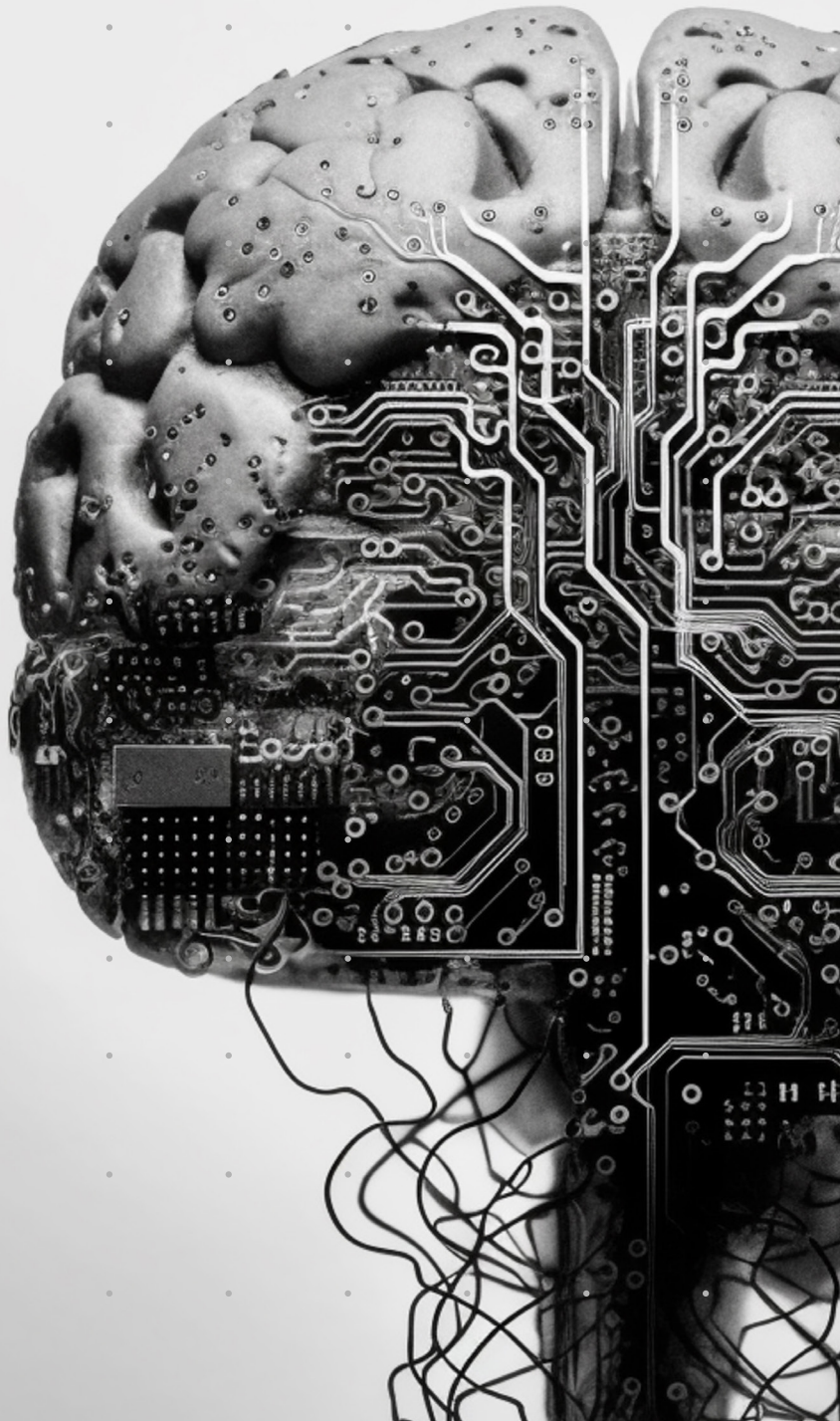
Advanced Medical Technologies in Iraq:

Scope, Challenges, and New Horizons



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Advanced Medical Technologies in Iraq: Scope, Challenges, and New Horizons

This brief is a collective effort done by the contribution of various departments at KAPITA.

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Abbreviations

AR	Augmented Reality
ART	Fertility and Assisted Reproductive Technologies
CDS	Clinical Decision Support
EMR	Electronic Medical Records
FET	Frozen Embryo Transfer
IVF	In Vitro Fertilization
KRG	Kurdistan Regional Government
ICSI	Intracytoplasmic sperm injection
MENA	Middle East and North Africa
MedTech	Medical Technology
MOOC	Massive Online Course Teaching
MPL	Modular Prosthetic Limb
NGOs	Non-governmental Organization
PGD	Pre-implantation Genetic Diagnosis
VR	Virtual Reality (VR)
3D	Three Dimensions

Executive Summary

It is undeniable that, over the decades, the Iraqi healthcare system is not fully up-to-date with international counterparts in terms of technology and treatment, yet it is slowly catching up and showing promising indications, especially regarding medical technology. In order to have a better understanding of the current technologies, this brief highlights some of these technologies and addresses the challenges and opportunities surrounding them.

The Iraqi healthcare system, within a decade, went into a spiral of rapid decline in services. The healthcare system goes back to the 1950s. Up until the 1980s, the health sector witnessed remarkable prosperity and development. Similar to the other sectors, wars and sanctions heavily undermined the system as Iraq experienced a rise in the number of casualties and a decline in oil exports. The state of the health sector deteriorated after 2003 with around 12% of hospitals destroyed.

The healthcare system is still implementing outdated approaches to the treatment and prevention of diseases, yet several technologies have evolved to fill that gap and improve the state of the healthcare sector. These technologies include 3D printing, Electronic Medical Records (EMR), and robotics. The implementation generally benefits the healthcare industry through better healthcare accessibility, medical care error reduction, and easier and more accurate access to patients' records.

Despite being one of the oldest systems in the region, Iraqi medical education is effectively incapable of providing medical students with the proper education and hands-on experience opportunities. This is due to the lack of constant improvement, outdated curricula, political instability, and excessive numbers of students. Fortunately, utilization of technologies in medical education, such as online learning platforms, 3D printing, medical apps, electronic medical records, and virtual reality can actually change the current state of education as they offer accessible resources, dedicated platforms, modern learning experiences, and flexible learning environment to name a few.

The Electronic Medical Records (EMR) is a system allowing healthcare hospitals, pharmacies, and laboratories to share patients' medical records more efficiently instead of the traditional paper charts. Attempts were made to use this technology in the Iraqi healthcare system, yet they faced lack of flexibility, higher costs, and poor technical support. However, there are several simple implementations of the EMR

concept in Iraq, such as Razi, Tadawi, and Tabib Iraq. The aim is to provide online booking, medical service, consultation, and doctors' information.

3D printing is yet another cost-effective and high-accuracy technological advancement across a wide range of fields in the medical industry, such as dentistry, orthopedics, and vascular surgery. 3D printing is a process of creating 3-dimensional physical objects from scratch using computer digital design. Despite the benefits and application, 3D printing in Iraq is not gaining enough attention, due to poor facilities supporting this technology, lack of government support and social awareness, and most importantly the limited investment opportunities by the private sector. These challenges hinder the adoption and development of 3D printing in the Iraqi health sector.

