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Smart Health:
Intelligent Healthcare Systems in the Metaverse, Artificial Intelligence, and Data Science Era

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ABSTRACT

In recent decades, healthcare organizations around the world have increasingly appreciated the value of information technologies for a variety of applications. Three of the new technological advancements that are impacting smart health are metaverse, artificial intelligence (AI), and data science. The metaverse is the intersection of three major technologies — AI, augmented reality (AR), and virtual reality (VR). Metaverse provides new possibilities and potential that are still emerging. The increased work efficiency enabled by artificial intelligence and data science in hospitals not only improves patient care but also cuts costs and workload for healthcare providers. Artificial intelligence, coupled with machine learning, is transforming the healthcare industry. The availability of big data enables data scientists to use the data for descriptive, predictive, and prescriptive analytics. This article reviews multiple case studies and the literature on AI and data science applications in hospital administration. The article also presents unresolved research questions and challenges in the applications of the metaverse, AI, and data science in the smart health context. For researchers, in addition to providing a good synopsis of the development and applications of the metaverse, AI, and data science in the healthcare area, this article identifies possible future research directions and discusses the possibilities of the metaverse, artificial intelligence, and data science in smart health. For practitioners, this article provides both hospital decision-makers and healthcare workers with practical guidelines and a smart health management model.

KEYWORDS

Artificial Intelligence, Data Science, Hospital Management, Smart Health, Smart Hospital

INTRODUCTION

The healthcare industry is moving in the direction of smart health and intelligent healthcare systems. Three new technologies that are impacting and transforming the healthcare industry are metaverse, artificial intelligence, and data science.

The metaverse can be considered as a network of 3-D virtual worlds. Earlier versions of the virtual world include Second Life, Mozilla Hubs, VRChat, Furcadia, and OpenSimulator (Siau *et al*., 2010).

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The metaverse is based on the fusion of technologies such as virtual reality (VR) and augmented reality (AR) that enable multi-sensory interaction with virtual environments, digital objects, and people (Mystakidis, 2022). While the metaverse is still in its infancy, 3-D virtual worlds are already being utilized in healthcare, education, and many other areas (Eschenbrenner *et al*., 2008; Chen *et al*., 2012; Nah *et al*., 2017; Thomason, 2021). In smart health, metaverse combines technologies such as artificial intelligence, virtual reality, augmented reality, Internet of medical devices, Web 3.0, intelligent cloud, edge, and quantum computing with robotics to provide a new direction for healthcare (Chen & Zhang, 2022).

Artificial intelligence (AI) is an information technology system with the ability to complete tasks that normally require human intelligence (Yang & Siau, 2017; Hyder *et al*., 2019). Machine learning is an approach to achieving AI, and deep learning is a branch of AI and a technique for realizing machine learning. Deep learning focuses on algorithms inspired by the structure and functioning of the human brain (Yang & Siau, 2018). Machine learning and deep learning typically use massive datasets to train computers to mimic human intelligence (Janiesch *et al*., 2021).

Data science is a comprehensive scientific field that involves statistics, mathematics, and programming to analyze and study big datasets (Egger & Yu,2022). In general, data science involves steps for analyzing data and generating insights (Raghunandan *et al*., 2022). AI uses computer algorithms to study the data and mimic human cognition to interpret and "understand" the results (Siau, 2018).

In this article, we review the current developments in the metaverse, AI, and data science. Specifically, we discuss how different AI methods and data models can offer substantial support to all aspects of hospital management, including hospital workflow, human resources, medical devices, patients, medical imaging and diagnosis, drug discovery, and precision medicine, and improve patient services (Lai *et al.,* 2022). The article starts with a brief history of AI development in hospital management. This is followed by a review of related work on data science in hospital management (e.g., AI algorithms and radionics used for chest X-rays and Olivia (AI agent) used for human management). Challenges and limitations of AI and data science in healthcare and hospital management are also discussed. The possibilities and potential of the metaverse are also discussed in this paper.

BACKGROUND AND RELATED WORK

Metaverse is a new concept for the disruptive changes expected in many aspects of our lives – and the use of metaverse in healthcare is no exception. For many decades, the delivery of healthcare has required physical interaction between patients and physicians as a means of diagnosing patients' issues, prescribing medical treatments, and performing surgical procedures on patients. This approach has only changed slightly with the advent of telehealth services. The rapid technological advancements in the past few years present unprecedented possibilities to transform healthcare. The metaverse has the potential to revolutionalize healthcare, from virtual health to mental health and from reality management to virtual management (Marzaleh *et al*., 2022).

