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IMPACT OF ADVANCED HEALTHCARE TECHNOLOGY AND MEDICAL ADVANCES IN UPCOMING HEALTHCARE FACILITIES OF HOSPITALS

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ABSTRACT

Over the last few years, technology has made massive advances in different fields of knowledge that altered our lives significantly. One of the main fields that benefited from technology and still has huge potential for development is Healthcare. **Aim:** this study aims to depict how the futures healthcare facilities can be organized based on healthcare technological advances such as Artificial Intelligence (AI), Information Technology (IT), robotic surgery and 3D printing. **Methodology:** this study has been carried out by reviewing and discussing the published literature concerning the recent technological developments in the medical fields and their upcoming application in the healthcare facilities in the near future. **Results:** Based on the analysis of information, with future medical advances, several machines will be implemented to collect our health information continuously, integrate it into our medical reports and make informed and intelligent decisions regarding our conditions and treatment plans. Physicians can conduct their visits and consultations via telemedicine and virtual reality when they are countries apart and hospital procedures will mainly be done by robots and AI, from reception to detection (radiology, scans, etc.) to surgery. 3D printers will be able to print almost everything, from medical equipment to human body parts such as artificial bones. **Conclusion**: Technological and medical advances will affect our future hospitals. We must prepare for a digital future and we need to plan for the role of robotics in our hospitals and

invest in research and development to further benefit from the use of technology in healthcare.

INTRODUCTION

We live at a time where everything in our lives is affected by technology. Similarly, the practice of medicine and healthcare have witnessed an enormous change lately due to the development of technology.

Medical technology in particular can be defined as the application of science to develop solutions to health problems or issues such as the prevention or delay of onset of diseases or the promotion and monitoring of good health.[1] Advances in medical technology have improved population health in those at risk for a disease, as well as for those diagnosed with a disease. Medical technologies for disease prevention include vaccination and drug prophylaxis. Screening using diagnostic imaging or other procedures can identify diseases at earlier and more treatable stages. Diagnostic imaging, devices, surgical procedures, and new prescription drugs can increase cure rates, slow disease progression, and/or reduce symptoms after diagnosis.[2]

Healthcare facilities as we have known them are facing major developments with the introduction of new technologies. Approaches towards a more electronic or even robotic system are taking place. At the present, various changes are occurring in so many ways from the methods used for saving patients' medical records, to the surgical procedures performed solely by robots. The spread of the Internet, mobile phones and social media has also encouraged both patients as well as medical personnel to be more accepting towards these changes.

Additionally, the traditional methods for training medical students and interns are slowly being replaced, by utilizing new technologies such as virtual reality and 3D printing to help them understand how things work based on a practical experience.

Other technologies applied in healthcare include wearable devices, digital patients' information collection, telemedicine, artificial intelligence as well as medical robots.

Thus, as digital health become more available, it is important to keep informed about all the technological advances and its integration within day-to-day practices in the medical scope,

since it will not only affect the active medical care given to the patient but it will also alter their experience completely from the moment they enter a healthcare facility.

In this review article, we concentrate on the landscape of current use of the previously mentioned technologies, the areas of development and the predicted impact on the future of healthcare facilities.

MATERIALS AND METHODS

A search of PubMed (http://www.ncbi.nlm.nih.gov/pubmed) was performed for several terms related to healthcare technology, including "Medical Technology", "Digital Healthcare", "Telemedicine", "Surgical Robots", "Innovative Treatment", "Artificial Intelligence" and "3D printing". From these results, articles from the past 5 years were selected to exemplify the use of technology in various medical fields and their expanded roles in the future.

Digitalization of healthcare

Digital hospitals are complex ecosystems with various clinical and business processes comprising numerous sub-processes. Through proper integration using Information and Communication Technologies (ICT), these processes unite patients, health care practitioners, assets, and information throughout the hospital, and thereby deliver the right information and resources at the right time to the point of care.[3]

Smartphones

Mobile devices can empower patients and their caretakers in controlling health problems and reducing their dependency on physicians for health information. These devices can use digital technology to present research information online, share experiences, and identify treatment options. They provide access to health information and education, which are important drivers of patient engagement.[3]

Also there are smartphone connected rhythm monitoring devices that has proven to be very efficient in healthcare, one such technology is the iECG, a smartphone case that incorporates electrodes for wireless cardiac telemetry monitoring (AliveCor), and was approved for use by the US Food and Drug Administration (US-FDA) and EU Medical Device Directive (EU-MDD) in 2013. In which a real-time display of the cardiac rhythm is created by conversion of an electrical signal into ultrasound and is captured by the smartphone microphone providing the user with an immediate rhythm analysis of atrial fibrillation.[4]

In addition they are considered a valuable source of information for health practitioners. For example, fitness and wellness applications are widely available health applications that provide information related to health.

