effects.

***Atomwise***

This uses ML and three dimensional neural networks to speed up drug discovery for Ebola, MS and malignancies like leukemia. Five years earlier, the organization's AI based solution helped in the discovery of two new medications to battle the Ebola virus. The point to be noted here is that it took just one day for the analysis process before the drug discovery.

***twoXAR***

To treat diseases like glaucoma and liver cancer, this uses huge volumes of biomedical data like gene expression measurements and clincal data.

***Berg Health***

This start-up based out of Boston has a unique way of drug discovery. It analyses the reasons behind a few people’s survival while the others succumb to the illness. It, then applies this to existing framework to develop new drugs.

***Stanford University***

A group of researchers from Stanford University developed a type of DL algorithm that requires a comparitively smaller volume of information to develop drugs. When the volume of data was considerably less, the researches were worried about the efficacy of the algorithm. However, in the year 2017, ACS Central Science published the test results for the method which turned out to be positive.

***Insilico Medicine***

This organization utilizes another DL method known as a GAN which utilizes the bio-chemical data to envision new cancer molecules.

### 2.3.9. Administration

***Prior authorisation***

Most healthcare plans and PBMs need early approval of labs, devices and procedures. gadgets, sturdy hardware, labs, and methodology. In order to get prior authorisation, it is mandatory to submit patient data along with proposed request, citing the reasons for the procedure. AI can help automate the process, improving the speed and quality of decisions at the same time reducing bias.

Artificial intelligence could just be utilized to sort cases to the proper degree of reviewer like nurses, physicians, surgeons or medical officers. On the other hand, AI could recognize and feature significant data in long documents to estimate risks or benefits to help the patient make an informed decision.

Automation in this area will help decrease administrative expenses and frustration from disappointment thus enabling the healthcare providers to deliver high quality of medical care.

***Fraud claims***

If there should be a complaint regading a particular issue and subsequent claims, AI can assist with recognizing those cases which are deceitful. This diminishes costs and work on the quality of care that is being given to the patients.

***Provider directory management***

By investigating available healthcare providers from different sources, AI can help in the development of a catalog containing all the data required by the patients to get access to their healthcare providers. This lessens patient frustration through exact provider information.

***Adjudiciation***

Artificial intelligence can help decide whether a clinic ought to be paid for an admission or consultation. This is done by examining patient EHR data which guarantees compliance and assists to enable easy and accurate payments.

***Automated Coding***

The ICD 10 CM is a framework utilized by healthcare professionals characterize and code all diagnosis, symptoms and treatments in the US. AI accesses the patient EHR data and helps automate this coding.

***Chart Abstraction***

AI can make a summary of repetitive patient information on the charts into a reasonable and coherent line-up of data which significantly optimises the process of scheduling, ultimately leading to improved customer (patient) satisfaction due to improved provider eficiency.

***Patient scheduling***

In a clinical set-up, when the paitent doesn't appear for an appointment, AI can follow the data, highlights no-shows and helps make better schedules. This improves patient satisfaction by improving the provider efficiency through incorporation of time saving measures.

### 2.3.10. Public Health

Public health experts are centered around answers for more efficient and effective administration of public health programs and services, disease surveillance and research.

Artificial intelligence can assist with identifying populations and geographical locations where the disease prevalence is on the high. There have been succesful endeavors where neural network analysis patterns out associations between obesity and the geographical environment.

Shin et al. (2018) applied a machine learning approach that utilizes both biomarkers and sociomarkers to identify the risk of developing pediatric asthma upon visits to the hospital.

Artificial intelligence and machine learning have been utilized to understand the pattern of narcotic usage in Indiana. This enables interventions by public health professionals in small population to encourage behavioural change and life style modification which will benefit them in the long run.

### 2.3.11. Patient engagement and adherence applications

Patient commitment and adherence has for some time been viewed as the 'last mile' issue in healthcare. To bring about an attitude of a proactive approach surrounding personal health in patients holds immense promise in creating better outcomes in healthcare. AI makes this a reality by ensuring patient commitment to their current regime of medical care.

In a survey of 300 healthcare professionals, over 70% of the respondents revealed that less than 50% of their patients were commited to their treatment regimes while 42% of respondents said less than 25% of their patients were.

Machine Learning can help with this problem by driving the interventions along the area. This utilises patient EHR data and delivers messages and alerts nudging the user to stick to their treatment regime. This can be applied in the case of information delivery to healthcare providers as well.

## 2.4. AI in healthcare- Developed countries

Developed countries are on the pursuit of automating certain aspects of healthcare. The government bodies are laying down regulatory laws, pertaining to the use of Artificial Intelligence in healthcare to ensure patient safety and to deal with their medico legal implications. While the UK Government has established a new body, NHSX that is responsible for laying down policies around the use of digital technologies in England, China has introduced the system of smart hospitals which features information-based service systems including a database of patients' medical records, a registration system, a hospital navigation system and a logistics management system. European Union has Medical Device Regulation (MDR) and InVitro Diagnostic Regulation (IVDR) that includes several generic requirements that can apply to software.

A few examples entailing the two major tech giants to observe the extent of advancement of AI in the developed countries are documented here.