AI and data science in hospital management provide additional possibilities, although they are not two new endeavors. As early as the 1970s, the first AI application, MYCIN, was used to help identify blood infection treatments (Väänänen *et al.,* 2021). Data science has been utilized to handle a huge amount of data on blood infection patients. Data science helps to analyze and study patients' blood problems using recorded data.

In 1979, the American Association for Artificial Intelligence was formed (Upjohn *et al.,* 2021). The first international AI journal, Artificial Intelligence in Medicine, was founded in 1980. From 1980 to 1990, AI was incorporated into clinical settings, from designing minimally invasive surgery to working on the concept of telepresence during surgery (Shah & Vyas, 2014). In 1994, with the help of data science and machine learning applications, AESOP (Automated Endoscopic System for Optimal Positioning), a voice-activated endoscope, was launched, allowing surgeons to see the inside of the patients' bodies (Wang, Zeng & Sheng, 2021). Despite various issues with AESOP, significant technological progress has been made over the years. Launched in 1997, the Compumedics sleep monitoring system (K955841) is a data management tool that records and evaluates data about sleep and sleep-related respiratory disorders (Radhakrishnan *et al.,* 2022). In 1998, with the advent of deep learning technologies in data science, the FDA approved the use of algorithms to detect cancers in medical images. The ZEUS Robotic Surgical System (ZRSS) is a medical robot developed by the American robotics company Computer Motion in 2001 to assist surgery. ZRSS has three robotic arms remotely controlled by the surgeon, one of which is the improved AESOP (Reilly, 2021). In 2003, following the merger of Computer Motion with Intuitive Surgical, the new company subsequently developed the Da Vinci Surgical System. This system is not a robot. The platform was created by scientists to conduct robotic-assisted minimally invasive surgery (Xie *et al.,* 2021). In 2007, a panel was held at the Artificial Intelligence in Medicine Europe (AIME) conference in Amsterdam, The Netherlands, to discuss various topics on clinical data mining, knowledge-based healthcare, and temporal data mining. Undoubtedly, AI and data science are important tools for healthcare. Artificial intelligence in Medicine (AIM) researchers aim to develop a wide array of AI-inspired methods to tackle a broad range of important clinical and biological problems (Choudhary & Connolly, 2021). Furthermore, the deep neural networks launched in 2012 have exhibited good performance characteristics compared to those of more conventional AI, demonstrating that deep learning technology has important applications in smart health and intelligent healthcare management (Esteva *et al.,* 2021). Recent years have seen a significant uptick in investment in AI and data science in healthcare applications. With the application of artificial intelligence in the metaverse, and data science applications in primary care, remote disease diagnosis, telemedicine, virtual health screening, and many other smart and intelligent healthcare applications are emerging. Such applications include remotely monitoring critically ill patients, analyzing clinical patient data, blood glucose monitoring, heart rate tracking, enhancing physical fitness tracking capabilities, and other new and previously unimaginable medical and health services in a three-dimensional immersive way (Hsieh & Lee, 2018). For example, the tech company Oculus taken over by Meta has been helping in orthopedic surgery. Google Glass is helping new mothers struggling with breastfeeding. Medtech startup AccuVein is using AR technology to make both nurses' and patients' lives easier (Mesko, 2018). Such applications and tools can also assist healthcare professionals and extend their skills. AR can help surgeons become more efficient at surgeries. Whether they are conducting a minimally invasive procedure or locating a tumor in the liver, AR healthcare apps can help save lives and treat patients seamlessly. Sync AR developed a software program to give surgeons "X-ray vision" by fusing digitally enhanced images directly into the microscope of a surgical device.

AI and data science applications are also appearing and experimenting everywhere in hospital management and are growing rapidly (Asha, Kanchana Devi & Sahaja Vaishnavi, 2022). The STATISTA website has published the growth rate for the AI global healthcare market from 2014 to 2021 and predicted the growth rate to be 55 percent in 2021 (see Figure 1) (Liu, 2021). Further, Sage Growth partners reported that 90 percent of hospitals globally have an AI strategy in place, and 75 percent of hospital executives consider AI an important tool for the medical hospital environment in light of the COVID-19 pandemic (Yoganandhan *et al.,* 2021). AI in medical diagnosis investment is also expected to grow from $505 million in 2020 to $387,87 billion by 2025. Government initiatives will continue to increase the demand for AI tools in the medical field to reduce the workload of doctors (Sheel *et al.,* 2022).

