Integrating Information Technology to Healthcare and Healthcare Management: Improving Quality, Access, Efficiency, Equity, and Healthy Lives

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A study published in 2022 identified the top 10 Countries with the best healthcare as (1) Denmark, (2) Switzerland, (3) Australia, (4) France, (5) Singapore, (6) The United Kingdom, (7) Germany, (8) Canada, (9) Austria, and (10) Japan. The United States spends more money per capita on healthcare than any other country. Still, the United States healthcare did not make the top twenty. Another study published in 2021 ranked the US last in access to healthcare, equity, and outcomes among the 11 high-income countries, despite spending a far greater share of its GDP on healthcare (Luhby, 2021). The World Health Organization's ranking of the world's health systems put France at #1and the United States at #37 (World Health Organization, 2019). This paper examines a broad IT-related healthcare literature and seven key IT tools and technologies that should be integrated into a comprehensive U.S. healthcare system. Properly integrating these IT tools and technologies should narrow the gap and improve the five critical success factors: Quality, Access, Efficiency, Equity, and Healthy lives.

Keywords: information technology, healthcare, big data analytics, electronic health records, the internet, wearable computing, mobile computing, virtual reality, robotics, artificial intelligence, healthcare security threats

INTRODUCTION AND BACKGROUND

A study published in 2022 identified the top 10 Countries with the best healthcare as (1) Denmark, (2) Switzerland, (3) Australia, (4) France, (5) Singapore, (6) The United Kingdom, (7) Germany, (8) Canada, (9) Austria, and (10) Japan. The United States spends more money per capita on healthcare than any other country. Still, the United States healthcare did not make the top twenty. Also, its life expectancy doesn't even appear in the world's top fifty (Carlson, 2022).

Another study published in 2021 ranked the US last in access to healthcare, equity, and outcomes among the 11 high-income countries, despite spending a far greater share of its GDP on healthcare (Luhby, 2021).

The World Health Organization's ranking of the world's health systems ranked France as #1, Canada as #30, and the United State at #37 (World Health Organization, 2019).

Another study that examined countries with the best healthcare systems in the world put the United States as #11. The United Kingdom, Australia, and the Netherlands were the top three (internationalinsurance.com, 2019).

According to a study conducted in 2014, United States healthcare ranked last compared to 10 other industrialized nations as follows: (1) United Kingdom, (2) Switzerland, (3) Sweden, (4) Australia, (5) Germany & Netherlands (tied), (6) New Zealand and Norway (tied), (7) France, (8) Canada, (9) United States. The Key variables used in the study were quality, access, efficiency, equity, and healthy lives. They are briefly explained below (Unknown, 2014):

- Quality- This includes effective care, safe care, coordinated care, and patient-centered care.
- Access- Due to the high cost and lack of universal healthcare for the nation, the healthcare system is not available to everybody compared to their counterpart nations in the study.
- Efficiency- Due to high administrative costs, avoidable emergency room use, and duplicative medical testing, efficiency is relatively low.
- Equity- Due to high cost, the healthcare system is mostly available to wealthier people and those with full-time employment.
- Healthy lives- Measured based on mortality amenable to medical care, infant mortality, and healthy life expectancy.

In 2023, US healthcare spending is estimated at $9.55 trillion, this includes $6.37 trillion federal, $2.11 trillion state, and $2.17 trillion local (US Health Care Spending, 2023).

We believe properly integrating IT tools and technologies into healthcare and healthcare systems can play a major role and positively impact all the five key variables mentioned above. We define electronic health (e-health) as: The integration of IT tools and technologies into healthcare and healthcare systems to reduce overall costs and improve quality, access, efficiency, equity, and healthy lives. Integrating IT tools and technologies into healthcare and healthcare systems in addition to improving healthcare in general could also improve reporting, claims processing, data management, and process automation that collectively should reduce the growing cost of healthcare and healthcare systems (HAHS).

LITERATURE SURVEY: THE LANDSCAPE OF ELECTRONIC HEALTH

A recent survey on the status, applications, deployment, challenges, and opportunities presented by e-health reveals interesting facts as follows:

A study published in 2022 outlines the role of IT in healthcare as transforming healthcare with artificial intelligence, adopting robotics in healthcare, monitoring health through wearable technology, increasing cloud computing deployment in healthcare, increasing utilization of telehealth systems, ensuring data privacy and security, and focusing on healthcare inequalities with social determinants of health (Marley, 2022).

During the Covid-19 Pandemic, some companies have been offering benefits such as virtual therapy and meditation apps for reducing employee’s stress and improving their general health. Meditation apps such as Headspace, Tiatros, Tripp, and Calm and virtual therapy services like Lyra Health, Mindgram, Sober Peer, and Modern Health have seen major employer adoptions (Levy, 2020).

Coronavirus could be a major benefit for telemedicine, as the health industry expects to keep patients out of the hospital. Telemedicine apps like Plushcare, OnCall Health, and Mend offer significant potential, especially during a health outbreak (Farr, 2020).