***Google's DeepMind***

DeepMind has introduced an application named Streams, which can identify early manifestations of AKI by analysing the patient blood sample data. The underlying technology used here is Deep Learning. In addition to this, DeepMind has established a few successful partnerships, some of which are listed below.

Table-5: Partnerships of Google's DeepMind and their objectives

| Partnership | Objectives |
|---|---|
| Department of Radiotherapy, University College London Hospitals (UCLH) NHS Foundation Trust | ♦ To minimise Radiotherapy time for Head and neck cancer treatment.<br>♦ To develop a similar framework for other cancers. |
| Moorfields Eye Hospital, UK | ♦ To develop an algorithm like this one, that can be used for other cancers |

***Microsoft***

Some of the notable efforts by the AI developed by Microsoft are as follows:

- Analyse tumours and design new medication regimes
- Track cancer progress in patients
- Create programmable biological cells
- Develop three dimensional views of tumours with InnerEye
- Personalised medical care with Project Hanover
- Chatbots for prescreening symptoms as a self assessment tool for patients
- Integrate Microsoft's AI research with other users to decrease manual data entry operations and to provide easy medical care for patients with Healthcare NExT.

### 2.5. AI in healthcare- Developing countries

A worldwide health crisis like the corona virus is a major focus on the healthcare business, with each healthcare worker battling from the forefront. The pandemic has been known to create a structural shift towards digital healthcare in numerous nations including India.

Many have said that this is the ideal opportunity for India to reboot healthcare and support health tech new ventures in order to bridge the gaps in the conventional healthcare framework. A ton of healthcare ventures in India additionally need automation for different undertakings and they are utilizing AI to help them in their industry.

On the flipside, India's healthcare space is relied upon to grow at a CAGR of 23% to a $280 billion market by 2020. What's more, with the 'Digital India' initiative, the Government has been supporting all endeavors towards overcoming any issues in health tech, a region where Indian start-ups, as of now have already achieved a momentum.

Between April 2000 and June 2019, Indian healthcare organizations, pulled in Foreign Direct Investment (FDI) worth $6.34 billion. This confirms that Indian healthcare market is one of the nation's quickest developing areas. As per the India Brand Equity Foundation (IBEF), India's healthcare industry is required to reach $372 billion by 2022. Health-tech is a distinct advantage, in spite of the way that India has far to go with regards to utilizing the technology to offer health-related services. It is expected to create 40 million job positions by 2030.

Similarly, the healthcare utilization of AI in Africa has just seen a couple of pilots and experiments. For instance, in South Africa, a multinomial strategic classifier-based framework is being applied to HR planning, particularly to foresee how long health workers may remain in public health service. An AI planning application is being developed for enhancing the planning and scheduling of community health workers (CHWs) in African communities.

Ubenwa, a start-up based out of Nigeria utilizes signal processing and ML to work on the diagnosis of birth asphyxia in low-resource settings. An investigation led by Bellemo et al. in utilizing Artificial Intelligence to analyze diabetic retinopathy prevalence in Zambia which demonstrated better outcomes when compared to human contributions and work abilities. The CAD4TB software developed by the Delft Institute has been used for the pulmonary TB diagnosis. This is made possible by CAD where AI analyses the chest radiographs obtained from the patients of Zambia and Tanzania. The outcomes were extremely promising as the working of the CAD4TB software was equivalent to that of human specialists.

Developing countries face realities and challenges in terms of infrastructure and investments that differs from that of developed countries. Countries like India are still on the road to reshaping their healthcare market with the implementation of AI. The Government of India's initiative NiTi Aayog proposed "AI for All" which is expected to improve the incorporation of AI in healthcare services. For uninterrupted implementation of AI in healthcare services, there is an essential requirement of large amounts of data which is currently unavailable or extremely difficult to collect, in the developing countries.

### 2.6. Conclusion

AI in healthcare is ready to make groundbreaking advances in the field of medicine. It is judicious to bring a balance to the requirement for smart, comprehensive AI that effectively oversees and reduces expected potential negative side-effects, while not giving in to the profit motives. The smartest direction for AI is to begin with genuine issues in medical services, investigate the best arrangements by drawing in applicable partners, frontline users, patients and their families—including AI and non-AI alternatives—and carry out and scale the ones that meet our Quintuple Aim: better health for all, improved quality of care, clinician well-being, lowered cost of care and health equity all through.

Regardless of the expanding consideration on AI in healthcare in the developed countries, its presentation remains more slow than anticipated. An impressive bit of healthcare professionals in these countires have never been associated with developing or sending AI arrangements in their organization. Subsequently, changing the abilities of healthcare specialists that would empower them to work close by useful AI applications and incorporation of this aspect in the long term medical education is deemed mandatory in these areas.

Advancement of AI in developing countries, faces real challenges in terms of infrastructure and capital that is different from that of the developed countries. However, the conceivable outcomes that Artificial Intelligence provides in changing while further developing the available healthcare options in low-asset, developing countries is extremely promising. Rather than developing an excitement to evaluate new techniques, an

evidence based approach ought to be utilized in making decisions and in implementing Artificial Intelligence to support healthcare in these areas.

A valuable lesson from the expertise of AI professionals serving in low and middle income areas is that the implementation of Artificial Intelligence must zero in on incorporating knowledge into the present frameworks and organizations instead of beginning without any preparation or expecting to replace existing frameworks.

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