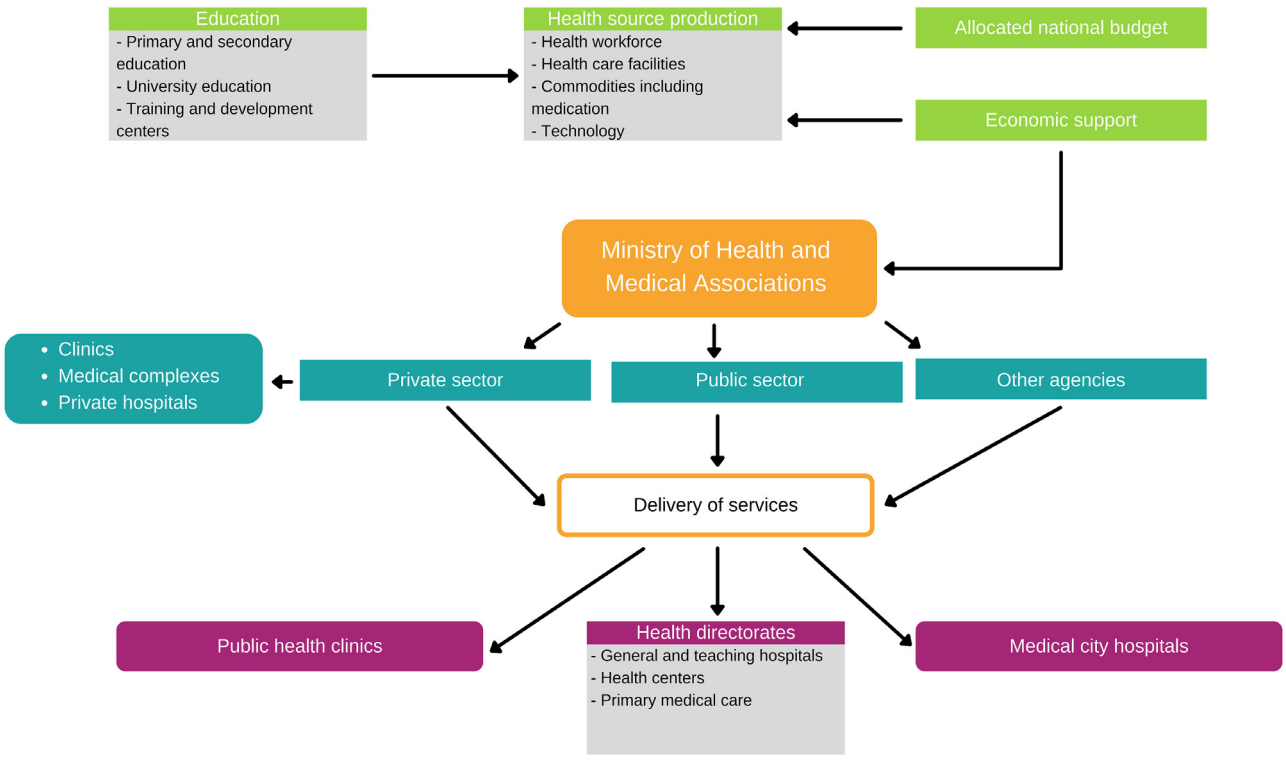
Fertility and Assisted Reproductive Technologies (ART) are gaining more attention from the Iraqi community and investors alike. The number of centers providing this treatment has increased as well as the types of services provided. The fertility rate has fallen to 3.4 in 2022 from 6.6 in 1980, which has led to the adoption of different technologies, such as In Vitro Fertilization (IVF), Intracytoplasmic Sperm Injection (ICSI), Frozen Embryo Transfer (FET), Pre-implantation Genetic Diagnosis (PGD), and Cryopreservation. These technologies vary in operations and treatment methods, yet the common goal is fertility and pregnancy. The ART has presented a great business and investment opportunity while still being challenged by limited equipment and experts, higher treatment costs, cultural and religious resistance (gradually fading away), and political instability.

Introduction

Birth of the Iraqi Healthcare System

The Iraqi healthcare system dates back to the 1950s when the Ministry of Health was established. Rising oil production and prices embarked on a new era of rapid modernization. The structure of this sector was created in the 1970s and remains at the core of the Iraqi healthcare sector, regardless of the multiple amendments that were applied to it in the following decades.

The Iraqi healthcare sector reached its peak during the 1970s and early 1980s, it was considered the best in the region. 172 hospitals and 1200 primary healthcare clinics were established which offered free services.



Source: Iraqi Healthcare Sector Overview, KAPITA, 2021

Deterioration of the Iraqi Healthcare System

This peak period came to a halt in the 1980s when funding was diverted away from the healthcare sector due to the Iran-Iraq war which lasted almost a decade. The high number of casualties and wounded in action added substantial pressure on healthcare providers and facilities (Al-Bayan Center for Planning and Studies, 2018).

In 1991, the sector was nearing its collapse as a result of the aftermath of The Gulf War. Destruction of the southern oil wells and export restrictions led to the depletion of almost 90% of the funds directed towards the healthcare sector. The lack of supplies and equipment rendered most facilities inactive offering only a fraction of their services. Living standards in general started to deteriorate as a result of the UN-imposed sanctions that continued until 2003. There were some attempts by the United Nations to relieve this suffering through the establishment of the Oil for Food programme, but the situation continued to decline (Al-Bayan Center for Planning and Studies, 2018).

The Healthcare System Post 2003

Additional challenges were imposed on the healthcare system following the war of 2003, around 12% of Iraqi hospitals were destroyed in addition to a few public health laboratories. Looting of stocks of medical supplies and pharmaceuticals left many Iraqis unable to receive medical healthcare even after the end of the sanctions.

In parallel to the period of civil war and lawlessness, many healthcare professionals started seeking employment in other countries. The restrictions on medical diplomas in 2007 and the implementation of return programmes were ineffective and were met with even more anger and frustration (Al-Bayan Center for Planning and Studies, 2018).

This steady decline from the late 1980s forward rendered the country's healthcare system inefficient, limited, and with unequal accessibility. This system received another shock as a consequence of the war against ISIS in 2014. The rising numbers of serious health conditions and injuries were a common concern with growing violence and instability. The situation was exacerbated by the destruction of every medical facility in the areas that were held by ISIS militant groups.

Although many areas were liberated from ISIS, they still suffer from a lack of infrastructure as many of those facilities functioned with many shortages and challenges (Al-Bayan Center for Planning and Studies, 2018).

The Medical Technology (MedTech) Field

The MedTech field has been an increasingly important part of healthcare over the past decade. It includes a set of products and services aimed to improve people's lives through diagnosis, prevention, and treatment. This sector is dynamically evolving with a range of technologies, such as 3D printing, Electronic Medical Records (EMR), and robotics. In Iraq, the healthcare system has been suffering from outdated approaches towards treatment rather than prevention of diseases.

The impact of the Covid-19 pandemic has uncovered the necessity of e-health in Iraq to reshape the healthcare system through advanced technologies that would provide efficient medical services. Recently, there have been efforts to introduce new technologies into Iraqi healthcare; yet, certain challenges emerged threatening the sustainability of these technologies.

MedTech: Benefits to the Healthcare System

The picture of healthcare being confined to the four walls of a hospital building is rapidly blurring now. Technology is pervading every field in society, and healthcare is no exception. These advancements in technology are revolutionizing the healthcare system to become more proactive, personalized, and convenient than ever before.

There are multiple benefits of technology in the healthcare industry which include:

- **Easier and more accurate access to patient's records**

The development of Electronic Health Records (EHR) allows patients' information to be more accessible to healthcare providers, which helped reducing the time spent searching through paper records and permitting a smoother workflow between different departments.

- **Improved access to care**

Cost, distance, and physical limitations have affected the universality of healthcare, particularly affecting disadvantaged populations. However, through the evolution of Telehealth, this disparity has been greatly reduced as healthcare providers can treat patients from miles away without the need for a shared physical space.

- **Reduction in medical errors**

Medical errors constitute a major public concern as medical errors are the third leading cause of death. Reduction of those errors is established through a new technology known as The Clinical Decision Support (CDS) system. This system can provide healthcare professionals with relevant information to aid their decision in diagnosis and treatment thus reducing the frequency of medical errors.
In addition, a reduction in medical errors can dramatically reduce costs for both patients and practitioners (UNO Technologies, 2021).

MedTech: Aspects of Different Technologies

Iraq's healthcare system is suffering from major challenges that are represented by old problems, such as the rise in the rates of infectious diseases, diabetes, and cancer. In addition, new issues are emerging, represented by a weak geographical distribution and rising costs of health services. These setbacks make the existence of a digital healthcare system a mandatory approach to ensure that nearly 44 million people can benefit from universal health coverage. This was further emphasized by The World Health Assembly in 2005 when it urged its member states to develop a plan to implement e-health services to promote equal and cost-effective healthcare to all members of society. In 2013, the approach to e-health was standardized by the World Health Assembly (Al-Bayan Center for Planning and Studies, 2022).