Data-driven digital health technologies are bringing major changes to the healthcare industry, delivering better outcomes, increased efficiency, and lower costs. Improving data collection and analysis could save the healthcare industry as much as 25% of its costs. Incomplete or inaccurate medical records can impact patient safety and prevent the delivery of seamless patient-centric care. It can also negatively impact the accuracy and speed of claim processing. According to experts, records duplication can cost as much as $1,950 per patient per inpatient stay and over $800 per ER visit (Kalra, 2021).

An Israeli health company Healthy.io has developed an FDA-approved at-home smartphone urinalysis test to help people test their kidneys for proteins, a sign of damage to the organ. It is estimated that thirty million Americans have chronic kidney disease due to diabetes and hypertension; that is 1 in 9 adults, according to the National Kidney Foundation. Early detection makes a significant difference in avoiding complications from kidney disease (Ioannou, 2019).

Chatbots that analyze patients' symptoms and offer advice are here. A Northern California-based hospital chain Sutter Health is using it. Ada Health, a European tech company, has developed the app. Almost four million people have downloaded the app (Farr, 2019).

According to Google Cloud's healthcare advisor, data and machine learning can transform healthcare, without privacy risks. There are huge data sets that can be analyzed with the help of AI and machine learning (Sun, 2018).

As the resistance reduces, IT leaders are helping more and more healthcare providers move to the cloud from on-premise IT computing (Linthicum, 2014).

The experience of Angelina Jolie, the well-known actress, highlights how cloud computing can help address cancer by cutting the cost of genomic sequencing and enabling data sharing (Puranik, 2017).

Amazon launched a patient data-mining service to assist doctors through its Amazon Web Services platform. It offers an AI engine that can gather useful information from millions of unstructured electronic files, including patient electronic medical records (Mearian, 2018).

AI and machine learning could transform healthcare. As an example, in 2018, the U.S. Food and Drug Administration approved the first AI diagnostic — a test for diabetic retinopathy that produces a result without the need for human intervention (Johnston, 2018).

Apple is working with a start-up called Health Gorilla to turn the iPhone into a personal hub for all its customers' medical information. This could add diagnostic data to the iPhone, including blood work, by integrating with hospitals, lab-testing companies such as Quest and LabCorp and imaging centers (Farr, 2017).

The Apple Watch is getting a new feature that can monitor heart health called an electrocardiogram. As a result, more patients could perform ECG at a moderate cost (Farr, 2018).

The Apple Watch is becoming a valuable tool for medical researchers and practitioners to track symptoms associated with Parkinson's. It is improving at detecting tremors and shakes (a-Farr, 2018).

Apple and researchers from Stanford Medicine recently released the results from an eight-month study of more than 400,000 participants who had access to Apple Watches to monitor their heart rhythm for signs of a medical condition known as atrial fibrillation. The watches were able to detect abnormal heartbeats (b-Farr,2019).

An article published in 2022 lists Apple Watch health features as accurate heart rate monitoring, ECG, fall detection, blood oxygen readings, noise level notifications, medication tracking, Afib history, and VO2 Max (Schuler, 2022).

London's Moorfields Eye Hospital used DeepMind (from Alphabet) to scan and identify more than 50 ophthalmological conditions. According to Moorfields, DeepMind's machine-learning technology made correct diagnoses 94 percent of the time (Browne, 2018).

According to a Black Book Research report, 91 percent of CIOs believe cloud computing provides more agility and better patient care with the proliferation of healthcare data (Linthicum, 2018).

Healthcare providers and insurance companies are adding various AI technologies, such as machine learning to improve internal processes and doctor productivity, assist patients with disabilities, and find new disease treatments. AI is getting into real products and delivering tangible results (Petersen, 2018).

Starting in the summer 2019, a patient can talk to a therapist through Amazon's Alexa. For the many people who struggle with anxiety and depression, it is a major challenge to find an affordable therapist. Now, many apps, including Talkspace, Whereby, Spruce Health, and The Difference, are looking to solve the problem by using technology to improve access (Farr and Evans, 2019).

Medical mistakes in the U.S. hospitals and healthcare institutions are the third leading cause of death, and nearly 98,000 people annually lose their lives in this way. E-health could significantly reduce this (Ehteshami, et al., 2013).

The 'doctor's bag of the future could be a 3D printer that allowing doctors to create or make wherever they are, in space or a remote rural area (Strickland, 2017).

Senate bill pays doctors to use Facetime or similar technologies with patients enabling physicians and other healthcare providers to evaluate patients via video chats remotely (Mearian, 2017).

IBM Watson, in conjunction with FDA, is exploring blockchain for secure patient data exchange, the initial focus for blockchain will be oncology-related data exchange (a-Mearian, 2017).

IBM Watson's artificial intelligence platform has joined forces with researchers at MIT and Harvard to use genomic data to defeat drug-resistant cancers (Mearian, 2016).

Artificial intelligence could help diagnose mental disorders using machine learning to train software to spot verbal tics associated with schizophrenia, depression, and bipolar disorder (Frankel, 2016).

Aetna gave away 50,000 Apple Watches to its employees and subsidized others for customers. It works with Apple on iOS-exclusive integrated health apps for iPhone, iPad, and Apple Watch devices (a-Mearian, 2016).

A toy-like cardboard contraption that sells for less than $20 online from Alphabet, as a virtual reality tool, has helped save the life of a baby who was so sick that doctors told her parents to take her home to die (Cohen, 2016).