Clinical document management is another area for AI and data science in hospital management. Approximately 1.2 billion clinical documents are generated each year in the United States. Out of these, 20% of the data are structured, and structured data can be easily stored electronically and analyzed. Further, nearly 80% of the data are in the form of notes written by doctors, medical images,

Figure 1. Growth rate for the AI healthcare market worldwide from 2014 to 2021 (published data from statista.com)

and clinical documents. Thus, data science can be applied to analyze and study a large number of clinical documents and data in the medical field to reduce the workload of the healthcare worker.

In Table 1, we grouped AI applications in hospital management into seven categories. Some representative papers in each category are listed.

Metaverse, AI, and Data Science in Smart Health

The use of advanced information technologies to support and revolutionize healthcare is not new. Terms such as e-health (Siau *et al*., 2002) and healthcare informatics (Siau, 2003a; Siau & Shen, 2006) have been used in the past 2-3 decades. These efforts aim to make healthcare services more competitive (Siau, 2003b). The COVID pandemic also propels the importance of smart health, intelligent healthcare systems, and the use of advanced information technologies in healthcare to a new height (Xie *et al*., 2020; Shiau *et al*., 2021).

In this paper, we discuss the smart management model, including employing intelligent healthcare management and patients care to improve hospital management, using virtual worlds such as metaverse to provide an immersive experience, and deploying advanced technologies such as AI tools and data science tools to enhance the quality of healthcare. Deployed correctly, AI and data science can advance healthcare management and delivery. Many AI applications rely on machine learning, and machine learning typically requires large datasets. Data science has an important role in advancing hospital facilities and processes. It helps boost productivity in diagnosis and treatment and enhances the workflow of hospital systems (Au-Yong-Oliveira *et al*., 2021). This paper lists seven examples to explain the important role of data science in hospital management, and it also reflects the specific role of the smart hospital management model in those aspects.

1. Using data science to increase operating room utilization. Many hospitals have a problem scheduling operating room usage. Scheduling operating rooms impacts patients' access and recovery, surgeons' skills, and care quality. Many hospitals still use phone calls and computers to develop a utilization timesheet. The tasks depend heavily on the employees, and they will make mistakes at times. Further, the optimal use of the operating rooms is important for all. Data science provides predictive analytics, cloud computing, and predictive models to increase operating room utilization. For example, UCHealth is a scheduling application. The functions include easy scheduling of operation rooms for patients and surgeons. With the tool, UCHealth