Medical Education

Medical education in Iraq faces multiple challenges in the form of old curricula, outdated teaching methods, and a lack of proper training facilities and centers. The lack of clinical expertise creates a difficult learning environment, where students fail to apply the gained theoretical knowledge. This eventually leads to disappointment and loss of motivation. So far, there have been no real steps taken to improve the educational system.

Reformation of the educational system could be implemented in several ways by rebuilding the curriculum according to international guidelines. Furthermore, the issue does not lie within curricula alone but also includes outdated teaching methods and teacher-focused learning.

Active learning should be encouraged and teachers need to understand their roles as facilitators who guide students. Technologies can be utilized through the introduction of online teaching, such as massive online course teaching (MOOC) and interactive teaching sessions with peers abroad. On the other hand, advanced technologies, such as simulation and wearable technologies can be used to tackle clinical aspects of learning (Alshamsi, 2017).

Electronic Managing Systems and Medical Records (EMR)

As healthcare is becoming more complex, paper-based patient charts have become an outdated method to maintain patients' records, especially when there is a massive load on hospitals totaling to 20,000 patients per month (Medecins Sans Frontiers, 2019). Because paper charts are limited to a single location at any given time, they cannot be shared between multiple physicians at the same time, which has negatively impacted the quality and productivity of the healthcare provision.

The development of electronic medical records will allow for information to be shared between different departments and institutes, allowing for more integrated and harmonious interaction while still ensuring the patient's privacy, reducing medical errors, and minimizing time spent on writing and interpreting patients' notes.

The number of pharmacies in Iraq has grown significantly in the last few years reaching 22,120 registered pharmacies (Aljumaili & Hussain, 2013). Therefore, a digitalized pharmacy management system can unify their work while also notifying physicians about possible side effects and toxicities of drugs prescribed. In addition, it allows for better and more efficient time management as it reduces time-consuming manual tasks, such as verification and making inquiries about physician orders. In laboratories, this system will manage requests and sort test results in electronic health records. Furthermore, the finance and billing system can issue bills and finalize costs rendered to patients.

However, despite the rising number of hospitals in Iraq that reach 429 hospitals (KAPITA, 2021), they still do not have the required infrastructure to implement e-health. This could be drawn back to multiple barriers, such as financial factors, technological factors, and policy barriers (Sabur & Neamah, 2016).

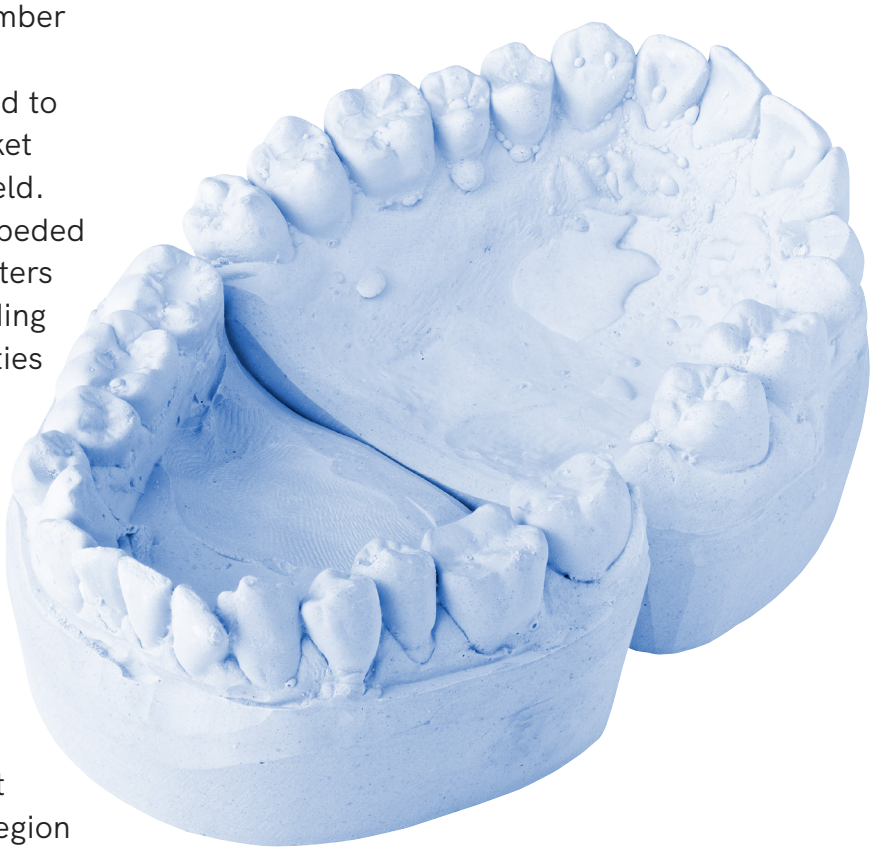
Another concept of e-health is telemedicine, which is defined as the use of telecommunication systems to remotely deliver healthcare services over the telecommunication infrastructure. It helps eliminate distance barriers and ensure an equal delivery of healthcare services to rural areas (Jaber, Ghani, & Herman, 2014). The fact that there are no specific laws and regulations that target the practice of telemedicine in Iraq does not completely suppress its practice (Takieddine, & Gemayel, 2021).

3D Planning and Printing

3D printing is a layer-by-layer addition approach to turn three-dimensional designs into customized medical equipment and products. A 3D model is developed through computer aided design with the help of a 3D scanner, a digital camera, or a 3D modeling software.

This new technology can play a major role in the production of dental implants, prosthetics, hearing aids, and tissue engineering. The rising number of dental and orthopedic malformations are expected to boost the 3D printing market growth in the healthcare field. However, this growth is impeded by the high cost of 3D printers and the lack of understanding of the 3D printing capabilities (Data Bridge, 2021).

Medical 3D printing applications have faced general disinterest in the MENA region, which seems to be tied to the indifference towards the 3D printing industry as a whole. This lack of interest is uncharacteristic of the region as it is usually first in line for newly developed technologies (Grunewald, S. 2016.However, in the last few years, 3D printer manufacturers have started to target the Middle East, and the market is expected to gain growth in the forecast period of 2021 to 2028. Experts have analyzed that the market is growing with an annual growth rate of 16.0% in the forecast period of 2021 to 2028 and is expected to reach USD 2,390.78 million by 2028 (Data Bridge, 2021).



Fertility and Assisted Reproductive Technologies (ART)

The fertility rates in Iraq have been in a continuous decline in the past few decades. Those rates have fallen from 6.6 in 1980 to 3.4 in 2022 (Macrotrends, n.d.). Social and economic changes taking place in Iraq have inevitably influenced fertility behaviors. As a result, advancements in infertility treatments and technologies are showing a rapid growth in the area.

There are multiple active centers in Iraq offering different modes of treatment including artificial insemination, in vitro fertilization (IVF), blastocyst transfer, and intracytoplasmic sperm injection.

Many of those centers are receiving governmental support, making the cost of those technologies relatively cheaper in comparison to services offered in other countries. Additionally, the stigmatization attached to infertility has relatively faded within the society and has shifted towards actively seeking those treatments. This has helped with their popularity within Iraq and has aided its growth (Sadeghi, M. 2015).

MedTech: Experts' Opinions

Experts working in the aforementioned fields were interviewed to get a closer look at the history, scope, benefits, and challenges of these technologies in Iraq. The profile of experts is as follows:

- Medical Education: Faculty members of the University of Baghdad, College of Medicine were interviewed. They had several years of experience teaching undergraduate and postgraduate students and were responsible for bringing new innovations into the educational system of the college.
- Electronic Managing Systems and Medical Records: Business owners and developers were interviewed to get insights about EMR technology in Iraq. They utilized the latest advances in the field and brought AI technologies into the scene.
- 3D Planning and Printing: Surgeons with several years of experience of working in different fields from dentistry to orthopedics and neurosurgery were interviewed to gain insights into 3D printing technologies. They are considered pioneers in the field.
- Fertility and Assisted Reproductive Technologies: Healthcare providers and managers of pharmaceutical companies were interviewed. They had several years of working in fertility field and helped in bringing new technologies into Iraq.