Because of the availability and access to healthcare data, government, and industry leaders caution that medical data must come with context to provide meaningful insights for patients and researchers (Corbin, 2014).

IBM and Pathway Genomics have developed an app that uses personal history and genetics to assess risks and plan exercise to keep people healthier (Gaudin, 2014).

A Pew Internet study indicates that rising smartphone adoption in the United States and around the globe appears to be motivating people to use mobile health (Eastwood, 2013).

Healthcare workers in the developing world are using mobile phones to address critical health needs ranging from maternal mortality to HIV testing to clean water (Kim, 2012).

By analyzing over 2 billion public tweets, John Hopkins University scientists discovered health patterns, including misuse of medications (Samson, 2011).

IoT medical devices will play a major role in the healthcare system; according to recent surveys, healthcare providers, manufacturers, and regulators believe cybersecurity risks of IoT medical devices and connected legacy systems are a top security concern (Kawamoto, 2017).

Many hospitals transmit health records unencrypted due to a lack of budget and personnel to address security concerns (b-Mearian, 2016).

Hackers want your healthcare data which is much more valuable than credit card information (Rashid, 2015).

A report from California's DOJ regarding data breaches illustrates that most losses in healthcare revolve around stolen devices due to weak use of encryption that poses the greatest risk to healthcare data (Yegulalp, 2014).

A report published in June 2023 indicates that Mayo Clinic is using a generative AI search tool that allows the Clinic to create customized chatbots. This technology enables healthcare workers to analyze data such as a patient's medical history, imaging records, genomics or lab works efficiently and easily (Capoot, 2023).

The following five case examples set the stage for our presentation.

Case #1 – The Power of Big Data Analytics

Based in St. Louis, Missouri, Express Scripts provides pharmacy benefits management. It processes nearly 1.5 billion prescriptions for approximately 100 million consumers per year. The company regularly analyzes its massive amount of data on prescriptions and insurance claims to speed up delivery, reduce errors, and increase profitability. Big data analytics has enabled Express Scripts to quickly find out if customers are filling their prescriptions through mail order, which is cheaper, or going to a retail pharmacy. The company can intervene and provide cost options for customers not using mail order. By using analytics, the company can also be proactive and present customers who are taking drugs on a long-term basis with cost alternatives. Express Scripts has recently expanded into predictive analytics with a Screen Rx system. The system aims to screen and identify patients with chronic diseases (such as high blood pressure, diabetes, or cholesterol) who are not sticking with their prescriptions. This system uses 400 factors (such as family history, past diseases, gender, and where the customer lives) to identify these patients and then offer proactive recommendations. Nonadherence is the most expensive healthcare-related problem in the United States, with an annual cost of over $317 billion. The Screen Rx system can bring this cost down by intervening proactively (King, 2013).

Case #2 – Electronic Health Records at Kaiser Permanente-The Foundation of Big Data Health Analytics

According to an article in InfoWorld, only 9 percent of U.S. hospitals were using even a basic form of electronic health records (EHR) in 2009, but that has changed. As of 2021, 78% of office-based physicians and nearly all non-federal acute care hospitals (96%) adopted a certified EHR. This is substantial progress since 2011, when 28% of hospitals and 34% of physicians had adopted an EHR (Quick Stats, 2023). Kaiser Permanente, a managed care consortium with over 12.6 members as of 2023, implemented an EHR system that became fully operational in 2010. It took Kaiser 10 years to implement its system, costing $4 billion ($444 per member). The Kaiser system, which covers every department and every patient, is called HealthConnect, and it uses data mining and analytics to improve patient service and reduce their bills. For example, the system reminds a patient about a particular test or a need to refill a prescription. According to Kaiser, duplicate testing is approximately 15 to 17 percent of total healthcare costs. HealthConnect eliminates this cost by integrating all the patient's medical records, including X-rays and ER visits. The system also allows patients to access their medical records (including lab results) from iOS and Android devices and e-mail their doctors directly through the system. Kaiser has already launched the next phase of its EHR system, Health360, which embraces the latest in mobile technology (Snyder, 2013). Much other heart care providers have adopted such a model ever since.

Case #3 – 3D Printing and the Medical Field

3D printing technology is increasingly used in the medical field to improve patient care and reduce medical costs. They are also used for presentations, media events, and other medical PR activities. 3D printing lowers the risk and cost of complex surgeries. Boston Children's Hospital has used the technology to assist surgeons, doctors, and medical students; it helped a neurosurgeon save the life of a 4-month-old. Cincinnati Children's and New York-Presbyterian Morgan Stanley Children's hospitals have used this technology to print organs, such as hearts, made from their patients' CT or MRI scans for practicing complex surgical procedures ahead of time. A 3D-printed model of a 5-year-old child at Miami's Nicklaus Children's Hospital assisted surgeons in seeing exactly how to operate before the first incision (Lee, 2018). The technology also helped save the life of a 56-year-old mother of three with a brain aneurysm at Kaleida Health's Gates Vascular Institute in Buffalo, New York. 3D printing could help the medical field in the following areas, such as creating tissue with blood vessels; low–cost prosthetic parts; prescription drugs; tailor-made medical sensors; medical models, such as cancerous tumors; bone that promotes the growth of bone in any shape; heart valves; ear cartilage; medical equipment; cranium replacement; synthetic skin; and organs such as the liver, heart, and kidney (Meskó, 2018).