Connected devices

The concept of connected devices, or the Internet of Things (IOT) applies to devices that have the ability to communicate information remotely over an intranet or the Internet.[5] Depending on the specific application, the method used for data collection could be active, passive, or both.

Wearable devices (Passive)

Beyond the smartphones-based devices, continuous 24-h ambulatory devices have been manufactured to incorporate passive date collection without burdening the patients significantly. Most importantly, the machine learning algorithms embedded on these devices could detect not only the duration of activity but also the characteristics of those activities and share the data with health care providers in real time and in high accuracy. Moreover, wearable technologies have been demonstrated to be efficacious for monitoring biomarkers such as blood pressure and glucose, as well as the assessment of several behaviours such as sleep monitoring, gait analysis, posture detection, and fall detection.[5,6]

A recent prospective trial was done to investigate the utility of acquiring activity data as a measure of health status for ambulatory cancer patients who were ongoing chemo radiotherapy. After collecting the date from the continuous activity monitors that were provided to a number of thirty eight cancer patients during their period of chemo radiotherapy course, they concluded that continuous activity monitoring during concurrent chemoradiotherapy is feasible and well-tolerated. Also, that step counts may serve as powerful, objective, and dynamic indicators of hospitalization risk.[7]

Non-Wearable devices (Active)

On the other hand, there is another type of internet connected devices which is being used in health care settings. The Non-wearable devices differ from wearable ones mainly in the method of data collection, as it needs active patient interaction for discrete data acquisition periods.

Despite the active nature of data collection, requiring patients to explicitly interface with the connected device and the corresponding potential concern of patient burden, there is significant potential for improving value, patient education, patient outcomes, and quality of life (QOL) with the use of these devices. Also, the clinical integration of these technologies seems feasible, and preliminary outcome results are encouraging.[5]

Telemedicine/Telehealth

Recently, there has been increased growth in the use of Telemedicine, which is defined as "the use of electronic information and telecommunications technologies to support long-distance clinical health care, patient and professional health-related education, public health, and health administration,".[8] Telemedicine may take place synchronously, asynchronously, or blended with in-person care. The patient and the consultant may engage virtually via fully interactive video technology in real time or asynchronously by storing and forwarding clinical data elements, such as medical reports, images, and video recordings, to be interpreted at a later time.[9]

Telehealth offers the potential for blending both audio and visual interaction with a remote patient or to those with mobility issues such as the elderly, and allows for bidirectional information flow.[5,10] it also enables international standards of medical treatment, health education, and public health services to be provided.[3] Telemedicine also helps patients to engage with their healthcare providers more frequently, in a convenient way, which may result in a better doctor–patient relationship, and it may provide an opportunity to reduce healthcare spending and save time for the patient and caregiver.[10]

The wide reach of internet and the availability of mobile phones makes telemedicine use easier, for example conducting follow up visits via telemedicine for different subgroups of cancer patients was found to be both feasible and acceptable.[5] Furthermore, in various cases microscopic examination can also be done by using telemedicine, more specifically telecytology (TC). As it was the case with the Memorial Sloan Kettering Cancer Center (MSKCC) which developed two models for performing Rapid On-Site Evaluation (ROSE) allowing remote viewing of microscopic images, the first model used off-site control robotic microscopes while the second model was conducted by streaming high-definition video microscopy technology. The two models showed a perfect correlation of 92.7% and 93% respectively.[9]

Electronic health records (EHR)

EHR records are now being created, used, edited, and viewed by multiple independent entities including primary care physicians, hospitals, insurance companies, and patients. They are increasingly being used in primary-care exam rooms to document and access patients' records along with online medical information and decision-making tools, and prescribe medications. Providers are now using order sets, voice recognition, barcodes, and documentation templates to directly enter information into the HER.[11]

Furthermore, to maximize the potential benefit of digital health technologies, Fast Healthcare Interoperability Resources (FHIR) are being used to allow for secure exchange of health care data between developers and various EHR platforms using standardized language, allowing for direct integration of external software with EHRs without requiring disparate and proprietary solutions.[5]

As healthcare practice becomes more patient centred, it led to more personal use of the EHR. Personal Health Records (PHRs) are now interfaced with applications within EHRs and are used by most large facilities and vendors. Also, other than the patients' health information, family health histories are also being entered into EHRs. They are used to assess disease risk and offer insight into the interplay between inherited and social factors relevant to patient care. Additionally, the human genome has now been decoded and whole-exome and whole-genome sequencing results are now being stored in the HER.[11]

As for population health, EHRs are being used to surveil various populations, leading to better surveillance of infectious diseases, improved management of patients with chronic diseases, and identify populations with higher risk factors. It has also been found that regular use of the EHR can reduce fragmentation of data and increase continuity of care between providers if the providers participate in health information exchanges.[12]