Medical Education: Educators' Perspective

The history of modern medical education in Iraq runs in parallel with the history of the Iraqi Royal Medical College (currently the College of Medicine, University of Baghdad) which was established in 1927 and adopted the Western model of education. At the time, students had hands-on experience in each subject of study (cadavers for anatomy and physiology, tissue samples for pathology, chemicals for biochemistry) which helped in gaining a deep understanding of the material. The facilities were sufficient for the number of students.

As time passed, the number of students increased while the facilities witnessed minimal improvement. Conflicts and political instability have also played negatively into the current state of medical education. At present, students study the majority of the material using softwares with minimal hands-on experience. Additionally, hospitals reached the maximum capacity to accommodate the practical education of students in subsequent years of medical college. On the other hand, the curriculum witnessed two phases of major development:

first in the mid-20th century and the second in recent years to keep pace with international standards. There has been an increase in partnerships between colleges and international universities to upskill human resources, enhance curriculum, and collaborate on research projects.
The scope of technologies in medical education expanded significantly in recent years. As for Iraq, the pace is slowly moving forward yet surely gaining momentum.

Applications in Medical Education

- Online Learning Platform: Several universities developed platforms to make it easier for students to access resources, take quizzes, and communicate with educators, making the learning experience more flexible and engaging. These platforms are meant to minimize the dependency on social media regarding the sharing of resources or news.
- 3D Printing: This technology is underutilized in medical education although it can solve the shortage of anatomical models. 3D Printing will allow visual representation of complex structures, which will help in knowledge retention.
- Medical Apps: Apps can help in providing easily accessible materials for students. These apps can cover a wide range of topics from basic sciences to clinical subjects. The existing apps are general and are not based on the current curriculum. These apps can extend further to provide telemedicine allowing students to participate in consultations and virtual clinical experiences.
- Electronic Medical Records: Access to data of patients (anonymized and with consent) can prove a rich source of experience. Students can use the records to understand the management of patients and clinical courses. Additionally, these records can be used to conduct studies and gain a deeper understanding of public health principles.

- Virtual Reality (VR) and Augmented Reality (AR): The use of these technologies can accommodate the increasing numbers of students by allowing them to practice clinical skills and procedures in suitable environments. The immersive experience will also help in the visualization of structures or in simulating doctor-patient interactions.

Benefits of Technology in Medical Education

Integrating technology into medical education offers numerous benefits that revolutionize the learning experience. Firstly, it provides easily accessible resources on dedicated platforms, allowing students to access educational materials anytime, anywhere. Lecture notes, textbooks, multimedia content, and practice questions can be conveniently accessed through online platforms, ensuring a seamless and efficient learning process.

Secondly, technology enhances the learning experience through interactive tools, simulations, and virtual models. By leveraging multimedia elements, students can engage dynamically with the content, improving their understanding of intricate concepts and complex anatomical structures. Visualizations such as 3D models, animations, and videos provide a more immersive and interactive learning environment, fostering deeper comprehension and knowledge retention.

Moreover, it enables a flexible learning environment that accommodates diverse learning styles and preferences. Students can progress at their own pace, revisit challenging topics, and access personalized resources tailored to their specific needs.

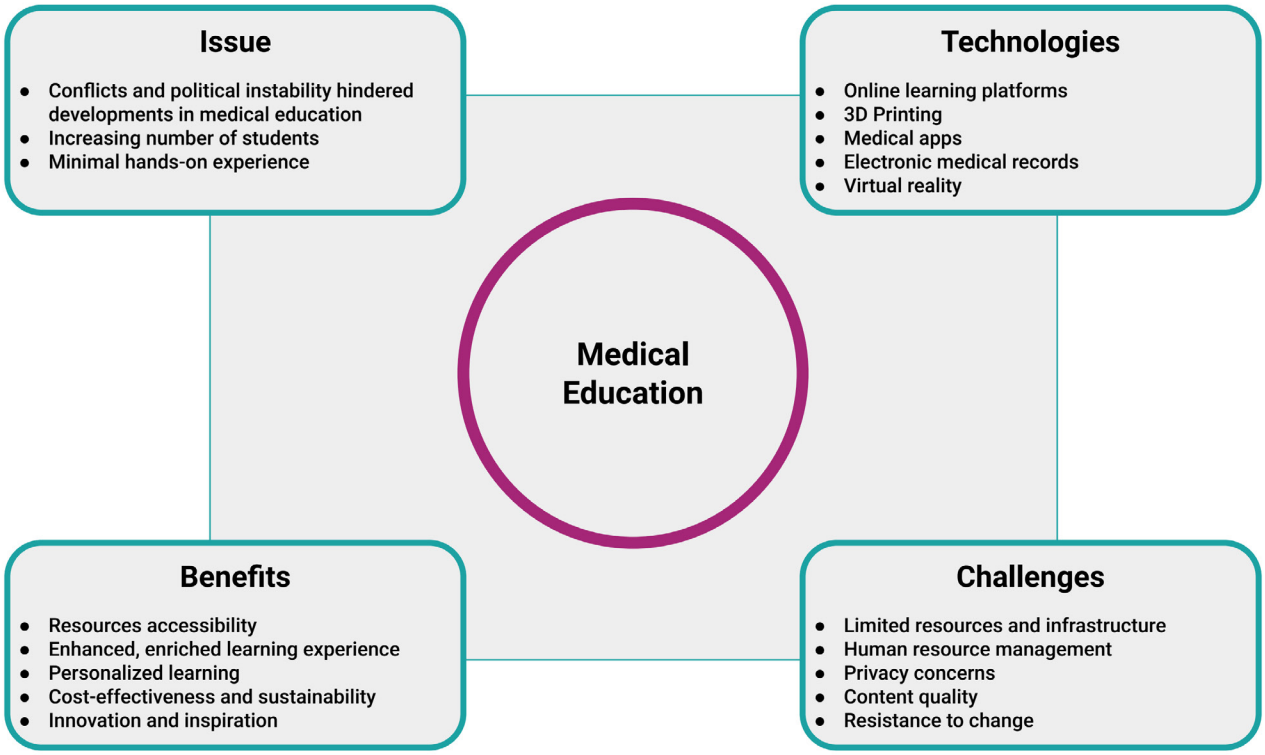
Integrating technology in medical education also brings cost-effectiveness and sustainability. By reducing reliance on physical resources like textbooks and infrastructure, digital alternatives can be employed, leading to significant cost savings. Additionally, the ability to continuously update and enhance educational content without the limitations of physical resources ensures the sustainability of cutting-edge medical education.

Lastly, it acts as a catalyst for innovation and inspiration among students. It exposes them to the latest advancements, research breakthroughs, and real-world case studies, stimulating critical thinking and fostering creativity. Collaborative learning opportunities enabled by technology connect students with peers, experts, and researchers globally, nurturing a broader understanding of the medical field and inspiring novel ideas and approaches.

Challenges Ahead

Despite that, there are certain challenges that hinder employing these technologies including:

- Limited resources and infrastructure: Medical education technologies require investments to develop and have constant improvements; the infrastructure (mainly the internet) may pose a major challenge to fully utilize the potential of these technologies.
- Human resources: Medical education follows the traditional method of education, and integrating technologies will require investments in developing the skills of faculty members and staff.
- Privacy issue: Greater access to technology requires greater attention to the privacy of both users' and patients' data.
- Content: It is safe to say that content quality is trusted as the current educational system is rigorous. However, developing a unified content that is approved by all universities is challenging and will require considerable collaboration and effort.
- Resistance to change: As with every technology change, some will resist the change. Nevertheless, increasing awareness and training on these technologies will make them acceptable to the majority of users.