Case #4 – Robotics and the Medical Field

At 5 feet, 4 inches, and 140 pounds, the RP-VITA (Remote Presence Virtual 1 Independent Telemedicine Assistant) by iRobot Corporation is the first robot to receive FDA clearance for hospital use (Unknown, 2013). To make the robot resemble humans as closely as possible, it has a video screen for a head, a microphone and speaker for a mouth, and two high-definition cameras for eyes. One of its functions is to assist doctors in making hospital rounds remotely. Controllable by a tablet computer using a wired or wireless network, it can move around and is intelligent enough to avoid obstacles. RP-VITA does not offer medical advice, nor does it treat patients. Instead, it is used by doctors and nurses to communicate with their patients. It can also be used with InTouch Health's cloud service to provide doctors and nurses with real-time electronic medical record information. The robot can also connect with diagnostic devices such as otoscopes for examining the inside of the ears; it can also perform an ultrasound (Mearian, 2012).

Case #5 – Vulnerabilities of Medical Devices

Medical devices controlled by computer software—from heart monitors and pacemakers to mammogram and X-ray machines—are new targets for computer viruses and malware (Talbot, 2012). This could put patients at risk, although no injuries or deaths have been reported. The Food and Drug Administration (FDA) is warning the manufacturers of medical devices about the problem and is requesting them to review the parts of their security plans related to these devices when they seek approval from the government agency. In October 2016, Johnson & Johnson warned patients that use its insulin pumps to exercise cushion as it has learned of a security vulnerability that a hacker could exploit to overdose diabetic patients with insulin. However, the risk is low (Finkle, 2016). A Department of Veterans Affairs report has shown that 327 devices at VA hospitals have been infected by malware since 2009. In January 2010, a VA catheterization laboratory was temporarily closed due to infected computer equipment used to open blocked arteries. And in a case at a private Boston Hospital, computer viruses exposed sensitive patient data by sending it to outside servers. The increased applications of electronic record systems as a part of the 2009 stimulus package add to this risk. In addition to privacy issues, hackers can change patients' medical records and treatment plans. If the system does not have a strong login access, some patients can access a system and alter their medications, such as those taking narcotic substances. Hackers could use Shodan, a search engine for locating Internet-connected devices, using terms such as "radiology" and "X-ray" (Niccolai, 2015). Manufacturers must improve the security features of these devices, making them more difficult for hackers to break into. And there needs to be close coordination between the manufacturers and healthcare providers to further enhance security. Also, hospitals and medical facilities must ensure that all the software running these devices is up to date and any updates have been installed. Finally, these devices must be blocked from Internet access (Weaver, 2013).

With this background information, we now concentrate on the seven key IT tools and technologies, assess the security and privacy risks, and then offer an implementation plan.

INTEGRATION STEP #1 – THE INTERNET

With patient records stored on the Internet, healthcare workers can order lab tests and prescriptions, admit patients to hospitals, and refer patients to other physicians more easily; also, test and consultation results can be directed to the right patient records automatically. All patient information can be accessible from one central location; finding critical health information is faster and more efficient, especially if a patient falls ill while away from home. Electronic medical record systems offer some unique advantages, including the following:

- Improve patient care.
- Increase patient participation.
- Improve care coordination.
- Improve diagnostics & patient outcomes.
- Offer practice efficiencies and cost savings.
- Solve the what medication that you are taking dilemma.
- Enhance sustainability and promote "going green" phenomena.

However, these systems have potential problems involving information privacy, accuracy, and currency. Health-related Web sites could play a major role in patient awareness and self-diagnosing for patients in remote and hard-to-reach areas. Popular health-related Web sites include:

- nih.gov- National Institutes of Health
- healthline.com- Medical information and health advice
- mayoclinic.org- Mayo Clinic
- webmd.com- WebMD

There are other uses for healthcare Web sites. Telemedicine, for example, enables medical professionals to conduct remote consultations, diagnosis, and conferencing, which can save on office overhead and travel costs. In addition, personal health information systems (PHISs) can make interactive medical tools available to the public. These systems use public kiosks equipped with Internet-connected computers and a diagnostic procedure that prompts patients with questions. These systems can be useful in detecting the early onset of diseases (Ruiz, 2009). In addition, virtual medicine on the Internet and private networks enable doctors and health professionals at major hospitals to operate on patients remotely. Telepresence surgery, as it is called, allows surgeons to operate all over the world without physically traveling anywhere. A robot performs the surgery based on the digitized information sent by the surgeon via the Internet. These robots have stereoscopic cameras to create three-dimensional images for the surgeon's virtual reality goggles and tactical sensors that provide position information to the surgeon. The Internet also facilitates communication among patients, doctors, and health providers. It enables remote monitoring and provides tools for "Doctors on Demand" where doctors and psychologists can provide virtual visits for less than $40. Clinical collaboration is another application of the Internet where health providers can integrate and coordinate the data provided by every healthcare team member, from the doctor to the patient (Kibbe, 2009).

