

HAIMLC701 AI & ML in Healthcare

6.0		Future of Healthcare using AI and ML	07
	6.1	Evidence based medicine, Personalized Medicine, Connected Medicine, Digital Health and Therapeutics, Conversational AI, Virtual and Augmented Reality, Blockchain for verifying supply chain, patient record access, Robot - Assisted Surgery, Smart Hospitals, Case Studies on use of AI and ML for Disease Risk Diagnosis from patient data, Augmented reality applications for Junior doctors.	
	6.2	Blockchain for verifying supply chain, patient record access, Robot - Assisted Surgery, Smart Hospitals, Case Studies on use of AI and ML for Disease Risk Diagnosis from patient data, Augmented reality applications for Junior doctors.	

Evidence-based medicine

- David Sackett, a pioneer “the conscientious explicit and judicious use of current best evidence in making decisions about the care of individual patients.”
- The integration of the best research evidence with clinical expertise and patient’s values and situations
- To integrate the experience of the clinician, the values of the patient, and the best available scientific information to guide decision-making about clinical management
- The term was originally used to describe an approach to teaching the practice of medicine and improving decisions by individual physicians about individual patients

Evidence-based Medicine

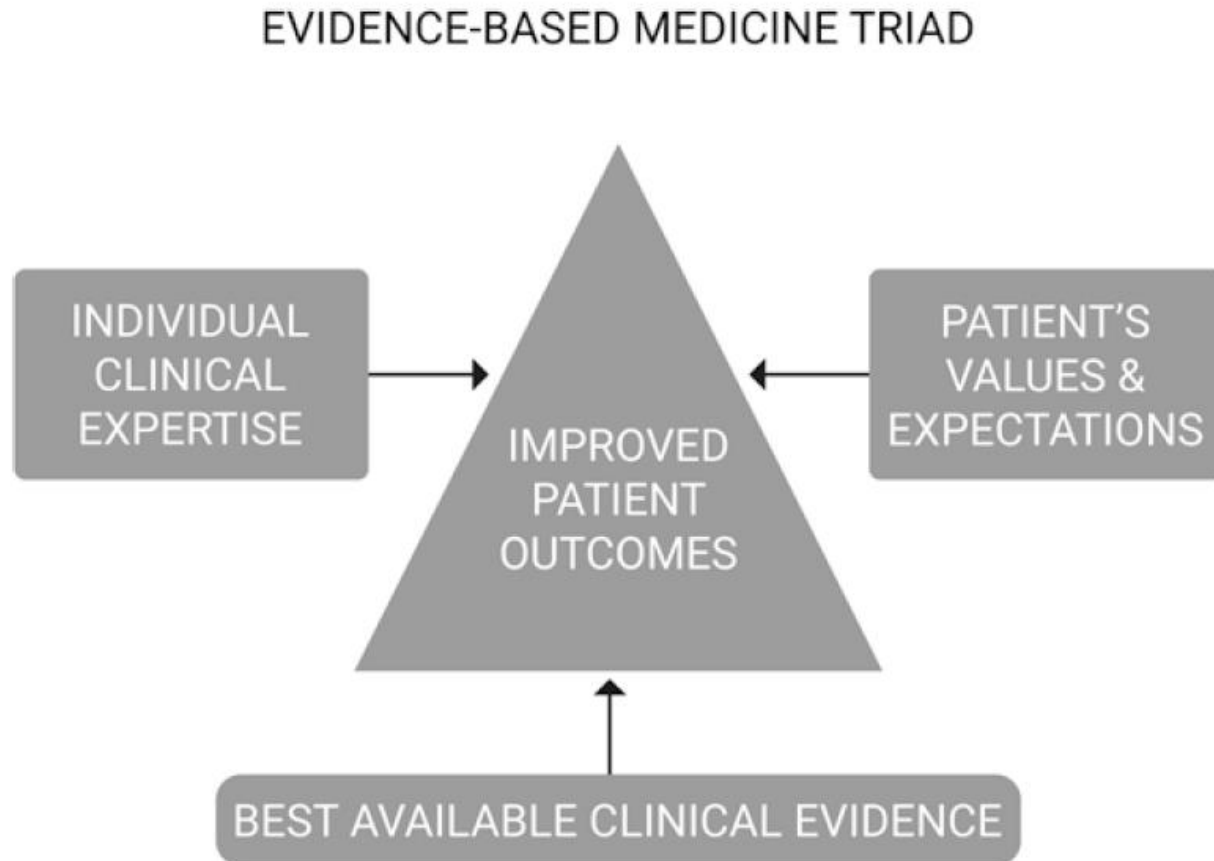


Figure 7-1. Evidence-based medicine

Evidence-based Medicine

- Randomized controlled trials (RCTs) -most robust and reliable form of evidence for assessing the efficacy of a treatment
- Evidence demonstrates that many factors can influence the reliability of RCTs, including methodological quality, reporting quality, and source of funding
- Pharmaceutical companies fund the majority of clinical research that is undertaken on medications and face a conflict of interest
- Studies have demonstrated bias in favor of industry in research funded by industry, which undermines confidence in medical knowledge
- Datafication of human experience through mobile phones, social media, digital communities, health apps, nutrition tracking, wearables, and health IoT has empowered patients to become their own evidence base and influence healthcare academia and understanding