Electronic Managing Systems and Medical Records (EMR) in Iraq: Leaving Paper Behind

The early use of the technology was by modifying the existing management systems of healthcare through the use of software developed by non-Iraqis. This approach has its shortcomings, such as lack of flexibility in the system, high costs, poor technical support, and a wide gap between the customer needs and the software service. Thus, attempts were made to develop softwares, specific to healthcare institutions, by local talents.

The early developed softwares were limited to a specific sector like hospital management, patient medical records, drug store, or lab management. The lack of integration had the users bear higher costs as they required multiple softwares and had less accuracy and flexibility. The softwares are not integrated, unreliability and inconsistency of technical support services.

The expert's thought on this matter is as follows:

"There are softwares that deal with tickets and E-records, while others connect the healthcare providers and others connect the labs only.

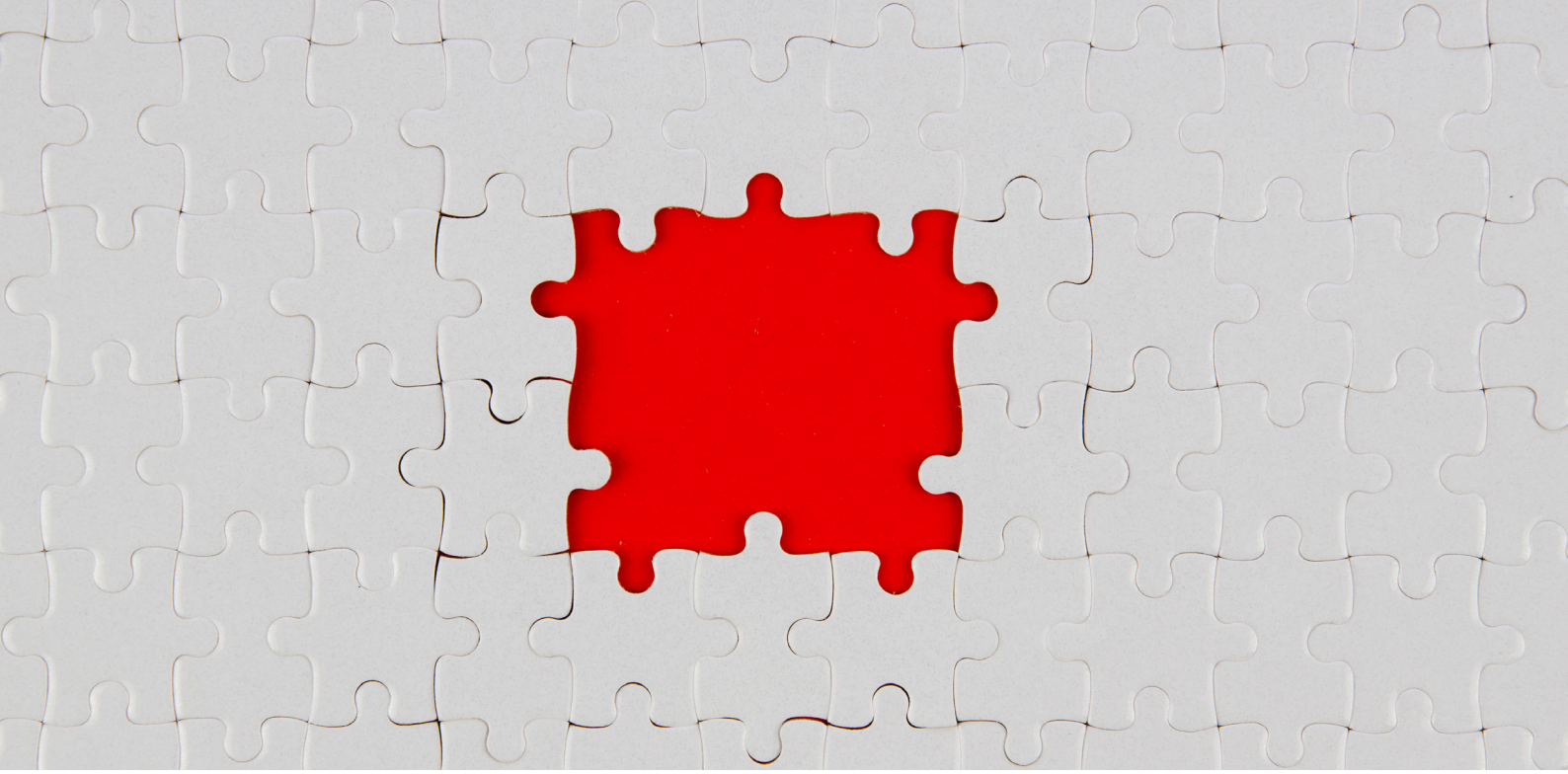
This lack of integration is due to the highly segmented sector as there are several players in the market and some of them are non-Iraqis. The issues with current softwares include the high cost, unreliability due to crashes, and the user interface. Now, we're attempting to solve this issue by creating a system that connects the chains of the healthcare system in one place at an affordable price with advanced technical support. "

Benefits of Electronic Systems

The integration of advanced medical record systems offers several advantages. Firstly, it ensures high accuracy in data management as information can be easily stored and retrieved, promoting precision and minimizing errors during multiple patient visits. Secondly, the use of voice recognition technology allows for faster data entry, enhancing efficiency and streamlining the documentation process.

Additionally, the adoption of cloud storage enables the easy accessibility of patient data regardless of time or location. This accessibility ensures that healthcare providers have the necessary information at their fingertips, enabling prompt and informed decision-making. Moreover, the richness of data is enhanced as systems can store various formats such as videos, images, and previous reports, facilitating comprehensive and detailed patient records.

These advanced systems contribute to a reduction in medical errors by employing intelligent models that can alert healthcare providers about potential drug interactions or identify trends in patient data, promoting patient safety and improved outcomes.



Furthermore, the high level of security ensures that access to sensitive patient information is limited to authorized individuals involved in direct medical care, safeguarding patient privacy and confidentiality.

Moreover, the integration of medical record systems enhances the overall performance of healthcare institutions. Seamless integration between different departments, such as the receptionist, doctors, laboratory, pharmacy, and finance officers, enables better coordination and communication, leading to improved workflow, patient care, and operational efficiency.

Challenges to the Technology

There are several challenges associated with the adoption of electronic medical record systems in healthcare settings.

Firstly, convincing providers or stakeholders to transition from paper-based systems to electronic systems can be a challenge. Resistance to change, concerns about data security, and the need for training and adaptation may hinder the acceptance and implementation of these software solutions.

Cost is another factor that can pose a barrier to adopting electronic medical record systems. The initial investment required for purchasing and implementing the software, as well as the associated hardware and infrastructure upgrades, can be substantial. This financial burden may be a deterrent for some providers, especially those with limited resources.

Busy clinics with limited human resources may find it difficult to allocate time and manpower for data entry and system implementation. The additional workload required to input and manage patient data electronically can strain already stretched resources, potentially leading to resistance or delays in adopting these systems.