INTEGRATION STEP #2 – BIG DATA ANALYTICS

Big data analytics is being increasingly used to help improve patient care and outcomes. By analyzing large datasets, healthcare providers can identify patterns and trends that enable a better understanding of the factors currently impacting wellness and disease. The foundation for any big data analytics is the existence of an electronic medical record (EMR) system that enables the capturing and storing of all relevant patients' information. Big data analytics helps to implement a proactive versus reactive HAHS. Other applications of big data analytics in HAHS include (Marr, 2018):

- Prevention.
- Better diagnostic.
- Picking up warning signs of serious illnesses.
- Help to fight diseases such as cancer.
- Offering personalized healthcare.
- Better and faster identification of patients at risk.

The Pittsburgh Health Data Alliance – which aims to take data from various sources (such as medical and insurance records, wearable sensors, genetic data, and even social media use), with the help of big data analytics, offers a comprehensive picture of the patient as an individual, to offer a tailored healthcare package (Leventhal, 2017). Apple and IBM are collaborating on a big data health platform allowing iPhone and Apple Watch users to share data with IBM's Watson Health cloud healthcare analytics service. The goal is to discover new medical insights by analyzing real-time activity and biometric data from millions of potential users (Marr, 2018). Big data analytics is also helping the fight against the spread of epidemics. For example, in Africa, mobile phone location data is proving highly valuable in tracking population movements, which helps predict the spread of the Ebola virus. This gives insight into the best areas to provide treatment centers and allows movement restrictions to be put in place when necessary (Fabian, 2016). A Big data analytics solution has even been proposed to cure cancer. Flatiron Health has developed a service called the OncologyCloud, based on the idea that 96% of potentially available data on patients with cancer is not yet analyzed. The goal is to take data gathered during diagnosis and treatment and make it available to clinicians to further their study (Marr, 2018). Personalized care or patient-centric care is one of the objectives of big data analytics by tailoring medicines to a person's unique genetic makeup – and is developed by integrating a person's genetic blueprint and data on their lifestyle and environment, then comparing it with thousands of others to predict illness and determine the best treatment.

INTEGRATION STEP #3 – WEARABLE COMPUTING

Wearable computers are small computers embedded into many daily devices such as cellphones, cameras, watches, etc. Because people usually carry these devices around, the term "wearable" has been coined to describe them. Wearable computers are increasingly used in medical monitoring systems to provide real-time health information. Wearable medical sensors used widely in hospitals and health facilities are spreading into the mainstream as tech companies increasingly incorporate them into popular handheld devices such as Apple watches and Fitbit fitness bands. Princeton University scientists are working to take these sensor technologies one step further by developing software that could one day use multiple health signs from wearable sensors to diagnose countless diseases in real time. When fully developed, the system would warn a patient who is at risk for diabetes, as an example (Shekhtman, 2018). There are many platforms and several players in this market. The following are five popular examples:

- Apple Watch- Provides easy access to critical health information.
- Google Glass—Displays information in a hands-free format; can communicate with the user and the Web in a natural language.
- Nike+ FuelBand—Uses a sensor that runners can slip into their shoes to track performance.
- Fitbit- measures data such as the number of steps walked, heart rate, steps climbed, and other personal metrics.

A new type of wearable computing using ingestible sensors and implantable chips may soon become common. These devices can be used to collect information about what is going on inside a patient's body. They can be used for treating chronic illnesses and could assist the medical community in producing more suitable drugs faster. At the same time, these devices may create some legal issues. For instance, they could reveal that someone has a particular illness, resulting in a higher insurance fee (Thompson, 2013). The popularity of wearable devices continues to grow; in 2015, Target Corporation announced that it would give its 335,000 employees in the United States Fitbit Trackers as the company focuses more on wellness (Unknown, 2015). In 2016, health insurer Aetna announced that it will provide Apple Watches at no cost to its nearly 50,000 employees participating in the company's wellness reimbursement program (Unknown, 2016). In 2018, United Healthcare a giant insurer, announced that it will offer free Apple Watches to customers who meet walking goals. It requires walking 10,000 steps per day. This could bring the device to its more than 20 million members (c- Farr, 2018).

INTEGRATION STEP #4 – MOBILE COMPUTING

Mobile computing has become a familiar term because of the popularity of mobile apps. An app is designed to perform a specific task and can run on mobile devices, such as smartphones, tablets, and other handheld devices. Today, an app is available for just about any task or application with a general audience, including games, social media, retail, banking, finance, and medicine. Many of the apps are free; some must be purchased. As of 2022, over 350,000 mobile health apps were available on the market for both iOS and Android devices, where Android is in the lead (a-Unknown (2022). Medical mobile apps perform a variety of tasks in HAHS. Below are a few examples (Savitz, 2012).

- Provide mobile bedside assistance and monitoring.
- Improve access to care through virtual visits.
- Improve patient engagement with care providers (medication reminder app).
- Improve patient safety- an app can remind patients to take pills, monitor side effects, and transfer the information to a doctor.
- Reduce Medicare fraud ($60 billion annually from Medicare) by tracking the information among all the key players.

TABLE 1 lists several popular medial apps and their specific functions (Reisenwitz, 2018).