Evidence-based Medicine

- For example, a trial for type 2 diabetes medication may focus on people who have type 2 diabetes only and no other comorbidities; whereas in the real world, the comorbidities of hypertension and high cholesterol are often present in people with type 2 diabetes
- This approach means there is often a gap between what is reported in RCTs and what is reported by patients
 - This is where digital technology can help bridge the gap between pharmacological intervention and real-world patient experience
- Digital communities, for example, can provide real-world evidence on medication side effects
 - As an example, health community Diabetes.co.uk provides medication side effect data back to pharmaceutical organizations through a mobile application in the form of analysis of patient discussion and reported side effects

Evidence-based Medicine

- The world's second-most commonly prescribed drug for diabetes, Metformin, for instance, has a side effect of diarrhea reported to affect 1 in 10 people taking the drug
- Real-world evidence from Diabetes.co.uk members demonstrates this is 400% more common and reported by over 48% of people with type 2 diabetes
- Real-world evidence has historically been viewed as anecdote by the medical community
- However, the datafication of patient lives now means that data is directly received from devices, wearables, and sensors, ensuring that data cannot be misreported
 - Real-world evidence is growing at a pace that healthcare is struggling to keep up with

Personalized Medicine

- Each person has a unique version of the human genome
- Groups of particular patients may share common genome characteristics and thus the risk of disease
- For instance, research demonstrates people of South Asian descent have a higher prevalence of type 2 diabetes compared to British Caucasians in the United Kingdom
- Personalized medicine/stratified /precision medicine- approach that stratifies patients into groups & makes informed clinical decisions for the delivery of treatment and interventions based on the patients' anticipated response
- approaches to disease management are tailored to the patient
- Patient health is managed on an individual level to achieve the most optimal state of health possible
 - For example, our genetic variations determine how our bodies would respond to a particular drug. One drug might not fit everyone's requirement

Personalized Medicine

- Two people taking the same dose of the same drug might respond differently
- Using personalized medicine, a right combination of a drug and its dose can be selected for everyone
- It has never before been possible to predict the risk of disease, how the human body will respond to a particular medication, or print treatments out of materials other than ink
- Predictive tools can be used to evaluate health risks and develop personalized healthcare plans to mitigate patient health risks, prevent disease, manage disease, and treat a disease precisely if it occurs
- As healthcare becomes increasingly personalized for patients in both treatment and service delivery, it is critical that access is widened to ensure participation from all groups of society

Personalized Medicine

- Diagnostic tests, such as blood tests, are typically used to identify appropriate treatments based on a patient's physiological analysis.
- The selection of optimal therapies will be increasingly personalized to the patient genome
- Healthcare providers will be able to diagnose current illnesses, predict future risks of diseases, and identify predicted response to treatments and subtle traits within an instant
- Genetic testing has started to make an impact in personalized medicine; DNA results are limited to being imported into services that can personalize treatment regimes, diet plans, or education to a patient
- Currently, DNA test results take weeks to receive. An era of instant genetic test results will empower patients to make informed choices about treatment, services, products, medications, and outcomes

Vision of the future

- DNA profiling of the embryo within the mother's womb
 - create an immediate profile of the person's health status and risk of disease
 - enable the development of health and lifestyle treatment plans from the beginning of life
- Ethical concerns in fertility will move to tackle making decisions based on an embryo's genetic status
 - Genetic profiling to detect potential concerns and alter or delete potential genetic defects or characteristics that are unfavored
- Predisposition to disease will be estimated, with healthy life care plans developed for patients to follow as a daily routine
- Patients will constantly be monitored, with their data fed back to update their health records and focus on optimal wellness—driven through innovation in wearable technology, innovation in medicine, healthcare delivery, the IoT, and smart homes, smart cities, and smart communities

Vision of the future

- Data monitoring and predictive analytics
 - instantly alert health professionals and patients should there be a deviation to the norm—alerting users to poor health, possible illness, or nudging the user over an unhealthy lifestyle
- One will be able to download a clinically validated app
 - that would be able to detect, diagnose, and treat many diseases before attending a physical doctor's surgery
 - Sensors will become far less invasive—chips under the skin and smart tattoos that keep constant connectivity
- Visiting the doctor's practice will be very different
 - Your digital personal assistant, perhaps Siri or Alexa, may suggest you see the doctor based on your voice sounding ill, or at least different
 - Social media platforms, health communities, and phones will alert you to mental health problems based on what you type
 - No matter whether it's a hospital in Malibu or Manchester, your health record will be accessible and available on your phone and validated through a distributed ledger such as Blockchain, to which healthcare providers would continue to add to over time

Vision of the future

- Advancements in robotics, automation, and digital health enable healthcare professionals to focus their time where needed most: with patients
- Treatment will be personalized, based on health records, genetic analysis, and AI analysis of patient data
- Medicines will also include 3-D printed treatments and digital interventions delivered through mobile apps
- Digital interventions, measured by engagement, and health outcomes, will be hyper-personalized, based on demographics, behavior, health, goals, and Preferences
- Care will be delivered through a hybrid of digital and face-to-face engagement
- Virtual and augmented immersive experiences will reinforce and maintain behavior change
- Drones will deliver your medication to wherever you are unless your autonomous vehicle takes you there
- Innovations will allow doctors, nurses, and wider healthcare professionals to be freed up to do the more human parts of the job
- Robotic AI will be used to carry out more physical tasks such as moving patients around, creating sterile environments, performing blood tests, radiology assessments, and so on.