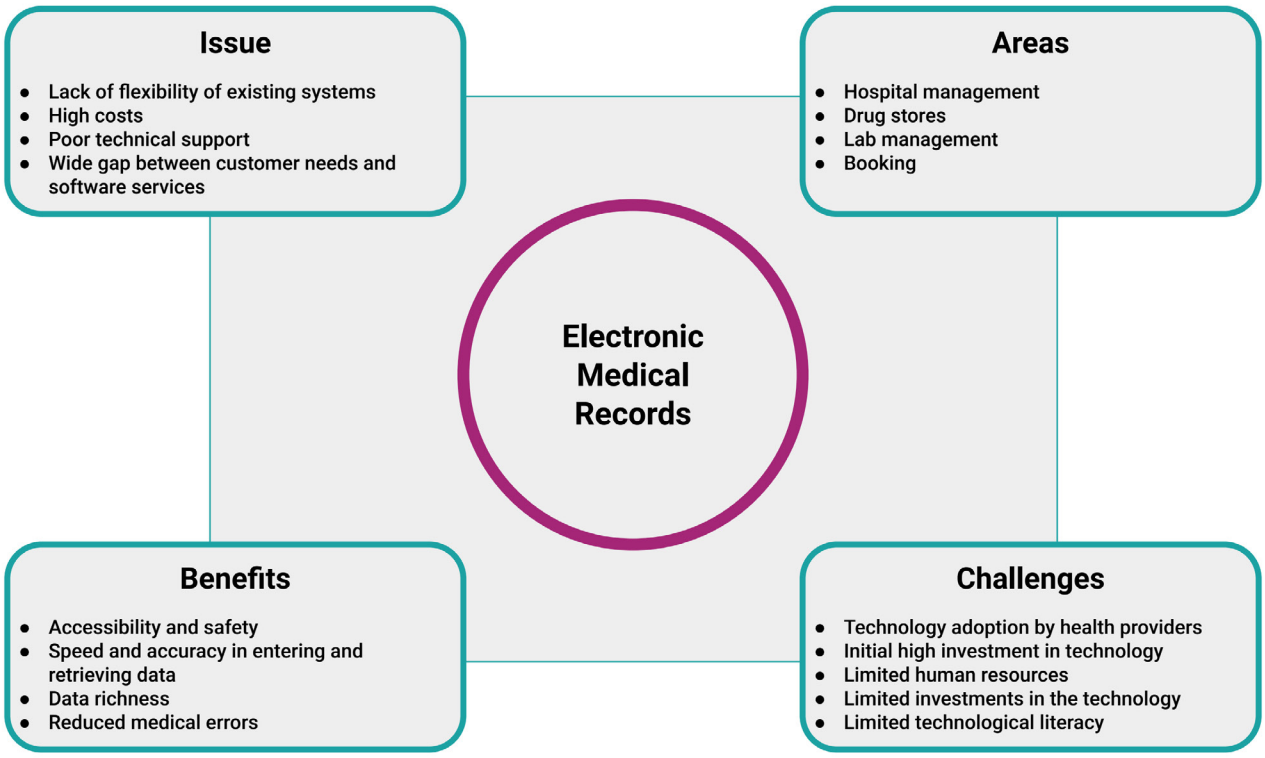
The technological literacy of users is also a significant factor influencing the adoption of electronic medical record systems. Some healthcare professionals may view the technology as too complex or unfamiliar,

leading to skepticism or reluctance in using the software effectively. Training and support programs are crucial to help users overcome these barriers and develop the necessary skills and confidence to utilize the technology.

Furthermore, limited investment in this technology has resulted in its limited expansion, primarily being concentrated in urban areas or the center of cities. This disparity in access and availability creates inequities in healthcare delivery, particularly for providers in rural or underserved areas who may have limited access to electronic medical record systems.

The expert commented on the challenges:
" We're facing challenges from different directions including a limited number of developers to meet the user demands, lack of investments to limited expansion and access to talent, and resistance by healthcare providers to use the technology. However, younger providers who are tech-savvy are adopting the technology rapidly."

The potential for the technology in Iraq is to expand into the public sector to integrate the different institutions and provide better healthcare.
The expert's vision of the future:
" The future for this technology is to contract private and public institutions. This will be the jackpot for entrepreneurs as it will allow rapid expansion both on the technological and regional levels. In return, patients will access the care easily and efficiently."



3D Planning and Printing in Iraq: Rosetta Stone of Technologies

The emergence of 3D printing technology in healthcare represents a significant advancement in the medical industry. In the early 2010s, international humanitarian organizations, such as Doctors Without Borders, began using this technology to treat children with congenital anomalies and skeletal deformities. However, due to the high cost involved in outsourcing, the use of this technology was limited in terms of scope and numbers.

With the increasing accessibility of 3D printing, the medical community expanded its use into other fields: including dentistry, where it was used to visualize, plan, reconstruct, and print dental models for patients with tumors. While these early printed models were not compatible with tissues, they were instrumental in planning surgical procedures and creating tissue replacements.

Applications of 3D Printing Technology

Despite these initial limitations, the use of 3D printing technology in healthcare rapidly expanded into other medical fields, such as neurosurgery, orthopedics, vascular surgery, and gastrointestinal tract surgeries. Today, 3D printing technology is widely used in healthcare for creating patient-specific models, implants, and surgical guides. This technology has revolutionized the medical industry, enabling clinicians to provide more precise and personalized care to their patients while reducing costs and improving outcomes.

The use of 3D printing technology in healthcare has brought about numerous benefits, both for patients and medical practitioners, which include the following: reduction of financial burden on patients, decrease in operation time and costs, reduction of complications and use of human resources, and increase accuracy in operations that would result in more predictable outcomes.

Benefits of 3D Technology

One of the key advantages of this technology is the ability to simulate the operation, enabling medical professionals to plan and visualize the procedure beforehand. This not only increases the accuracy of the operation but also enhances patient satisfaction, as they are able to see the planned outcome before undergoing the procedure.

Furthermore, the use of 3D printing technology in healthcare eliminates the need to outsource the printing process, reducing costs, and improving efficiency. Medical practitioners can now print patient-specific models, implants, and surgical guides in-house, allowing for a more streamlined and cost-effective approach to patient care.

Challenges to 3D Printing

The integration of 3D printing technology in healthcare presents several challenges that could potentially impact its future in Iraq. These challenges span across various levels and will require collaboration

among stakeholders, including healthcare providers, educators, and patients, to overcome them.

Poor Infrastructure
At the institutional level, the lack of facilities with infrastructure to support the technology is a significant challenge. Healthcare institutions require proper equipment, software, and technical support to effectively integrate 3D printing technology into their operations. Additionally, the lack of human resources with formal training on the use of the technology, its application in other medical fields, and technical support to troubleshoot issues, pose a significant challenge.

Scarcity of Investment Opportunities
The limited investments by the government, coupled with little interest from the private sector, also presents a challenge to the widespread adoption of 3D printing technology in healthcare. This lack of financial support may hinder the research and development of new technologies and equipment necessary to support the integration of 3D printing technology into healthcare.

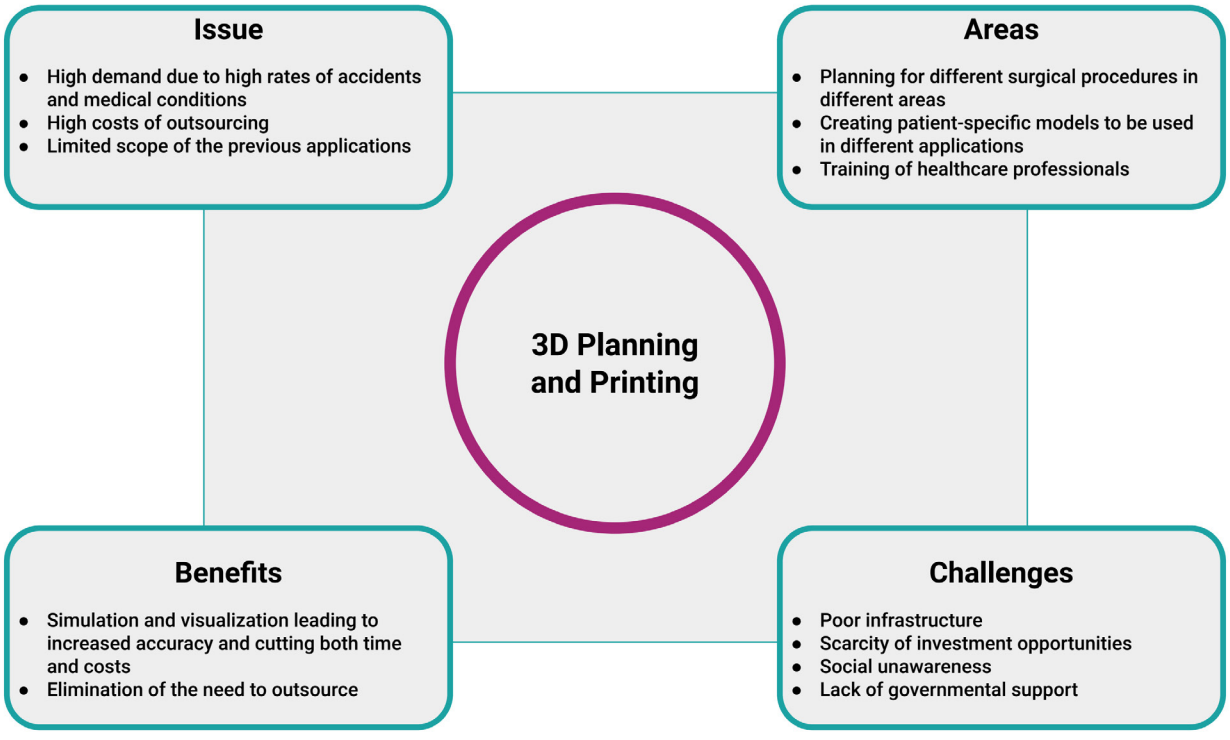
Social Unawareness
3D technology is still a foreign concept to healthcare providers and patients altogether. This is mainly due to the lack of awareness, education, and understanding the role of such technology. It is essential to educate these stakeholders about 3D printing technology in healthcare and highlight its benefits in terms of high accuracy, low operation time, and cost-effectiveness.