TABLE 1
SELECTED MEDICAL APPS

Name	Platform	Function
Epocrates	iOS and Android	Looks up drug information and interactions, find other providers for consultations and referrals, and quickly calculates patient’s measurements such as BMI
PEPID	iOS and Android	Helps doctors to diagnose faster by suggesting possible ailments based on patient’s symptoms, physical exam findings, and lab results
UpToDate	iOS and Android	Provides medical knowledge that answers clinical questions in real time
Medscape	iOS and Android	Looks up drug information based on the latest medical news
Figure 1	iOS and Android	Allows the medical personnel to view and share medical images with other physicians

INTEGRATION STEP #5 – VIRTUAL, AUGMENTED, AND MIXED REALITY

Virtual reality (VR), augmented reality (AR), and mixed reality (MR) could play a major role in HAHS. They can reduce the overall cost and improve patient engagement. AR has the potential to change healthcare and everyday medicine completely for physicians and patients alike. It can save lives by showing defibrillators nearby (a-Unknown, 2018). Mixed reality can be used for training future doctors and assisting in hands-free medical consultations. Google Cardboard is a VR platform developed by Google for use with an HMD and a smartphone app. The user places the smartphone inside the cardboard and views the objects through the HMD. The platform is a low-cost system to encourage interest and development in VR applications. This $20 device saved the life of a baby missing a lung and half a heart by providing images in three-dimensional virtual reality that cannot be seen in a 3D environment. In 2016, doctors at Nicklaus Children’s Hospital in Miami used the device to map out an operation that they couldn’t have envisioned otherwise. Using the device made it possible to move around and see the heart from different angles – like being inside the heart and checking out its structure (Cohen, 2016). Other areas in AR/VR/MR could play a major role in HAHS are listed below:

- Used for treatment of PTSD.
- Used for pain management.
- Used for AR-assisted surgery.
- Used by patients to describe their symptoms better through AR.
- Used by pharma companies to provide more innovative drug information through AR.
- Used by nurses to find veins easier with AR.

INTEGRATION STEP #6 – ROBOTICS

Medical robots are transforming the face of healthcare. They have been used to train medical personnel (doctors, dentists, and nurses) for several decades. They have assisted elderly patients during rehabilitation and have allowed surgeons to make smaller incisions for certain types of surgery. They have been used during the training process as dummies to mimic a live patient's feelings of pain. Microbots are being used that can scrape plaque from arteries and personal assistant robots that help care for patients. Socially assistive robots are assisting individuals suffering from dementia. As an example, since 2000, da Vinci Surgical Systems have been used in more than 3 million minimally invasive procedures (b-Unknown, 2018). In suitable cases, robotic surgery offers several advantages to patients compared to open surgery, including shorter hospitalization, reduced pain and discomfort, faster recovery time, and return to normal activities, and smaller incisions, resulting in reduced risk of infection and reduced blood loss and transfusions (c-Unknown, 2018). Robotically performed surgery is costly compared with open approaches. However, as the volume increases and further improvement in technology, the cost is expected to go down (Unknown, 2012). Below are the top six robotic applications in medicine (Crawford, 2016):

- Telepresence.
- Surgical assistants.
- Rehabilitation robots.
- Medical transportation robots.
- Sanitation and disinfection robots.
- Robotic prescription dispensing systems.

INTEGRATION STEP #7 – ARTIFICIAL INTELLIGENCE

Several areas within the AI field could play a major role in HAHS, including expert systems, case-based reasoning, machine leaning, IBM Watson, and natural language processing (NLP). A study published in June 2019 outlined five ways that AI is changing healthcare: (1) managing nutrition and fitness, (2) counseling for mental health and wellness (3) monitoring heart health, (4) diagnosing and treating diseases, and (5) creating more efficient digital appointments (Consumer Technology Association, 2019).

According to Google, a new AI-powered "dermatology assist" tool could help anyone with a smartphone to receive information about common skin conditions. The project has existed for three years **(**Palladino, V., 2021).

According to a recent study, diabetes is a growing global epidemic, with 642 million people expected to suffer from this metabolic disease by 2040, and AI-based solutions could play a major role in treating this disease and reducing its explosive growth (d-Unknown, 2018). According to IBM Watson Health general manager Deborah DiSanzo, in four areas, AI/Watson is making a big difference in HAHS (Speights, 2018):

- Managing care.
- Accelerating drug discovery.
- Identifying appropriate cancer treatments.
- Matching patients with clinical trials.

IBM and Pathway Genomics have developed an app that uses personal history and genetics to evaluate risks and recommend exercises and diet. It enables the delivery of real-time, highly personalized insights to empower people to change unhealthy behaviors, allowing them to live healthier lives in ways that have not been possible before (Baum, 2016). IBM Watson also provides tools that enable doctors to battle against certain types of cancer with advanced genomics (Mastroianni, 2015). Johnson & Johnson and Sanofi are using IBM Watson with big data to identify new applications for drugs that have already been developed (Baum, 2014).