Connected Medicine

- Wearables and the IoT hold the key to connected medicine
- Data captured by sensors in these contraptions -facilitating the development of patient-centric healthcare systems
 - particularly their use in clinical trials and academic studies to monitor patient health and lifestyle factors.
 - Forexample, studies can record participants' health vitals using an Android Watch, Apple Watch, Garmin, Fitbit, or another smartwatch device
 - Participants use apps to record their lifestyle habits, nutrition, activity, and medication adherence and to monitor medication side effects among others
 - Wearables and patient data are beginning to be used by insurance companies to incentivize wellness
 - Insurance companies have historically targeted such insurance products toward digital-savvy buyers, offering the latest gadgets to incentivize health improvements

Connected Medicine

- As sensors become faster, smaller, and more capable, patient health records profiles will eventually comprise of detailed sleep analyses, details of continuous blood glucose monitoring, heart rate, blood pressure, and approximate calorie burn
- A smartwatch will combine a variety of diagnostic tools, able to monitor blood pressure, heart rate variability, blood glucose, ketones, and more
 - Health sensors will become embeddable, biodegradable, and constantly connected, playing critical roles in such tasks as patient care
- Stress bands
 - Stress tracking and calming of the mind are two key markets for wearables
 - Wearables currently monitor breathing and heart rate, detecting signs of tension to improve breathing and the ability to reach a calmer state of mind
 - Fitness trackers offer mindfulness functions, and there are headbands that deliver waveforms to the brain

Connected Medicine

- UV sensor
 - Northwestern University has developed UV sensors that precisely monitor a person's UV light exposure
 - The wearable sensors, which are small enough to fit on a human fingernail, are wafer-thin
 - As a known and potent carcinogen, this has the potential to reduce overexposure to UV, complications such as heatstroke, and melanoma
- Smart tattoos
 - Smart tattoos place the sensor in the skin with significant strides made by researchers at MIT and Harvard
 - Smart tattoo ink reacts with the biochemical composition of the interstitial fluid to indicate the status
 - For instance, high blood glucose could turn a blood glucose smart tattoo red, whereas low blood glucose may turn the tattoo blue

Connected Medicine

- Smart medication
 - can tell a patient and their respective healthcare team as to the amount of medicine consumed, the time it was taken, and provide timely reminders if it looks like it may be missed
 - Today, Bluetooth-connected bottle caps and pill packets provide reminders to patients to encourage medication adherence
 - Bluetooth insulin pens and pen caps that log the time, amount, and kind of insulin injected typically push data from the device to cloud, with users engaging in a digital app interface to query their data
 - Smart asthma inhalers, for instance, can identify an oncoming attack before the wearer recognizes the symptoms
- Smart insulin
 - A form of smart medicine, smart insulin is next-generation insulin that responds automatically to changing blood glucose levels
 - The lower or higher blood sugar levels are, less or more insulin is released, respectively
 - smart insulin patch, which rests on the outside of the body, will use a system of micro-needles to automatically detect high blood glucose levels and administer insulin through live beta cells appropriately

Table 7-1. Applications of wearable technology

What?	Where?	Why?
Immersive technology	Head	Education
Military apparel		Behavior change
Helmets		Intelligence to intelligence
Mixed reality		communication
Smart contact lenses	Eyes	Blood glucose levels
Trackers		
Hearing aids	Ears	Sound
Headphones		
Trackers		
Odor detection	Nose	Smell
Smart tattoos	Arms/Wrist	Blood glucose
Trackers		Blood pressure
Patches		Oxygen saturation
Implantables		Ketone levels
Smartwatch		Education
Trackers		Rehabilitation
Clothing	Body	Rehabilitation
Chest straps		
Implantables		
Trackers		
Exoskeleton		

Chest straps
Implantables
Trackers
Exoskeleton

Clothing

Legs

Protection
Rehabilitation

Embedded footwear

Feet

Health metrics
Posture correction
Rehabilitation

Digital Health and Therapeutics

- Telemedicine- clinical application of technology that uses electronic technologies to support long distance patient care, patient and healthcare professional education, and health administration
- Digital therapeutics/digital health- an enhanced form of telemedicine that brings together digital and genomic technologies with health, lifestyle, and human factors to deliver personalized medicine to patients, enhancing the efficiency of healthcare delivery

Digital Health and Therapeutics

- There are more than 150,000 apps focused on health and wellness in the Apple App Store, which have been downloaded by over 50 million people
- Digital health tools allow patients to take a proactive approach to their health and wellness, looking to influence aspects of human behavior for the purposes of improving health
- As more of our healthcare interventions are focused on chronic rather than acute diseases, behavioral therapy is surpassing pharmaceutical intervention as first-line therapy
- Digital health and wider telemedicine have applications in a plethora of health conditions and are enabling healthcare and treatments to change rapidly
- For instance, patients scheduled for bariatric surgery can be prescribed a digital health app to assist in weight loss in preparation for surgery; a patient diagnosed with asthma can be prescribed a connected asthma inhaler and app; patients diagnosed with epilepsy can be prescribed an app to manage seizures

Conversational AI

- Refers to systems that can talk
- Rather than a UI based on text/code input, individuals can interact with conversational AI system with their voice
- Users are increasingly using chatbots to communicate with products and services
- Voice-driven AI such as Amazon's Alexa can synthesize natural language to provide recipes or exercise tips, order products, or call a cab
- The technology is catching on: 1 in 5 Americans owns a smart speaker, and there are over 100,000 Facebook messenger chatbots

