

Tech Frontiers in Healthcare: Opening up the Future with 5 Tech Innovations

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The healthcare industry is about to undergo a technological revolution. From blockchain to AI, and from IoT to AR/VR, all the way to 3D printing, these technologies may bring a brighter future to the healthcare industry, reshaping the doctor-patient relationship and reshaping the industrial value chain. This blog examines each of these technologies, exploring the opportunities they present to the healthcare industry and the challenges that come with the benefits.

Blockchain in Healthcare: See the Opportunity in the Challenge

Blockchain: B-l-o-c-k-c-h-a-i-n

Noticed this strange title? This is actually what you can imagine a blockchain would look like. In simple terms, a blockchain contains series of time-stamped blocks that store immutable data, and then these blocks are chained all together by computers. We can imagine what it is simply by thinking of the letters in the title as the blocks, and the hyphens as the chains. Even though it is not a visible physical object, figure 1 may be helpful.



Figure 1 (Coravos & Warner, 2017)

Opportunity VS. Challenge in healthcare

According to Darlington (2022), blockchain technology has three main pillars: decentralization, transparency, and immutability. Figure 2 is a good summary of how blockchain features can meet the needs of healthcare.

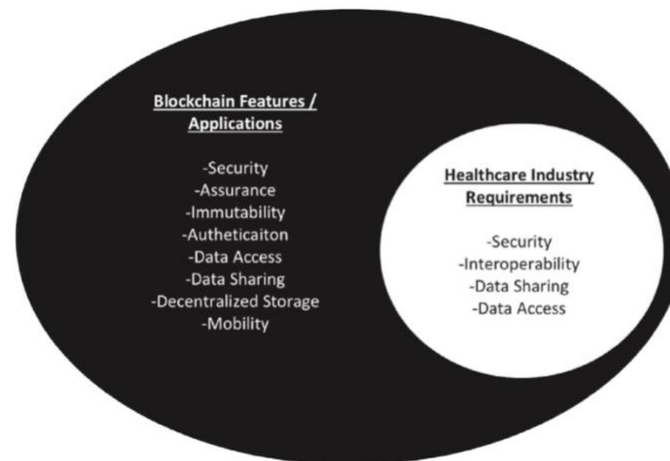


Figure 2 (McGhin et al., 2019)

Main opportunities (El-Gazzar & Stendal, 2020):

- Decentralization enables patients to self-manage health data → more interactive
- Only health information is stored, the identity of the patient is not shown → better privacy
- Health information be shared and accessible by all relevant medical personnel → possible improvements in medical technology and better treatment for patients
- Data is immutable → Patient care is more secure, and the process can be clearly documented
- Drug traceability → Blockchain technology can help trace the raw materials and supply chains of drugs to further resist counterfeit drugs and ensure the safety of drugs
- ...

Main challenges (McGhin et al., 2019):

- Key management → “One key for all block is unsafe... if key is compromised” (p. 67) → Patient's personal information is very private information, not having other safeguards and backup plans in place is a problem, for example, reducing the difficulty of hacking
- Scalability → Needs to balance the degree of decentralization with the delays of data → For healthcare, data delays can lead to treatment delays, and there is often a lot of data in the medical field
- Privacy leakage → The structural problem of decentralization: the key is within the network for verifying; Again, it is a big concern for healthcare sector.
- Lack of standardization → Each hospital, region has different data standards → difficult to achieve the ideal data interoperability
- ...

How to seize the opportunities in these challenges? Scientists, economists, and other experts are working on it to fulfill blockchain's promise. In my opinion, blockchain technology will bring huge changes to healthcare.

AI in Healthcare: Can Technology be a Doctor?

Let's start with an interesting fact that according to Mass General Brigham (MGB)'s research, ChatGPT received a score of "72% in clinical decision accuracy" (Fox, 2023). Thus, the good news is that doctors, you don't have to worry, the generative AI isn't ready to take your place. However, this also means that today's AI still has a lot of shortcomings and ethical issues to think about, and its practicality in Healthcare needs to be further studied.

The MD Anderson Cancer Center was a pioneer in the use of AI for cancer (Davenport & Ronanki, 2018). You can also refer to their official website for more detailed information: <https://www.mdanderson.org/cancermoonshots.html>. In 2016, the US government also demonstrated a keen interest in the field. President of the US Joe Biden spearheaded the National Cancer Moonshot (Gustke, 2017).