HAHS could significantly benefit from various NLP applications. NLP systems could reduce administrative healthcare costs and improve the accuracy of data. NLP-based clinical decision support can be used to set up patient colonoscopy follow-up. The system can extract relevant text from various files and then set a follow-up for the patient. An automated dictation system allows a doctor to read his/her diagnostic of a patient or an X-ray, and the NLP system generates a Word document to be sent to the patient or other doctors. An NLP-based system can extract clinical information from multiple reports and generate a single document for a doctor's review. It could accommodate such requests as scheduling an office visit or paying outstanding medical bills. Also, an NLP-based system can provide real-time translation with high accuracy for patients and clinicians, like those services offered by companies such as Google and Microsoft (Bresnick, 2018). Ten benefits of AI in HAHS are listed below (Shrivastav, 2019).

- Introducing better practices.
- Improving services.
- Improving quality assurance.
- Reducing manual activities.
- Improving controlled monitoring.
- Improving data capture and securing healthcare data.
- Analyzing data of research, diseases, patients, and treatments.
- Improving risk assessment.
- Improving data storage on cloud linked to the Web portals.
- Improving savings on medical expenses.

TABLE 2 (Kali, B., Collier, M., and Fu, R. 2018) lists ten Artificial Intelligence applications that could enhance HAHS.

TABLE 2
10 ARTIFICIAL INTELLIGENCE APPLICATIONS THAT COULD ENHANCE HAHS

Application	Potential Annual Value by 2026 in Billion Dollars	Key Driver for Adoption
Robotic-assisted surgery	40	Technological advances in robotic solutions for more types of surgery
Virtual nursing assistant	20	Increasing pressure caused by medical labor shortage
Administrative workflow	18	Easier integration with existing technology infrastructure
Fraud detection	17	Need to address increasing complex service and payment fraud attempts
Dosage error detection	16	Relevance of medical errors, which leads to tangible penalties
Connected machines	14	Proliferations of connected machines/devices (MIoT)
Clinical trial participation	13	Plethora of data; outcome-driven approach
Preliminary diagnostic	5	Interoperability/ data architecture to enhance accuracy
Automate image diagnosis	3	Storage capacity, greater trust in AI technology
Cybersecurity	2	Increase in breaches; pressure to protect heath data

TABLE 3 lists ten popular examples of healthcare AI-based apps that integrate human and machine capabilities in terms of intelligence and accuracy (Shrivastav, 2019).

TABLE 3
TEN POPULAR EXAMPLES OF HEALTHCARE AI-BASED APPS

da Vinci robot for robotic surgery
Sense.ly for virtual nursing assistants
IBM Watson Health & Microsoft's Inner Eye for diagnosis
Babylon Health for Analysis
Zephyr Health for Treatment design
Babylon Health & Sentrain for Digital consultation & monitoring
Splice Machine & QIAGEN Clinical Insight (QCI) for precision medicine
Google Deepmind Health for fast-track medical information
Careskore for patient health calculations
Drug Formulation and Discovery

Another promising area within AI that could play a major role in HAHS is ChatGPT. OpenAI and ChatGPT models are offering new capabilities that could further enhance HAHS. GPT (Generative Pre-trained Transformer) is an AI technology that can generate human-like text. It has the potential to greatly improve the efficiency and effectiveness of healthcare and the healthcare system by providing personalized recommendations and treatment plans to patients and helping healthcare professionals with their daily tasks. While there are challenges to overcome, such as the need for accurate and up-to-date data and concerns about privacy and security, GPT in healthcare holds great potential for the future. It could provide real-time, evidence-based recommendations to healthcare providers to improve patient outcomes. For example, GPT can suggest appropriate treatment options for a particular condition, flag potential drug interactions, and provide clinical guidelines for complex medical cases (Castro, 2023). Specifically, GPT could be used as a medical expert system and perform the following in a medical setting (Unknown, 2022 and Novella, 2023):

- Summarizing medical records based on patients' family history, symptoms, and lab results.
- Summarizing and analyzing research papers: such as listing keywords in an abstract or summarizing a long and detailed research paper for physicians not working in that field of interest.
- Working as a chatbot to answer FAQ-like questions for the doctors' office or handling appointments.

INTEGRATION STEP #8 – RISK ASSESSMENT

According to experts, ransomware will remain a big part of the cybercriminal's portfolio in 2021 and beyond. A report published on May 31, 2023, indicates that since the beginning of 2023, 15 healthcare systems that cove 29 hospitals have been attacked by ransomware. The report indicates data was stolen from 12 of the 15 facilities (Diaz, 2023). A cybercriminal's ability to disturb operations at a medical facility has life-or-death consequences in certain situations, which can motivate victims to pay the ransom (Nayyar, 2021). In February 2023, Tallahassee Memorial HealthCare remained offline almost a week after a ransomware attack. The hospital only performed "limited surgeries and procedures" during this period (Landi, 2023). An article published in CSO outlined the five biggest healthcare security threats as (1) ransomware, (2) botnets, (3) cloud misconfigurations, (4) Web application attacks, and (5) phishing (Vijayan, 2021).

NRC Health, which administers patient survey tools for hospitals, experienced a cyberattack on February 11, 2021, and shut down its "entire environment" to contain the issue. This incident ignited privacy concerns about private patient records stored by US hospitals (a-Farr,2020).