Conversational AI

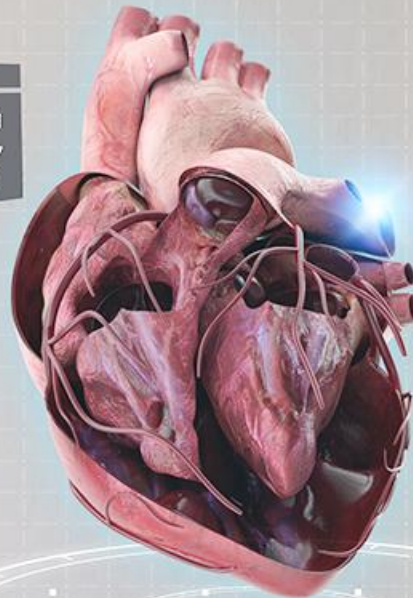
- Intelligent personal assistants will act as healthcare assistants
- By virtue of being voice-controlled, there are immediate applications for those less-abled, where only the voice needs to be used to perform tasks or instructions
- Within health, conversational AI enables simple questions that do not need the attention of a doctor to be answered
- For instance, new parents could bombard a conversational AI with questions without fear of embarrassment or consuming healthcare professional's time
- Questions such as what temperature a baby should bathe in, how often a baby should sleep, or whether there are developmental milestones taking place can all be instantly answered by an AI speaker
- With the assistance of a medical AI chatbot, patients can receive immediate assistance
- Continuing the preceding example, if a child's new parents had a medical question or were concerned by a symptom (say, a chesty cough), it would be burdensome for them to visit the doctor for a response to every question

Conversational AI

- As conversational AI develops, cognitive systems will analyze conversation to detect early signs of mental, physical, or neurological illness
- Voice-enabled devices such as Alexa will one day be able to identify symptoms of Asperger's, anxiety, psychosis, schizophrenia, and depression from conversational tones
- This will assist doctors to predict better and monitor and track disease
- Imagine how much time and resources will be saved when virtual assistants, healthcare chatbots, and digital tools give answers to basic medical questions that do not require the intervention of a medical professional

Virtual and Augmented Reality

- Surgeons performing CT scans will be able to layer their scans over a patient's body via augmented reality;
- Medical students will use virtual reality to explore the inside of the heart and burn victims will be virtually transported to a snow-covered mountaintop as a form of pain relief therapy
- Immersion into a completely digital environment, virtual reality, has mainly been used for games
- Virtual, augmented, and mixed realities are increasingly being implemented in a wide range of medical applications



Virtual & Augmented Reality for Training in the Healthcare Industry



Virtual and Augmented Reality

Virtual Reality

- Virtual reality (VR) is typically associated with gaming
- User's reality is replaced by an immersive, entirely digital environment is currently achieved through a headset and handheld sensors, which enable interactions within the environment

Augmented reality (AR)

- overlays a digital or 3-D environment in the form of objects, video, or data into the user's environment
- The user's real-world experience remains central to the user's experience, and the information is added to the user's existing reality to enhance their experience
- Information is distinctly digital and does not seek to emulate real-world objects

Virtual and Augmented Reality

Merged Reality

- Merged reality seeks to emulate digital objects that can be interacted
- This requires additional technology such as a headset
- Separate sensors track hand gestures and movement

Pain Management

- virtual reality environments can be used to reduce the amount of pain a human feels versus a control distraction
- The somatosensory cortex and insula, found in the brain are linked to pain
- Amputees often report pain in their amputated, missing limbs
- VR also works as a distraction
- In the future, children and adults alike will be given a VR headset from their doctor when receiving an injection to distract them from the impending prick

Virtual and Augmented Reality

Physical Therapy

- VR can track human movement, allowing patient movements to be monitored and analyzed
- VR gyms have been opened in San Francisco and Ohio
- Rehabilitation will become gamified, for instance, through kicking a virtual ball or catching a ball
- Recovery exercises can be delivered and tracked in a VR environment and retold to the patients if they were not to get it right

Virtual and Augmented Reality

Cognitive Rehabilitation

- The application of VR and AR in fears and phobias is apparent
- Performed as a medical treatment, patients can be gradually exposed, known as graded-exposure therapy. Data from sensors will be assessed to ensure patient safety and develop best practice
- Cognitive function can be improved for patients struggling to perform everyday tasks
- Similarly, patients with injuries to the brain or those that struggle with tasks can have digital environments created to represent real-life scenarios
- Patients can practice tasks and regain or develop cognitive function into VR in cognitive rehabilitation
- However, some applications of VR are effective in treating cognitive deficits in people with neurological diagnoses

Virtual and Augmented Reality

Nursing and Delivery of Medicine

- VR and AR will develop to become part of standard medical training
- Critical decision points can be reviewed and analyzed with peers and staff
- Virtual reality will be used more to learn medical specialties such as performing operations and anatomy Operations can be practiced with an expert monitoring and giving feedback in real time. The Royal London Hospital conducted the world's first VR surgery in 2016
- The learning experience is unparalleled and has the potential to disrupt medical training, particularly for countries that have limited healthcare resources
- Surgeons will have access to critical information in real time through mixed realities, delivered to their vision through glasses.
- Nurses, for instance, could use augmented or mixed reality to identify veins in the arm for a blood test