Figure 1 (Gustke, 2017)

The application prospect of AI in Healthcare is very broad, it can provide diagnosis and treatment plans, and may even be more accurate than a doctor. In addition, AI can improve medical efficiency and alleviating the shortage of medical personnel. For instance, AI-enabled robots replacing humans in some of the repetitive tasks in hospitals (Landi, 2019). Lots of examples online, explore it! These are the most significant benefits that AI can bring to people in the field of healthcare.



Figure 2 (Muoio, 2019)

However, there are many challenges and concerns associated with AI in Healthcare too. Firstly, the issue of privacy information leakage. In healthcare, this is very important since medical data are usually sensitive (Siwicki, 2023). Medical data contains a lot of personal information too, it is necessary to develop appropriate solutions to protect personal information security and prevent personal information from being leaked and used for undesirable purposes. Secondly, do people really trust a technology 100%? Especially this is for their lives. How many patients understand AI, or understand AI algorithms? Due to the complexity of the AI algorithm, it is difficult to analyze and explain why it gives such a diagnosis or recommendation, which will cause people to lack trust in it when it is applied. Finally, accuracy, transparency, and auditability are all complex challenges for AI in Healthcare. Who is responsible if a medical error by AI occurs? Is it the people who built it? Who has access to the data and how data quality can be regularly assessed is also important (Smallman, 2022).

In conclusion, using AI to improve medical standards is definitely the direction of development of healthcare. Although it still faces many challenges and ethical issues, we cannot ignore the opportunities it will bring to Healthcare and the benefits it will bring to humans. The formulation and regulation of corresponding laws are also particularly important.



Figure 1 (Burbank, 2022)

The Application of the IoT in Healthcare: What are the Important Implications We Need to Know

Imagine if you were traveling in a place with poor medical conditions during the COVID-19 pandemic and caught the virus. There is a shortage of medical staff so you may not be able to get the prescription and know the progress of your condition. Technology is there to give people a better life. In such a case, it would be much better if there were the Internet of Things (IoT).

Definition of the IoT

The application of IoT is very wide. The common application scenarios include smart homes and transportation. Chacko and Hayajneh (2018) define the IoT in an understandable way that it is “the networking of physical devices that are both connected and smart” (p. 1). These devices typically come with “embedded software and sensors” (Dantu et al., 2021) to exchange data and generate useful information.

The benefits to healthcare

The IoT is useful for diseases that need to be monitored and observed over a long period of time, such as diabetes and cardiovascular diseases. Patients do not need to be hospitalized, and doctors can perform remote health monitoring by “wearable smart devices in healthcare”, such as glucometers, heart rate cuffs, etc. (Gupta, 2023). By analyzing the data collected by these devices, doctors can make timely adjustments to drug dosage and orders. It also brings great benefits to patients in remote areas or places with inadequate medical conditions, allowing people there to easily obtain good medical care. In addition, for patients with mild illness, they or their family members can also perform self-monitoring to reduce the cost, time cost and occupied medical resources caused by unnecessary medical visits. People who are currently free of disease, especially the elderly, can also view the data themselves to gain a better understanding of their health status, and it can also be used for early detection of chronic diseases (Chacko & Hayajneh, 2018).

Another important benefit is to track the real-time location of medical enablers and equipment (Gupta, 2018). This will greatly reduce the time spent searching for equipment. The time saved can be turned into patient care time and rescue time for emergency patients. Better allocation of medical resources and a reduction in unnecessary visits could also bring economic benefits to the healthcare industry (Pisuwala, 2023).



Figure 2 (Matuszak, 2022)

Problems may follow

Data security and liability risks in healthcare are increasing due to IoT (Chacko & Hayajneh, 2018). How to protect patients' privacy becomes a big concern. Meanwhile, the IoT also requires medical staff and even patients to have the corresponding skills to apply it correctly. The high infrastructure cost of IoT implementation is another issue. Initial investments in hardware, cloud computing, etc. are high (Khmelnitski, n.d.).