Artificial Intelligence

Artificial intelligence (AI) is a field of computer science that aims to mimic human thought processes, learning capacity, and knowledge storage.[13] AI can be applied to various types of healthcare data (structured and unstructured). Popular AI techniques include machine learning methods for structured data, such as the classical Support Vector Machine (SVM) and neural network, and the modern deep learning, as well as natural language processing for

unstructured data. Major disease areas that use AI tools include cancer, neurology and cardiology.[14]

Machine learning (ML) methods have been investigated in diagnosis, treatment and outcome prediction for many diseases. For example, ML methods were applied to neuroimaging data to assist with stroke diagnosis. By using support vector machine (SVM) in resting-state functional MRI data, by which endophenotypes of motor disability after stroke were identified and classified. SVM can correctly classify patients with stroke with 87.6% accuracy.[14]

Another technique that is being used in medical applications is Fuzzy logic which comprise one of the three pillars of Computational intelligence which in turn is categorised under the broad field of artificial intelligence. The other two pillars are artificial neural networks and evolutionary computing.[15]

The use of fuzzy logic allows to design fuzzy classifiers, which have fuzzy rules and membership functions, which are designed based on the experience of an expert. To give an example, a study that was published in 2019 in which a fuzzy classifier was built with the objective of performing blood pressure level classification based on knowledge of an expert which is represented in the fuzzy rules. They designed an optimized interval type-2 fuzzy system with triangular membership functions that has a classification rate of 99.408%.[16] Similarly, Fuzzy Logic has been used in various areas, such as for prediction of early-stage coronary artery disease, mortality prediction after cardiac surgery, and cardiac arrhythmia detection.[13]

Robotics in healthcare

Since technology became a major part of our lives, there has always been a vast interest in the development of Robotics and their use in all aspects of our lives.

One such case is Medical Robots which are being used in surgery, therapy, prosthetics, and rehabilitation. Surgical Robots in particular are being designed to increase the effectiveness and reproducibility (standardization) of surgical procedures as well as to reduce their invasiveness. One of the robots implemented in cardiac surgery is the Robin Heart PVA robot, designed by the Zbigniew Religa Foundation for Cardiac Surgery Development, it is an answer to the need for a light, portable robot mounted on the side rail of a standard

operating table. Both the robot and the settings of the operating table can be controlled with a convenient remote panel. A mini-joystick mounted on the endoscopic tool was designed as well. Using just one finger, the surgeon can adjust the position of the robot's arm and display the image of the current surgical site, located inside the patient's body, on a monitor via the video system.[17]

Another example for the use for robotic technology in healthcare settings are the Physically-Assistive Robots (PARs) and Socially-Assistive Robots (SARs) which were created to support the physical and psychological needs of the elderly respectively. The PARO robot for example was designed as a pet therapy for older people with dementia, it has been used in multiple countries for more than a decade now. Although there are barriers to the use of PARO robots such as cost and workload, infection concerns, and stigma and ethical issues. But studies also show their demonstrated benefits in reducing stress, anxiety, and antipsychotics use among older people with dementia.[18]

3D Printing

Medical Three-Dimensional printing is a growing application which serves to aid physicians in the diagnosis, therapeutic planning, and potentially the treatment of patients with complex diseases. The high resolution images provided by Computer aided Tomography (CT) are ideal for the construction of 3D models. Individual bones can be segmented and modeled from a standard CT with thin section reconstructions (<1 mm). There are several important roles for 3D printing in Healthcare, for example a 3D model supplements the physical exam, allowing the physician to manipulate internal anatomy, evaluating pathology in a method not achievable with computer-based imaging. Also, models can be used to pre-plan surgical techniques, multiple surgical approaches can be tested prior to going into the operative room. In addition to treatment planning, research projects which are not feasible with living subjects can be simulated with identical 3D models. Most importantly it can be used as a therapeutic tool, 3D printers offer a unique means to customize orthotics, prosthetics, and braces to individual patient needs.[19]

CONCLUSION

We reviewed a variety of technological applications that are being integrated into the healthcare practice in the recent years, which have the potential to raise the standards of healthcare services globally and allow for medical personnel's time and effort to be used

efficiently in order to care for a larger number of patients and in a wider geographic range too.

However, many factors need to be considered to estimate the extent to which technological advances will benefit our healthcare system those include the interest of investors in research and development of these technologies as well as the behaviour of medical professionals, patients and caretakers towards the use of technology as an essential part of their healthcare services.

In this article we emphasised on the impact of using medical technology in our lives and the importance of remaining informed about the advances being made in this field in order to be prepared for the future and be able to reap the full benefits of these medical technologies.

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