Table 1. AI in hospital management

Category	Reference	Brief Summary
AI in Hospital Workflow Management	Maintenance workflow management in hospitals: An automated multiagent facility management system (Yousefli, Nasiri & Moselhi, 2020)	This paper describes the Multiagent facility management system (MAFMS), which is a web-based system that employs the Unified Modeling Language diagrams to support dynamic workflow management and resource allocation for facility managers in hospitals.
	Real-time capacity management and patient flow optimization in hospitals using AI methods (Munavalli, Boersma, Rao & Van Merode, 2021)	This paper uses the Multi-Agent System to explain why AI systems can expand hospital capacity and optimize patient flow.
	Workflow-based Adaptive Layout Design to Improve the Patient Flow in the Outpatient Clinics (Munavalli, Boersma, Srinivasan & Van Merode, 2021)	This paper describes how the AI system design contributes to hospital operations management. The Ant agent algorithm was used to reduce the waiting time and improve the patient flow in the outpatient clinics.
AI in Human Resource	Artificial intelligence, robotics, advanced technologies, and human resource management: a systematic review (Vrontis, Christofi, Pereira, Makrides & Trichina, 2021)	This review article examines 45 articles on AI, robotics, and other advanced technologies within HRM settings. These studies demonstrate the potential of AI as a new approach to managing employees and enhancing hospital performance.
	Evolving uses of artificial intelligence in human resource management in emerging economies in the global South: some preliminary evidence (Kshetri, 2021)	This paper reviews multiple case studies of AI in HRM in the Global South. With AI tools such as Olivia and Paradox, organizations can improve recruitment selection by accessing a larger candidate pool.
	AI-assisted hiring process and older workers: An exploratory study (Allam, 2021)	This paper describes AI recruiting tools in businesses, such as resume scanning and/or AI-assisted video interviews. AI can automate time-consuming routine processes to reduce repetitive tasks.
	The Top 12 best AI recruiting tools (Strazzulla, 2022)	This paper summarizes the best HR and recruiting software, including Loxo, Myinterview, Hirevue, and Eightfold.
AI in Medical Device	Approval of artificial intelligence and machine learning-based medical devices in the USA and Europe (2015–20): a comparative analysis (Muehlematter, Daniore & Vokinger, 2021)	The researchers examine various governmental and nongovernmental databases and identify AI and machine-learning-based medical devices (222 in the USA and 240 in Europe). Many of these devices are used in radiology.
	Beyond the hype: Medical device artificial intelligence (AI) (Gutierrez, 2021)	The paper looks at the use of AI in medical devices such as diagnosis of heart diseases, detecting cancer in mammography, diagnosis of degenerative brain diseases, sorting and recognizing cell types, imaging of the liver, and biosensors for monitoring vital signs biosensor
AI In-Patient Management	Use of AI-based tools for healthcare purposes: A survey study from consumers' perspectives (Esmaeilzadeh, 2020)	This paper describes how AI can provide improved patient care, diagnosis, and interpretation of medical data (e.g., by supporting patient-specific diagnosis and treatment decisions).
	AI-based natural language processing for the generation of meaningful information electronic health record (EHR) data (Kaswan *et al.,* 2021)	This paper discusses how natural language processing (NLP) converts paper records to electronic health record systems (EHR). This reduces treatment time and eases patient management.
	Artificial intelligence in the intensive care unit (Gutierrez, 2020).	This paper describes the advancement of AI applications in monitoring and treating patients in the intensive care unit.
AI in Medical Imaging and Diagnosis	On the role of artificial intelligence in medical imaging of COVID-19 (Born *et al.,* 2021)	AI algorithms and radionics for chest X-rays to support massive screening programs.
	Data preparation for artificial intelligence in medical imaging: A comprehensive guide to open-access platforms and tools (Diaz *et al.,* 2021)	The paper details medical image repositories covering different organs and diseases. The system is used to identify anonymized images, such as GDPR and HIPAA.
	Diagnostic accuracy of deep learning in medical imaging: A systematic review and meta-analysis (Aggarwal *et al.,* 2021)	Deep learning has the potential to transform medical diagnostics. For example, AUC is only an evaluation metric that cannot be used to diagnose disease. The researchers for this paper conducted a literature review to broadly understand the AUC of various DL models.

continued on following page

Table 1. Continued

Category	Reference	Brief Summary
AI in Drug Discovery	Artificial intelligence in drug discovery: What is realistic, what are illusions? Part 2: A discussion of chemical and biological data used for AI in drug discovery (Bender & Cortes-Ciriano, 2021)	Deep Genomics AI platform helps develop drugs for neuromuscular and neurodegenerative disorders by statistically raising the chances of successfully passing clinical trials while decreasing time and cost.
	Artificial intelligence in drug discovery: Recent advances and future perspectives (Jiménez-Luna *et al.,* 2021)	This paper reviews the impact of AI, such as QSAR/QSPR modeling, de novo drug design, and synthesis planning, on drug discovery.
	Artificial intelligence in drug discovery and development (Paul *et al.,* 2021)	This paper describes how AI can provide a quicker validation of the drug target and optimization of the drug structure design.
AI in Precision Medicine	Precision medicine, AI, and the future of personalized health care (Johnson *et al.,* 2021)	This paper discusses precision medicine methods to identify phenotypes of patients with unusual responses to treatment or unique healthcare needs.
	Artificial intelligence in precision medicine in hepatology (Su, Wu & Kao, 2021)	This research applies AI technology in the daily clinical practice of hepatology, including radiological imaging, EHR, liver pathology, data from wearable devices, and multiomics measurements.
	A new precision medicine initiative at the dawn of exascale computing (Nussinov *et al.,* 2021)	This paper describes AI methods in developing patient-specific strategy that predicts drug resistance targets of parallel (or redundant) proliferation pathways in specialized cells.

increases per operating room revenue by 4%, and the tool helps to enhance the revenue by an additional $15 million annually (Stephens, 2021).