In conclusion, the IoT is a useful tool to improve medical outcomes, improve medical efficiency, and bring economic benefits to healthcare. However, how to deal with privacy concerns, the huge initial investment, and the required education remain obstacles in real-world applications.

Tomorrow's Healthcare? The Promises of AR and VR

The words virtual reality (VR) and augmented reality (AR) may be familiar to you. They have applications in many fields, such as architectural design and games (Liu et al., 2021). In fact, they can also be widely used in the field of healthcare to bring benefits to medical teaching and patient care, thereby revolutionizing healthcare. Before we delve into the exciting news, let's first unpack what is VR and AR.

In simple terms, VR is “a complete 3-D virtual representation of the actual world...” (Farshid et al., 2018, p. 659) and allows several people to interact with each other in the virtual world (Liu et al, 2021). While AR is also real-time interaction, it is the combination of a physical world and virtual world (Liu et al). Figure 1 shows more of their differences.



Figure 1 (“Augmented reality (AR) vs virtual...”, 2021)

Both AR and VR can make contributions to medical teaching and research. Dorri (2017) indicates that AR can facilitate researchers to remotely collect research information and interview participants so that reducing the cost of running research. More importantly, healthcare is a highly practical subject, AR can bring medical students interactive courses rather than just pictures and theories in books (figure 2). With AR, medical students can more easily and clearly grasp complex anatomical structures (Swevens Immersive Studio, 2022).