Virtual and Augmented Reality

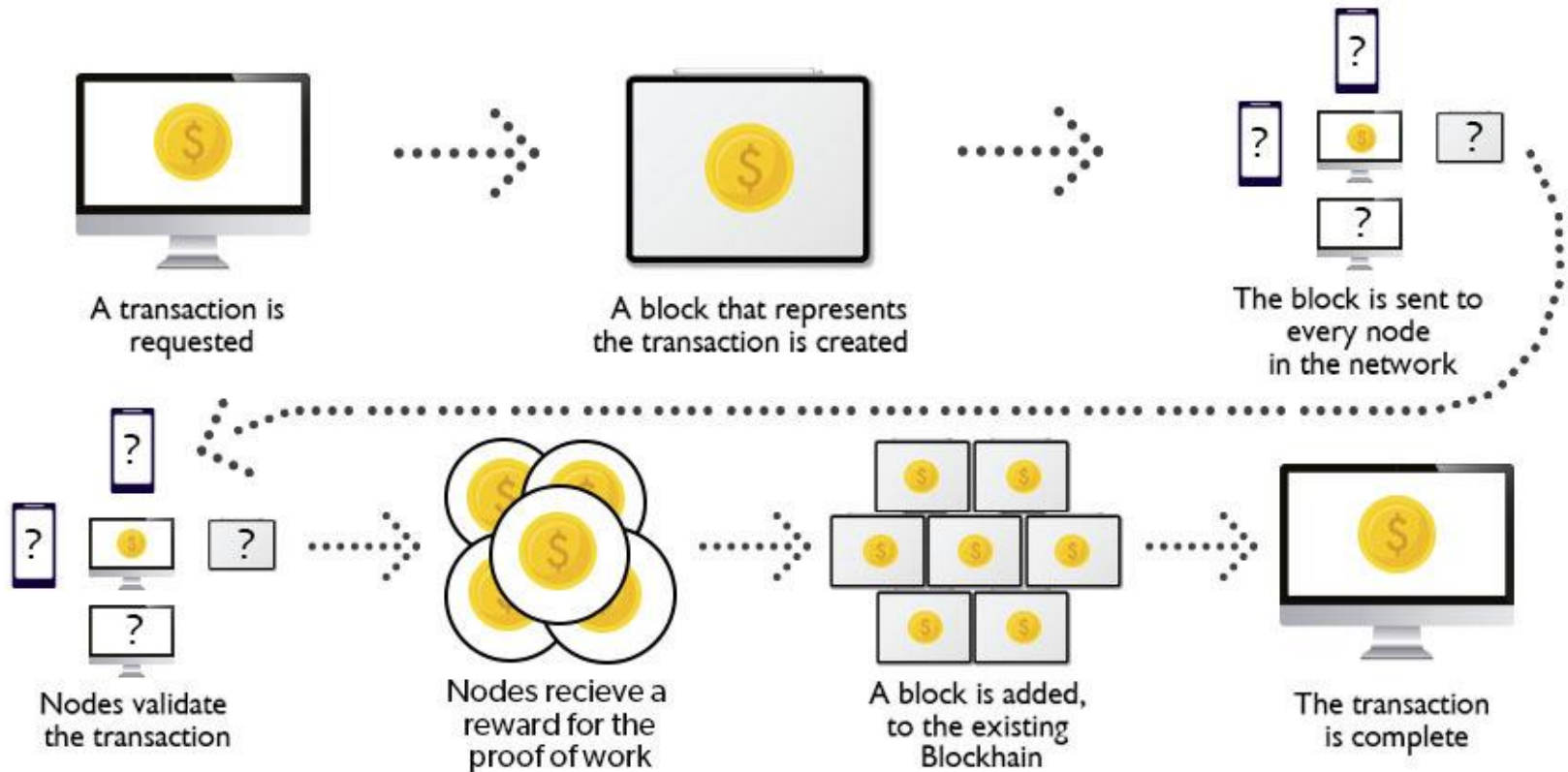
Virtual Appointments and Classrooms

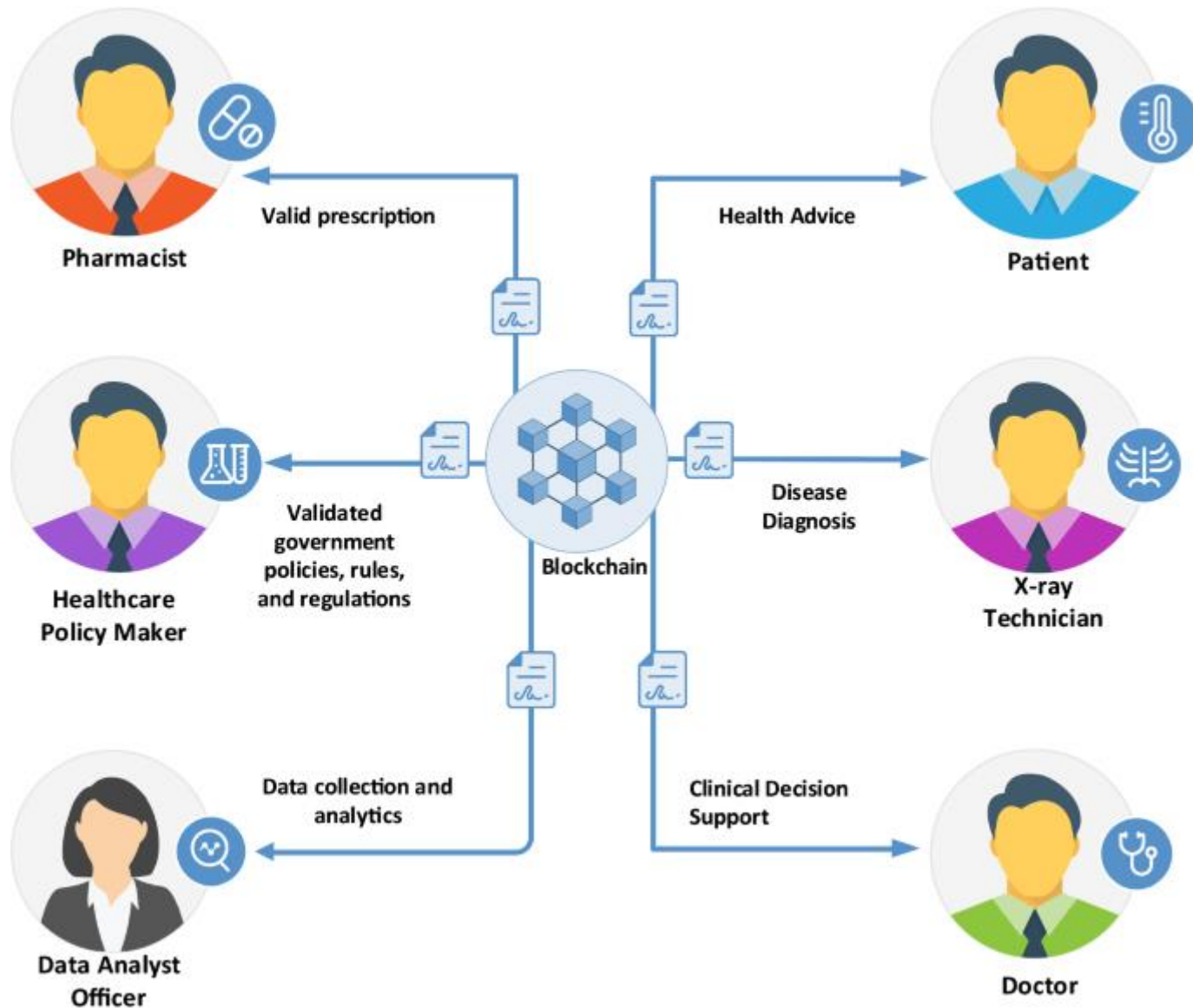
- As the cost for virtual and merged reality devices becomes more affordable, virtual appointments will become commonplace
- Virtual appointments remove the inconvenience of attending a clinic, saving time, Environmental resources and focusing healthcare professional time to where required
- Virtual appointments will become as familiar as webinars enabling stakeholders to be present without traveling
- As well as one-to-one appointments, virtual and merged realities provide an immersive and engaging experience suited for learning
- Virtual reality will become a staple tool for education and training—for both healthcare professionals and patients alike

Blockchain

- The digitization of patient records mitigates some of the traditional risks of centralized data stores
- However, this model still places the medical records in the hands of the provider
- Blockchain technology, popularized by the bitcoin cryptocurrency, has the potential to revolutionize data access, privacy, and trust
- Currently, blockchain is yet to be deployed for mainstream healthcare
- Blockchain- collection of data records with features:
 - an immutable, distributed public ledger whose authenticity can be verified by anyone: those who validate the data on the ledger are rewarded with value, which helps create trust in a trustless environment;
 - distributed peer-to peer control, which provides a high level of security; and the ledger can be programmed to trigger automatic transactions in the form of smart contracts, allowing for a widespread application of this technology

How Blockchain Works?





Blockchain

- PayPal, Visa, and Mastercard, for instance, act as central authorities for financial transactions: trusted institutions that act as intermediaries
