

Leveraging Technology for Enhancing Medical Research in Healthcare

Medical research is defined as scientific studies and investigations conducted to expand knowledge and understanding of medical condition, diseases, treatments, and healthcare practices which encompasses preclinical, clinical, and epidemiological arenas with an aim to improve patient care, outcomes, developing new therapies/interventions, inform health policy and advancing medical knowledge. Research is a formal, systematic approach to investigate identified phenomena. It involves various methods of solving a researchable problem. The purpose of research is to investigate, describe, explore, explain or to predict phenomena of interest, events, behavior, and situations. The goal of research is to develop, refine, and expand a body of knowledge. It involves Inductive and deductive approaches. Inductive research methods analyze an observed event, while deductive methods verify the observed event. Inductive approaches are associated with qualitative research and deductive methods are associated with quantitative analysis. Qualitative method gathers information from natural settings and is also known as interpretive approach. Qualitative paradigm is a way of looking at the world from the point of view of people and focuses on what people experience, feel, think, believe, and understand. Thus, the qualitative paradigm does not seek to test or prove any phenomena but is concerned with describing and understanding the quality of human experiences and the views of people who have had or are currently experiencing. Quantitative research is associated with a philosophy known as positivism, which is based on ideas about the existence of objective reality and the ability of human beings to discover facts. Positivist philosophy and quantitative methods underpin most research into the natural sciences (physical, chemical, and biological experiments), medical research (drug trials) and also some social science and nursing research (psychological experiments and social surveys). The quantitative paradigm focuses on scientific ways of viewing the world that are measurable thus provable. This paradigm deals with phenomena that are quantifiable i.e., can be counted and measured with proof to establish the cause and effect and associations between variables. Quantitative research often starts with a hypothesis, which is an idea that needs to be tested using scientific methods.

Evolving technology plays a crucial role in healthcare and medical research advancements. Technology and technology assessments are the harbinger of effectiveness and beneficence to the scientific community at large. The biggest advantage of technology is that it fulfils the primary criteria of accessibility to far flung areas. Telemedicine helps in **remote monitoring** during clinical trials to collect data and consultation, it also reduces cost and time in interview study. Technology like MRI, CT, PET provide detailed visualization which helps researchers in the study of disease and its progression and evaluate treatment efficacy better. Evolving technology like Machine learning, Data mining, Data collection and analysis facilitates researchers in identifying correlations and insights from these datasets. Mixed reality (including virtual reality and augmented reality) are used in simulators which also helps in training surgeons for augmenting surgical accuracy, improving outcomes, and reducing complications. **Big data analytics** refers to analyzing and extracting meaningful insight from complex datasets maintained by health-care organizations (in the form of EHRs, EMR, PHR). It provides individualized recommendations to patients and medicines. These will help in disease surveillance and outbreak detection, early disease detection. Drug discovery and development process by mining and analyzing vast datasets (which includes genomic, proteomic data and clinical trial results) help researchers in identifying drug target and predict drug efficacy and side effects which leads to efficient drug development. Clinical decision support system (CDSS) uses the principle of BDA to assist healthcare professionals in making decisions regarding.

Machine learning is a computer program by which machine learn from data and use statistical techniques and advanced algorithms (Supervised, Unsupervised Semi-supervised, and Reinforcement learning) and to make powerful prediction and making data driven system more powerful by replacing the rule-based system. Health care research with machine learning (ML) has been increasing steadily because it is difficult for humans to infer from the medical data and to make decisions. Accordingly, ML has been proposed in health care for better understanding of data and for better decision-making processes. Objective recordings from wearable sensors may better help to capture meaningful data than information from surveys, papers, and diaries that is retrospectively assessed. Others sensor like temperature sensor, pulse oximetry sensor, oxygen sensor etc. can be used in monitoring of patient in healthcare and this data is collected, stored, and used for development and improvement of ability to detect disease and predict outcomes by ML. These game changing technologies have ensured that time is gainfully utilized for bigger outcomes.

Immersion techniques are the next order of the day. Virtual reality (VR) technology is that which visually immerses the user in a computer-generated completely artificial environment. Computers may generate and stimuli and special hand-operated controllers that enhance the VR experience. The various uses of VR are surgery planning, surgery training robotic surgery, Rehabilitation, Consent taking, Diagnostic tool etc. Advantages of VR are uniform applicability, Cost-effective, simulation of Multiple scenarios and stress situations which enhances research potential and allows effective training, it reduces medication dependence and prevents depressive symptoms during pain management etc. **Augmented reality (AR)** provides a computer-generated overlay onto real world surfaces, providing the user stereoscopic visualization (depth perception). **Mixed reality (MR)** will produce a stereoscopic image, created by combining the three-dimensional virtual model produced from preoperative radiologic images (CT or MRI), with a real-world surface, but with MR technology allows the MR user to interact with both real world and the digital content that is added to it. **Artificial intelligence** is based on the idea that it can mimic human intelligence by learning from the collected data from diverse sources and performing tasks that humans can complete, recognizing patterns, or predicting outcomes. **Explainable artificial intelligence (XAI)** is a system which is capable of both making judgement as well as explaining models. Diagnosis or treatment decision is no longer decided purely by a doctor, yet judgments made in a major way by a machine-utilizing algorithms (These algorithms belong to a class that is very broad (artificial neural networks, classifiers, etc.), which are adjusted using examples to improve how well they classify new, undiscovered cases) and most typical use of ML-based techniques in healthcare decision making is skill learning but it lacks justification for decision. XAI is the model which explains

the judgements made by autonomous machines. AI technique CNN-based model: proposed COVID-Net tested for diagnosis of COVID-19 using chest X-ray with an Accuracy and Sensitivity of 93.3% and 91.0% respectively. Chat GPT is making huge waves and is placed to be the biggest disruptor of AI based domains.

With the advent of technology and its application comes a huge challenge of ensuring Ethics in Research. Research ethics are the moral principles that govern how researchers need to carry out their research study. Ethics is the branch of philosophy which deals with the dynamics of decision making concerning what is right and wrong during the research process. It is fundamental to understand and recognize the research ethics and governance, ethical codes, and scope of research ethics before undertaking any research. The first ethical question is whether the research is worth doing. Additionally, conducting research requires not only expertise and specific skills but also honesty, integrity, and truthfulness. The idea of conducting research should only be based on findings from a comprehensive literature review so that the answer to the research question will benefit patients and society. Conducting research study should include universal values such as: equality, human rights, obedience to the law of the land, concern for health and safety, confidentiality, and preservation of the natural environment. The intention of research should be to improve knowledge about treatment, care, diagnosis, and prophylactic procedures or to gain an understanding of people's experiences, perspectives, views, and behaviors. It is mandatory that researchers seek permission from the respective Research Committees prior to the research being conducted and have systems in place for the proper utilization of the funding available for the purpose of the research. Thus, it is evident that Technological advances and understanding the utility of them is paramount, utilizing them for leveraging cutting edge technology should be dwelled with care for the pace at which Technology is progressing cannot be matched with human understanding. It is important that global communities are built to monitor and channelize the research potential for proper outcomes.

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