Screenshots

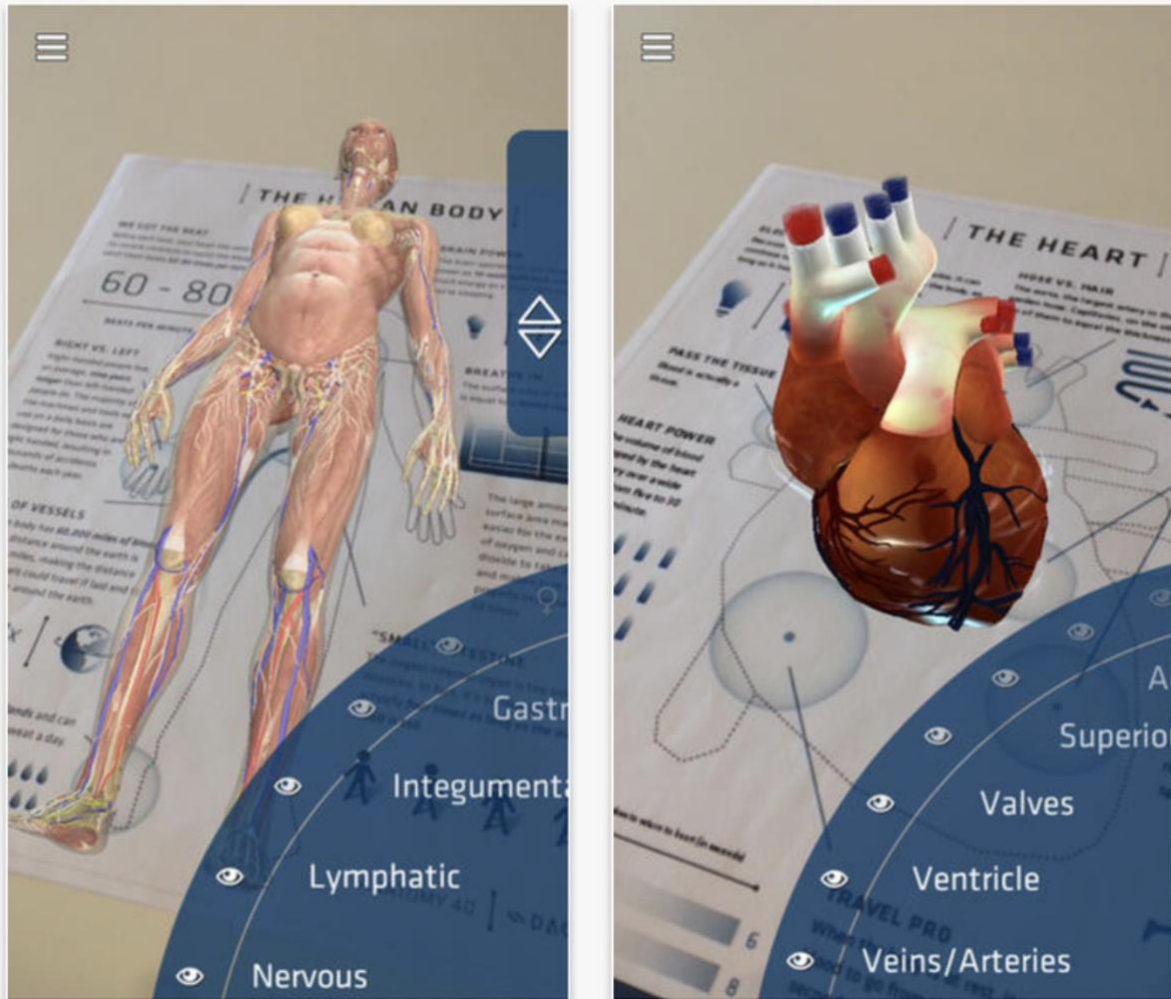


Figure 2 (Swevens Immersive Studio, 2022)

VR can be used to develop technical competencies (Haowen et al., 2021). Students can practice hard skills such as cardiopulmonary resuscitation through virtual but immersive 3D visualization without risks. Interestingly, VR can also be used to exercise empathy and communication skills with patients (Haowen et al.). In addition to their applications in medical education, they are also very good at optimizing the patient care experience. VR can save patients from the despair of pain. Studies have shown that VR can distract painful patients and reduce their pain by at least 24% (Li, 2023). For mental health issues, VR is an indispensable tool. Exposure therapy is often used to treat mental health problems, and VR can simulate the corresponding environment, exposing patients to the virtual space to achieve therapeutic purposes. Often used for fear of heights, post-traumatic stress reaction (Li). The typical benefit that AR brings to healthcare is in the rehabilitation department. Through computers, reality and virtuality are combined to accelerate the recovery of patients. Figure 3 shows a patient performing phantom limb exercises using AR.



Figure 3 (Swevens Immersive Studio, 2022)

Despite the future of AR and VR in healthcare is bright, they still face a series of challenges. Like other technologies, the high investment cost of equipment is a major obstacle to implementation (Sheasby, 2023). Moreover, they may cause discomfort to patients; Lots of feedbacks mentioned physical discomfort after use, such as dizziness (Kouijzer et al., 2023). Some people do not know how to use them, or still prefer traditional methods. Finally, as always, ethical and privacy issues. It is necessary to think about the different accessibility and ability of people to utilise VR software properly and whether healthcare providers can guarantee personal data to be protected (Sheasby).

The Rise of 3D Printing in Healthcare

3D printing, also known as additive manufacturing technology, can be simply understood as a technology to “enable the production of bespoke objects of virtually any shape and size, layer by layer” (Trenfield et al., 2019). The material of the layer can be various, such as metal, plastic, etc. The changes 3D printing is about to bring to healthcare are revolutionary.

Surprising benefits

For personalized medical solutions, typical applications of 3D printing include 3D surgical pre-planning models, 3D printed implants (prosthetics), and rehabilitation medical devices such as hearing AIDS (Dodziuk, 2016). In the field of regenerative medicine, researchers have made commendable progress of bioprinting tissues and organs (Trenfield et al., 2019).

Surgical pre-planning models are one of the most promising applications of 3D printing in healthcare. For high-risk surgeries, the information provided by CT and MRI can be sent to a 3D printer and the printer can directly print out the 3D model, which can assist the doctor to carry out accurate surgical planning, improve the success rate of surgery, facilitate the communication between the doctor and the patient on the plan, and reduce longer surgeries’

costs (Hurst). Figure 1 shows a three-dimensional-printed model for transcatheter aortic valve implantation (TAVI) procedure training.