- These centralized databases are subject to being hacked or manipulated
- Blockchain technology aims to solve data management, privacy, and security issues, improving interoperability and easing the flow of data between doctors, hospitals, healthcare systems, and insurance providers through the use of a decentralized, immutable database
- Data from EHRs IoT, wearables, and devices can be used within the ledger, in a trusted, secure, transparent, and interoperable environment

Blockchain

- The blockchain is an immutable database that is stored and maintained by all those using it
- Each new transaction or piece of data is encrypted and then approved by a particular proof-of protocol (consensus, work, stake) by other nodes on the networks that authenticate the transaction or verify the stored piece of data
- Each node on the network has an identical copy of the blockchain; and thus, the transaction is permanently recorded and linked to previous records
- The links, known as hashes, are traceable back to the very first block in the blockchain
- Therefore, any attempts to tamper with a block in the present would require the transaction and all related blocks to be also altered, on all records, distributed among the nodes holding a copy of the ledger simultaneously

Blockchain

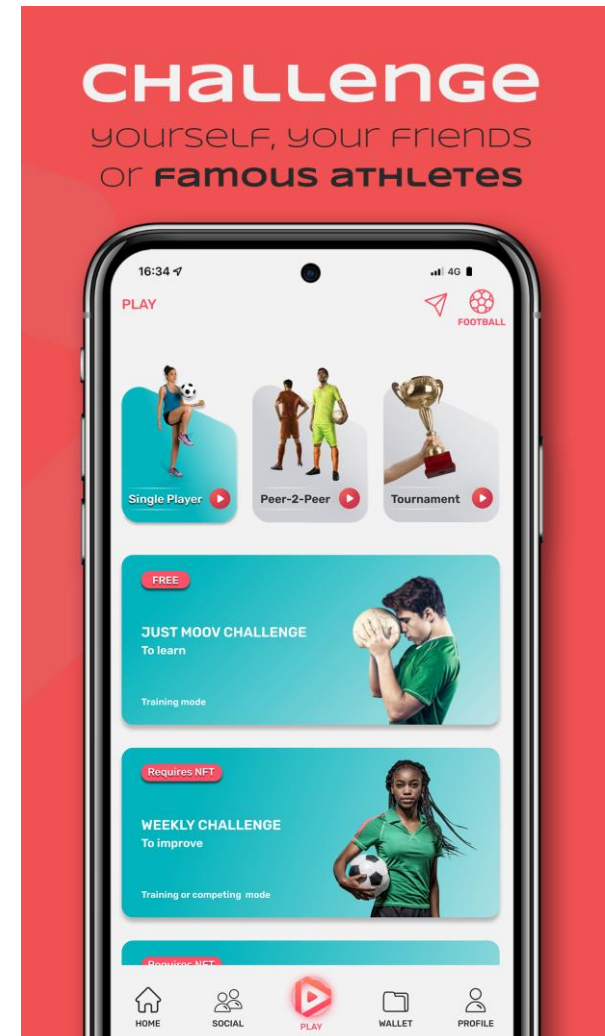
- Single points of failure are eliminated by decentralizing and encrypting the data
 - The blockchain is democratized
 - Anyone can contribute or store a version of the truth
 - Through ensuring consensus on events, the most likely version of the truth is held
 - A transparent and auditable ledger of events is provided through time-stamping
 - Game theory, crypto-economics, and hashing incentivize good behavior and ensure the events are without censorship
 - Blockchain technology has many applications in healthcare, with most technology currently in pilot or proof of concept stage