As we mentioned earlier, privacy and security risks are the major concern associated with e-health systems. These systems are vulnerable to security risks outlined in TABLE 4 and intentional computer and network threats outlined in TABLE 5. These systems must be protected against all these security risks and threats by comprehensive security measures listed in TABLE 6.

TABLE 4
SECURITY RISKS

Spyware and adware
Phishing ang pharming
Keystroke loggers
Sniffing and spoofing
Computer crime and fraud (ID theft, industrial espionage, and sabotage)

TABLE 5
INTENTIONAL COMPUTER AND NETWORK THREATS

Viruses
Worms
Trojan programs
Logic bombs
Backdoors
Blended threats (e.g., a worm launched by Trojan)
Rootkits
Denial-of-service attacks (Dos), and distributed Denial-of-service attacks (DDoS)
Social engineering
Ransomware

TABLE 6
SECURITY MEASURES AND ENFORCEMENT

Biometric security measures
Nonbiometric security measures (callback modems, firewalls, and intrusion detection systems)
Physical security measures (cable shielding, corner bolts, electronic trackers, ID badges)
Access controls (terminal resource security and passwords)
Zero login, brain passwords, DNA identification, authentication tokens, and implanted microchips
Virtual private networks
Data encryption

INTEGRATION STEP #9 – PREPARING FOR AN E-HEALTH PLAN FOR IMPLEMENTATION

An organization's employees are an essential part of the success of any e-health initiatives, so training and education on the strengths and weaknesses of this platform and security awareness and security measures are important. End users' lack of knowledge and awareness of e-health policies and procedures is a key issue and it must be addressed (Bidgoli, 2018). Some organizations use a classroom setting for training, and others conduct it over the organization's intranet. Participants should be given tests and certificates at the end of training sessions. In addition, making sure management supports the training program is important to help promote the adoption of this new technology throughout the organization. The following steps should be considered when developing an e-health implementation plan (Siwicki, 2016, Myers, 2013 & Bidgoli, 2023):

1. Set up an e-health committee with representatives from all departments as well as upper

management. The committee's responsibilities include the following:
  - Developing a clear, detailed e-health acquisition and use plan.
  - Providing e-health awareness for key decision-makers and users.
  - Conducting a basic cost/benefit analysis and calculating an ROI for the e-health acquisition.
  - Overseeing enforcement of the e-health policy.
2. Force software updates and work with the e-health technology providers to have the latest updates.
3. Define the organization's needs. A clear definition of needs will assist the organization to decide on the following:
  - Prioritizing the seven IT tools and technologies (discussed in the paper) for the integration.
  - Defining the full benefit of the seven IT tools and technologies as they relate to the organization's strategic goal.
  - Defining new areas within the seven IT tools and technologies for future adoption.
4. Post the security policy in a visible place, or post copies next to all workstations.
5. Raise employees' awareness of security problems in an e-health environment.
6. Revoke terminated employees' passwords and ID badges immediately to prevent attempts at retaliation.
7. Exit programs and systems promptly and never leave logged-on workstations unattended.
8. Limit computer access to authorized personnel only.
9. Examine security risks outlined in TABLE 4, and intentional computer and network threats outlined in TABLE 5 and offer a countermeasure outlined in TABLE 6.
10. Encrypt sensitive health data before storing them on servers and workstations.
11. Backup data files on regular bases.
12. Tell the users and employees to be skeptical: Don't click on any suspicious e-mail with an attachment.
13. Install the latest patches for all software.
14. Block popups.
15. Install cable locks on laptops and use biometric security measures.
16. Make sure confidential data is stored on laptops only when necessary.
17. Use logon passwords, screensaver passwords, and passwords for confidential files.
18. Adopt or migrate to alternatives to password outlined in TABLE 6.
19. Encrypt data stored on the laptop.
20. Install security chips that disable a laptop if unauthorized users try to access it. Some chips send out an audio distress signal and a GPS alert showing the laptop's location.
21. Have a continuity plan in place to get back to normal operation in case of a disaster.

CONCLUSION

This paper examined the existing literature in the e-health environment, reviewed five case examples, and then introduced seven key information technology (IT) tools that should be integrated into healthcare and the healthcare system (HAHS). This integration should improve HAHS and enhances the U.S. position in the world healthcare system. The seven key IT and technologies include (1) the Internet, (2) big data analytics, (3) wearable computing, (4) mobile computing, (5) virtual, augmented, and mixed reality, (6) robotics, and (7) artificial intelligence. The paper also assessed major risks associated with e-health systems, including security and privacy of medical records and risks associated with medical IoT devices, and then recommended an e-health plan for implementation. TABLE 7 shows the seven IT tools that could improve critical success factors (quality, access, efficiency, equity, and healthy lives) in the healthcare and healthcare system.

TABLE 7
INTEGRATION CRITICAL SUCCESS FACTORS

	Quality	Access	Efficiency	Equity	Healthy lives
The Internet	X	X	X	X	X
Big data analytics	X		X		X
Wearable computing	X	X	X	X	X
Mobile computing	X	X	X	X	X
Virtual, augmented, and mixed reality	X	X	X		X
Robotics	X	X	X	X	X
Artificial intelligence	X	X	X		X

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