Absence of Government Support
The lack of support from technology developers, due to the absence of formal contracts through the government, hinders the integration of 3D printing technology in healthcare. This makes it challenging for healthcare providers to access the latest technology and equipment needed to support the integration of 3D printing technology in healthcare.

An expert commented:
"Addressing these challenges requires a coordinated effort from various stakeholders: the government, private sector, healthcare providers, educators, and patients. In doing so, Iraq can fully leverage the benefits of 3D printing technology in healthcare and improve patient outcomes while reducing healthcare costs."

The expert commenting on the challenges:
"We're facing a lot of challenges starting by healthcare providers as they're skeptical about it and the patient is unwilling to pay for it but once tried, the patient and the provider are happy about it. Aside from that, the lack of skills is impacting the technology significantly as those who are working on it are self-trained and usually are busy training more individuals. This led to further issues like the minimal utilization of the existing resources (3D printers) which are found easily now in Iraq but few are using them in healthcare."

The expert on the potential of 3D printing technologies:
"The future of the technology in healthcare is bright and can be used to achieve gains for patients, investors, and the youth. The technology can be used in medical education to accommodate the increasing numbers of students and the poor infrastructure, it can be used to print biocompatible tissues and use them as replacements, and it can be used to do more complicated surgeries. The scope of this technology is virtually limitless."



Fertility and Assisted Reproductive Technologies (ART): The New Arena

The history of Assisted Reproductive Technology (ART) in Iraq has been marked by challenges and successes, reflecting the country's political instability and limited resources. Despite these challenges, there have been significant leaps in both technology and the number of ART centers throughout the country.

The limited availability of resources, including financial constraints and a shortage of trained personnel, have challenged the development of ART in Iraq. Many couples seeking ART services face high cost of treatment, which has been a significant barrier limiting their access to these reproductive options. The political instability in the country is another hindrance that has impacted the growth and development of ART centers.

The growing demand for ART services has presented a great opportunity despite the challenges. Therefore, there has been a noticeable increase in the number of ART centers in Iraq. The success rates of ART treatments in the country, on the other hand, have been fluctuating reflecting the limitations of technology and the lack of resources. The demand for ART treatment does not match the supply of services in the Iraqi market, which still challenges many couples who wish to get this treatment.

Applications in ART

- **In Vitro Fertilization (IVF):** A procedure that involves extracting the egg from the ovaries, which are then fertilized with sperms in a laboratory setting. The embryos are then transferred back into uterus for implantation.
- **Intracytoplasmic Sperm Injection (ICSI):** ICSI is a specialized form of IVF that involves injecting a single sperm directly into an egg, which can be used to overcome male infertility or other conditions that may affect sperm quality or motility.
- **Intrauterine Insemination (IUI):** IUI involves the placement of specially prepared sperm directly into a woman's uterus during ovulation, which can increase the chances of fertilization.
- **Frozen Embryo Transfer (FET):** FET involves the transfer of previously frozen embryos that were generated through IVF in a previous cycle. This allows for the storage and preservation of embryos for future use.
- **Pre-implantation Genetic Diagnosis (PGD):** It is the technique of screening embryos for genetic or chromosomal abnormalities before they are implanted into the uterus.
- **Cryopreservation:** It is the process of freezing and storing biological materials, such as ova (eggs), semen (sperm), and embryos, at very low temperatures in order to preserve their viability for future use providing flexibility and options for individuals and couples seeking fertility treatment.

The utilization of these advanced reproductive technologies extends beyond addressing infertility concerns. Increasingly, these technologies are being employed for a wide range of purposes that mainly concern mitigation and preservation.

Benefits of ART

By leveraging these technologies, couples facing genetic or chromosomal abnormalities can undergo pre-implantation genetic diagnosis (PGD) to screen embryos and select those that are free of inherited diseases or disorders. This enables couples to make informed decisions about the embryos to be transferred, minimizing the risk of passing on genetic conditions to their offspring. As a result, these technologies offer a compelling solution for families with a history of genetic diseases, providing them with the opportunity to have healthy children and mitigate the impact of genetic disorders.

Furthermore, these technologies also play a critical role in fertility preservation, allowing individuals to preserve their reproductive potential for future use. Cryopreservation of eggs, sperm, and embryos provides means for individuals to safeguard their fertility, particularly in cases where medical treatments, such as chemotherapy or radiation, may threaten fertility. This has significant implications for cancer patients, individuals with certain medical conditions, and those who wish to delay parenthood for personal or professional reasons.

From a business perspective, the increasing utilization of these technologies for purposes beyond infertility treatment presents new opportunities and challenges for fertility clinics, reproductive medicine specialists, and other stakeholders in

the field. This includes the need for specialized expertise in pre-implantation genetic diagnosis (PGD), cryopreservation techniques, and other advanced reproductive technologies. Additionally, the demand for these services may drive innovation and investment in the development of new technologies, services, and business models to cater to the evolving needs of patients and clients.

On this point, the expert commented: "First thing comes into mind when thinking about ART is to overcome infertility and increase the chances of getting pregnant. However, and as more individuals are focusing on their careers, preserving fertility is becoming the aim for some and this is not limited to professionals, but individuals who are being treated with medications that affect fertility are using these technologies to preserve as much as possible. Additionally, genetic testing is helping a lot of families with inherited diseases."