Verifying the Supply Chain

- The first application of blockchain is verifying the supply chain
- As the blockchain is created in a chronological and auditable manner, it can act as a means of verification for components of every link in the supply chain
- The journey of materials or treatments, for instance, can be logged onto a blockchain ledger, which could be used to identify fraudulent activity, anomalies, error, or a break in the chain through data entry or IoT devices
- For instance, the cold-delivery chain of delivering insulin from manufacturer to pharmacy could be confirmed to be untampered and appropriately cooled
- This is currently being used in developing countries to combat counterfeit medication
- It is also being developed to enhance genomic data protection, addressing the privacy challenges of big genomic data

Incentivized Wellness

- Blockchain technology could be used to incentivize wellness: through the use of a cryptocurrency as a digital token of value
- Engaging people with health services or a healthier lifestyle could save the global economy a tremendous amount of money in healthcare costs
- Health providers or employers typically see the cost benefit of this in the form of savings or profit, and this is rarely passed to the individual



Incentivized Wellness

- tokens could be created and distributed to patients through the blockchain to share the value of the savings and be treated as a tradable currency
- Individuals could earn tokens through behaviors
 - such as going to the gym, reaching their step goal, attending education sessions, engaging in mindfulness, completing a particular sports event, or adhering to medication or digital therapeutics.
 - The ecosystem rewards positive behaviors with an asset, or token of value
- The value of the token could be fixed
 - Extending this concept, positive health behaviors could be extended to the point where patients have health token savings accounts that could be used to transact in hospitals

Patient Record Access

- Patients are demanding access to their health record-This poses a significant challenge as to how to best share sensitive medical data
- Challenge for third-parties to verify the integrity of the data while ensuring privacy for the patient
- Presenting patient records on an appropriately permitted blockchain would give cryptographic assurance on data quality without any need for human involvement
- By using digital signatures, all records stored on the blockchain can be identified and used to create a comprehensive patient health record
- The use of digital signatures and cryptographic encryption ensures data travel securely and are accessible only by those with the relevant public keys
- By using blockchain technology, each addition to the EHR can be logged, with an immutable, auditable trail of transactions, while ensuring the most current version of the record is used
- Patients would be able to verify all attempts to access or process data
- Blockchain's decentralized structure enables any approved stakeholder to join the ecosystem, without the need for data integration or manipulation concerns

Robots

- The use of robotics is changing healthcare, although it will be some time before robotic technology will be widely affordable or implemented
- Indeed, it is also unlikely robots will entirely replace humans in the medical setting
- Currently, hospitals and healthcare systems are unable to meet the cost of the technology

Robot-Assisted Surgery



- Robot-assisted surgery enables enhanced vision, improved precision, and dexterity
- Currently limited in reach, robot-assisted surgery will become commonplace as barriers to entry such as the cost of hardware and training are reduced
- In the future, healthcare professionals may have to learn how to use an instrument as well as how to perform the surgery
- Robotic-assisted surgery blurs the lines of liability, which could prove to be a barrier to adoption

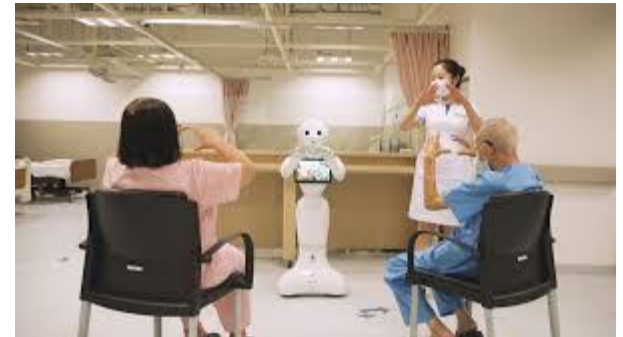
Exoskeletons

- Robotic exoskeleton technology focuses on enabling patients to perform tasks through the use of an external, integrated device
- Ekso Bionics is an organization that provides a wearable exoskeleton that assists spinal cord injury patients to stand and learn to walk
- In the future, exoskeletons will become a standard form of rehabilitation and aid human mobility in more activities, and in more environments



Inpatient Care

- Inpatient care can be enhanced through the use of robots for streamlining tasks
- Robots could be used to automate tasks such as collecting mail or delivering blood
- Delivery robots will deliver medications or important material autonomously
- Robots are already being used to disinfect rooms, where the risk to humans is minimized through using a robotic agent Soon, ingestible agents and smart pills will be able to monitor a patient's internal reaction to treatment;
- robotic nurses will become commonplace for automatable tasks, such as taking blood
- A robot will take your vitals and draw blood by identifying the correct vein with greater accuracy than a human nurse
- Robots will be used to support care for the elderly and those with long-term conditions