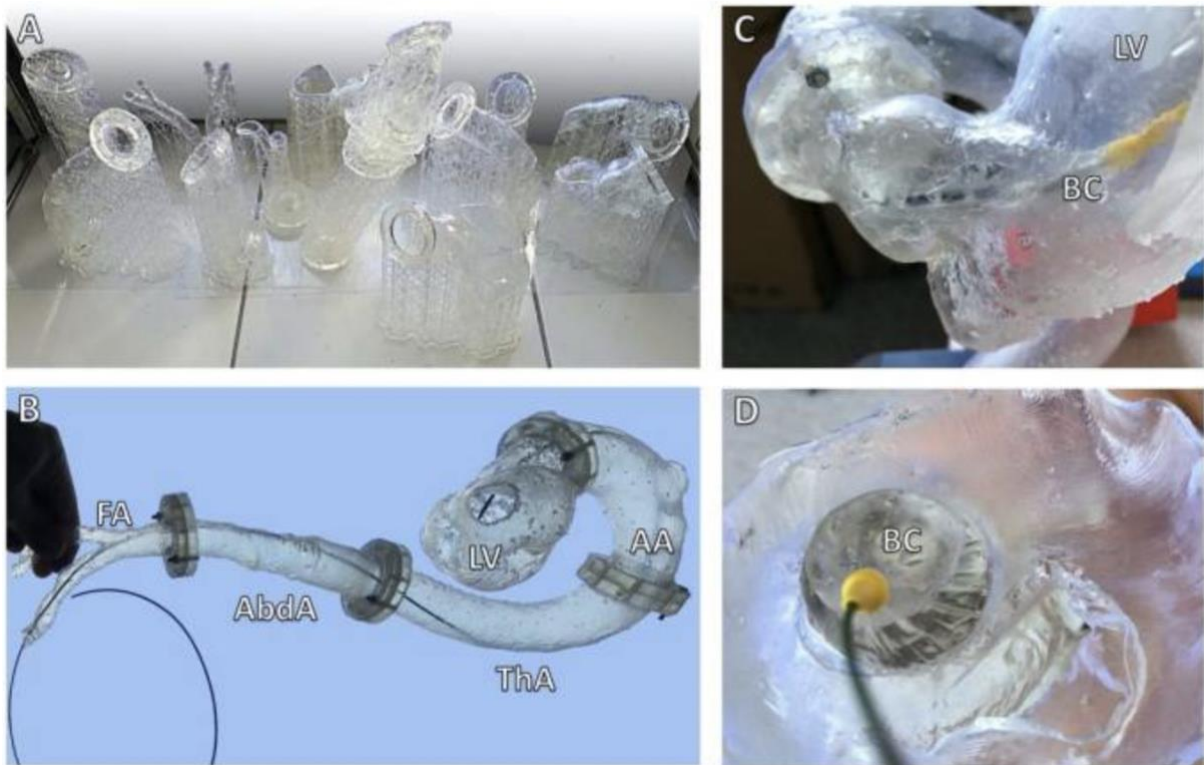


Figure 1 (Meyer-Szary, 2022)

In addition, customized, low-cost prosthetics also highlight the role of 3D printing in healthcare. 3D printing is much cheaper than traditional technology to customize prosthetics and the material is durable and lightweight (Team Xometry, 2022). It has also improved the speed of delivery of customized prosthetics, a customized prosthetics can be completed in as little as 24 hours (Team Xometry). Figure 2 shows a 3D printed prosthetic leg.



Figure 2 (Sprey, 2014)

“Today, 99% of hearing aids in the world are 3D printed” (Chae et al., 2015, as cited in Hurst, 2016). This is not hard to explain: hearing AIDS are usually small and require customization, and 3D printing can meet these requirements. Finally, bioprinting holds great promise for patients waiting for organ transplants. In the future, according to Trenfield et al., it may allow direct printing of organs and tissues needed without causing rejection reaction. However currently, standard bioprinting is still far from this goal (Hurst).

The challenges it has to face

The applications of 3D printing still need to undergo clinical testing for a long time. The lack of proper regulations and restrictions is likely to cause print quality problems and lead to safety issues (Hurst). In addition, Shahrubudin et al. (2020) cited issues such as limited materials, customer demand beyond current capabilities, low recycling rates, and the short life of materials; Regarding management, issues such as how to train medical personnel and lack of technical guidance need to be solved by more research in the future.

To conclude, each technology brings its own benefits and challenges to healthcare. Blockchain, artificial intelligence (AI), the Internet of Things (IoT), AR/VR and 3D printing are innovations in the context of the big data era of the 21st century, giving healthcare new opportunities. However, privacy concerns, costs, standardization and other barriers remain. We need to see opportunity in the challenge, and match technology with ethical considerations and reality.

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