Challenges Facing ART Adoption

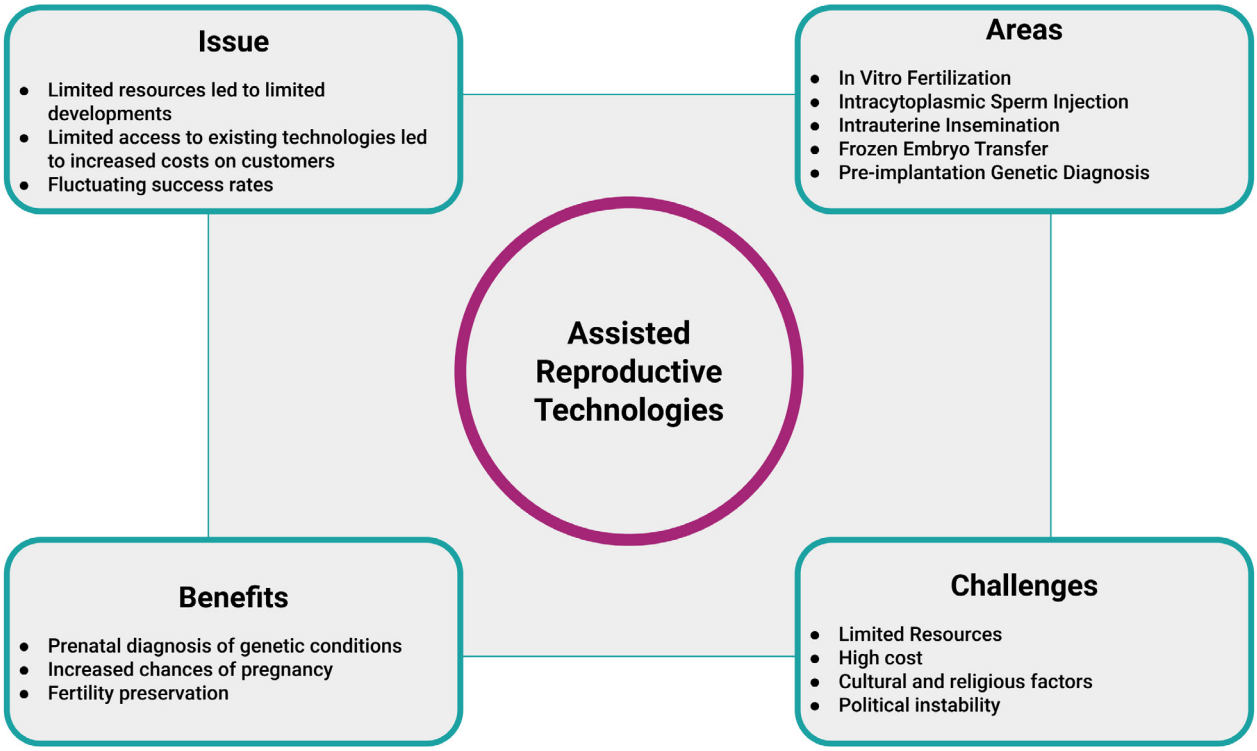
Despite the reported benefits, there are significant challenges that pose obstacles to the widespread adoption of assisted reproductive technologies (ART) in Iraq. These challenges may present opportunities for healthcare entrepreneurs to develop innovative solutions to overcome. The key challenges facing the utilization of ART in Iraq can be summarized as follows:

- **Limited Resources:** The field of ART requires advanced equipment and specialized personnel, yet access to such resources is limited in Iraq. The rapid evolution of ART technologies necessitates continuous investment in state-of-the-art equipment, which may not be readily available in all regions of the country. Furthermore, there may be a shortage of trained personnel with expertise in these technologies, further hindering their widespread adoption. This limitation in resources can disproportionately affect couples in need, particularly those residing outside major cities where ART centers are concentrated. This restricts their access to these technologies.
- **High Cost:** The cost of ART treatments can be prohibitive, posing a significant financial challenge for many couples. Limited resources and infrastructure in Iraq can drive up the cost of ART procedures, making them financially unattainable for couples with limited financial means. The high cost of ART treatments can further exacerbate the accessibility issue, limiting the options for couples seeking fertility treatments.
- **Cultural and Religious Resistance:** The use of ART technologies has been met with cultural and religious reactions that have posed challenges to their acceptance and adoption in Iraq. Even though the use of ART initially faced fierce resistance, education and spread of awareness have gradually facilitated acceptance of such technology. Nevertheless, cultural and religious considerations continue to influence the utilization of ART, and entrepreneurs in the healthcare industry may need to navigate these cultural and religious sensitivities in developing and implementing ART solutions.
- **Political Instability:** The political instability in Iraq and the region can directly impact the infrastructure and availability of ART services. Many ART

centers in Iraq are privately owned, and political instability can disrupt the operations and the accessibility of ART services. The uncertain political environment can also impact the investment scene and development of ART technologies in the country, posing challenges for entrepreneurs in the healthcare industry to establish and maintain reliable ART services.

The potential for ART in Iraq is promising and worth investing in. This can be achieved by collaborating with international partners and agencies, which will allow for the development of new technologies/innovation in existing technologies, increase of accessibility by customers, increase of market competition among ART providers, and reduce treatment cost. Campaigns to increase awareness are of major importance and can impact the legal framework and the cultural attitudes directly leading to the opening of new centers in the different regions of Iraq and encouraging more individuals to seek help.

The expert commented on the potential: "In recent years, there has been an expansion in the field of nutritional supplements in the field of fertility and now it's a huge market. ART is undergoing a similar transformation and more people are seeking help. Some demand technologies that exist in developed countries driving entrepreneurs and businesses to collaborate to bring these technologies to the country. The potential is huge and worth investing in."



Conclusion and Recommendations

Several medical technologies have emerged in the healthcare system targeting specific medical needs while others require more planning and investment. Medical technologies, such as 3D printing, electronic medical records, prosthetics, and FAT have the potential to grow as the demand for medical services increases. There are several challenges ranging from lack of awareness, political instability, shortage of expertise, and most importantly lack of investment opportunities.

- **Medical Education**

The integration of technology in medical education offers tremendous potential to revolutionize the learning experience and improve the quality of education. By providing easily accessible resources, enhancing interactivity and visualization, offering a flexible learning environment, and promoting cost-effectiveness and sustainability, technology can transform the way medical students learn and prepare for their future careers.

- **Electronic Managing Systems and Medical Records in Iraq**

Health providers should decrease skill outsourcing and work with local talents. It is important to seek Iraqi developers and invest in local talents to create and manage these Electronic Systems and Medical Records. Local developers can offer continuous technical support, lower costs, and most importantly they have experiential knowledge of these issues, which is something that foreign software developers do not possess.

Healthcare providers should address the lack of integration in the health sector through one unified system. Having multiple segments and a specific-sector software, software dealing with tickets, e-records, healthcare providers, and labs, hinder the medical electronic management revolution. One unified system can potentially reduce costs and increase efficiency.

The private sector should take the lead in this arena and invest in healthcare Electronic Systems and Medical Records. Such technologies are newly introduced to the Iraqi healthcare system, and they offer solutions to existing medical-related issues faced by healthcare providers and patients alike. Therefore, local and international companies can fill this market gap.

- **3D Printing Technology**

Fighting skepticism among healthcare providers through awareness educational campaigns is key to successful adoption of 3D printing technology. Spreading awareness among healthcare providers and educating them about the market's financial benefits, operation accuracy, and most importantly patient satisfaction can certainly shed light on this market gap and the need for such technology as it has many applications in orthopedics, vascular surgery, and gastrointestinal tract surgeries.

Stakeholders should take into consideration improving the state of skills of 3D printing technology among individuals within this field through training centers and programs. This will help popularize it and encourage local developers and other individuals to pursue careers in this field, which contributes to increase the skill level and as well as the pool of talent in Iraq.

Medical 3D printing is a neglected aspect of the Iraqi healthcare sector, and local and international investors should seize the opportunity and invest in this technology. The Iraqi healthcare sector lacks the essential equipment and resources required to implement 3D medical services that can bridge the gap between healthcare providers and patients. This is due to the limited investment by the Iraqi government in research and development in 3D printing technologies.

- **Fertility and Assisted Reproductive Technologies**

Local and international investors/ companies should invest more in Fertility and Assisted Reproductive technologies due to their financial benefits and the diversity of treatment provided. As time passes, the need for medical treatment for pregnancy and fertility and the need for better reproductive options grow. The Iraqi market requires more of the necessary resources and equipment to provide services covering the market demand.

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About KAPITA Business Hub

KAPITA is a private sector development company that aims to empower small and medium-sized enterprises (SMEs) through investment, research, incubation/ acceleration, and market development programs.

Our Services

- **Acceleration and Incubation Programs**

Through our partnerships with global and local accelerators and incubators, we provide startups access to a wide range of resources and support services, including mentorship, funding, and networking opportunities.

- **Investment and fundraising**

Our extensive network and deep expertise in the local market enables us to help investors identify high-potential startups and companies, facilitating meaningful connections with entrepreneurs in Iraq.

- **Research and professional services**

With a deep understanding of the Iraqi market and its unique challenges, we offer customized solutions and insights to help businesses succeed in today's competitive environment.