Companions

- Virtual assistants are becoming more human-like with developments in natural language processing
- As discussed previously, humans are already forming bonds with robots
- Robots can be used to provide companionship or treat loneliness in cases of mental health, elderly, and long-term care
- As robots evolve in their capabilities, robots will be able to perform increasing healthcare duties such as bathing patients, transporting patients, and so on.
- Robots will be able to monitor vital signs through IoT and wearables and aid the patient in real time



Drones

- Drones have the potential to alter the way medicine is delivered
- Drones can be used in hard-to-reach areas, places of conflict, and remote populations to deliver medication, vaccinations, and diagnostics
- Drones will be used to deliver medications from the pharmacy, just as they are being used in shopping
- Time-sensitive items such as blood, bodily fluids, and organs can travel shorter distances to go directly to where they need to be, within campuses or across larger distances



Drones

- Drones can also be used to locate and identify, particularly in remote locations
- One use case for drones is as a flying medication toolbox in cases of emergency
- Critical care in the minutes after a stroke, trauma, or heart failure is essential to accelerate recovery and prevent death
- An ambulance drone prototype, developed by Tu Delft, combined a heart defibrillator, medication, and two-way radio that could be dispatched to a patient to speed up the response before the first responder

Smart Places

- Intelligent homes, hospitals, places, and things promise to change the way we live
- Ubiquitous connectivity and an expanding sensor base provide a wealth of opportunity to people, patients, and providers alike
- In the United Kingdom alone, the number of people living to 100 increased by 65%
- Rather than going through the process of connecting and integrating apps, sensors, or devices, connected places will use automated sensors that do not require the user's constant attention, collecting tremendous amounts of real-time data
- Facial recognition, voice recognition, responsive notifications, and data-based suggestions will become the norm

Smart Places

- On waking, a wearable sleep monitor will assess the quality of your sleep while you perform mindfulness through your connected watch
- Your sleep monitor will even tell you when to go to bed for optimum recovery
- After brushing your teeth with a toothbrush that assesses whether you are hydrated or not, you drink your morning coffee, which controls the dosage of insulin released for absorption in your bloodstream
- Your fridge will inform you of out-of-date food and ensure none of your potential allergens are found in the food you purchase
- Virtual assistants and even mirrors will assess for signs of anxiety and depression and assess health biomarkers in natural language
- Should you develop a cough, your virtual assistant will tell you that you're coughing more than usual; and with the change in body temperature detected from your smartwatch, your assistant calls the doctor on your behalf and arranges an appointment
- As a closed environment, the smart home allows for AI to accommodate for the highly individualized needs of the user

Smart Places

- The future is not as far as it seems
- Bolzano in Italy is already working with IBM and various partners to empower aging people to age safely at home
- Safety and security are the main priorities, with the project using sensors installed into homes to monitor environmental factors such as temperature, carbon monoxide, and water leaks
- Data is pushed to an off-site control room where, depending on the individual need, family members, volunteers, emergency response staff, and social services are notified

Smart Hospitals

- A smart hospital is one that is connected, much like the smart home
- The objective of a smart hospital is to provide clinical excellence, an efficient supply chain, and superb patient experience—facilitated with technology
- Smart hospitals will use a continuous learning ecosystem, ranging across many areas including electronic data collection and health records, digital technology, robotics, 3-D printing, unstructured data, and robust analytics
- Non-emergency consultations will take place on the Internet, with AI prioritization enabling the right doctor, with the right skills and training, to treat the patient
- Treatment will be blended between offline, physical care and digital care—where adherence and accountability can be quantified and maintained

Smart Hospitals

- On attending a hospital, an automated and streamlined admission reduces patient waiting time
- On admission, patients will be tagged with a clinical-grade wearable to track vital signs through the inpatient stay
- Metrics are all sent wirelessly to a dashboard visible to your medical team
- Any anomalies or causes for concern are detected and prioritized
- Hospitals and surgeries will become hubs of data, with hospitals working with business to extract value from the data—regarding improving efficiency, minimizing mistakes, and for improving treatment and device decisions
- Healthcare will be delivered as a service, with patients incentivized with cryptocurrency to maintain sensible and healthy lifestyle choices
- All relevant data will be anonymized and accessible to digital health partners and internal departments to enable continuous learning from each patient's experience

Case Study: Improving Learning Outcomes For Junior Doctors Through the Novel Use of Augmented and Virtual Reality

- Increase the exposure to simulation and training environments for junior doctors without the use of simulation centers
- Give inexperienced doctors the experience they require in a noncritical environment
- Demonstrate effective and ineffective clinical practice.
- Encourage students to consider their own practices and thought processes
- Immerse students in a clinical learning environment and identify whether the use of virtual reality enabled them to become familiar with the healthcare setting, patient unpredictability, and provided the confidence to cope with high-pressure scenarios

Case Study: Big Data, Big Impact, Big Ethics: Diagnosing Disease Risk from Patient Data

- How patients appraise knowledge from online health communities in managing diabetes
- How a patient's healthcare professionals perceive and can potentially use such knowledge to innovate their clinical practice
- The study concluded the following:
 - The Diabetes.co.uk forum is a catalyst of innovation. The Diabetes.co.uk forum empowers patients, meaning
 - A good relationship with their healthcare professional
 - High confidence or self-efficacy in managing their condition
 - Feeling less emotionally burdened