2. Decreasing the waiting time of patients in the emergency department. Emergency events happen in the emergency department constantly, irrespective of the number of staff in the department. For example, when a new patient needs an X-ray, blood test, or other examinations, s/he has to spend a significant amount of time waiting for lab results or X-ray images. This is one of the main reasons for the crowded conditions in the emergency department. Data science can help by using predictive modeling to estimate the time of each patient's journey through the department and waiting time, enabling the staff to reroute patient traffic to improve efficiency. For example, a hospital uses a forecast model to estimate patients' demand for each lab test category by times of the day and days of the week. The forecast model reduces average patient wait times from one hour to 15 minutes, which significantly alleviates the emergency department's problems (Côté & Smith, 2018).
3. Slashing infusion center wait times. Infusion scheduling is another difficult task in hospital management. In general, it is easy to schedule fixed/regular patients but difficult to schedule random/walk-in patients. For example, even if a center has 50 chairs, the infusion time and dosage of each patient are different. Faced with this challenge, hospitals can use predictive analytics and machine learning to optimize their scheduling and reduce the waiting times for patients. The New York-Presbyterian Hospital applied a predictive platform(Murphy & Brown, 2021)that reduced 50% of the waiting time for patients in the infusion center.
4. Discharging patients. An efficient discharge system is important for the effectiveness of a hospital. If a patient cannot carry out the discharge procedures in one day and the patient is only discharged in the evening, the health worker may not be able to clean the free bed until the next morning. With analytics tools, a hospital can reduce the discharge length by half a day and schedule the discharge time of patients in the morning. For example, Medstar Georgetown University Hospital in Washington, D.C. (Emes *et al*., 2018) used an accelerated discharge planning system to increase its daily discharge volume by 21% and morning discharge to 24%.
5. Scheduling and assigning inpatient beds. With an efficient and effective discharge planning system discussed in (iv), hospitals can improve their service by using data science tools to forecast the number of inpatients. The number of free beds is usually known, and data science can assist in

quickly scheduling the available inpatient beds. This information can be available in real-time to doctors, nurses, and healthcare workers in the hospital. Further, the system reminds the healthcare worker to clean the free beds and let the doctors and nurses know about the patients who were moved to discharge lounges. For example, West China hospitals used a system for scheduling inpatients, saving a significant amount of time for patients and nurses (Zhu, *et al*., 2020).

6. Monitoring patient health. Data science and AI are essential tools for monitoring patient health. With the help of analytical tools, analyzing and monitoring data of patients' blood pressures, heartbeats, sleep times, and other vital signs are becoming common practices. The analytical tools and applications can also help to predict if a patient will face any problem based on his/her present conditions. Data science and AI can also assist doctors in making the necessary decisions to help patients in distress. For example, HealthARC is a remote patient monitoring (RPM) (Thakral, 2020) software designed for hospitals and patients. Metaverse provides much potential in this aspect by providing a more immersive and engaging environment.
7. Improving patient care. With patient health information in the healthcare system and utilizing data science and AI, healthcare professionals can use the predictive tool to predict patients' health. Early detection and warnings result in early treatment and prevention. These systems look like reminder systems that can improve patient care, help patients recover faster, and monitor patients' health conditions. For example, MyMedisafe (Otero, 2022) is a medication reminder tool that can help physicians prescribe medications quickly. Again, the metaverse provides new possibilities in this area.

The advancement of AI and data science has presented many opportunities for hospital management. Applying AI and data science appropriately can significantly improve healthcare management and patient care. Metaverse provides new possibilities and has the potential to move healthcare to another level. Nevertheless, metaverse, AI, and data science are cutting-edge technologies, and they pose significant risks for patients and hospitals. These challenges need to be researched and addressed.

CHALLENGES AND FUTURE RESEARCH DIRECTIONS

We discuss the new challenges and future research directions facing the use of metaverse, AI, and Data Science in smart health and intelligent healthcare systems.

Challenge 1: Explainable Systems

Most existing versions of AI, machine learning, and deep learning systems cannot show the details of how they arrive at a certain diagnosis, even if they give better diagnoses than human doctors. The inner processing of machine learning (not including the classical machine learning algorithms such as decision trees, simple statistical machine learning models such as logistic regression, and many others), which is usually called the "black box", means we cannot see any models or pieces of information directly (Angelov, *et al*., 2021). Because the diagnoses provided by the systems cannot be explained by human doctors, this results in the poor understanding and low trust of AI and data science systems by patients. Trust is crucial in all kinds of relationships and a prerequisite for acceptance (Siau & Shen, 2003; Siau & Wang, 2018). The Health Insurance Portability and Accountability Act (HIPAA) states that machine learning and deep learning are challenging to apply to patients. Some argue that AI technologies may be better used for applications such as drug discovery and development, and patient population/appointment management than for diagnosis and treatment planning (Preum *et al.,* 2021). Nevertheless, the potential of AI means that machine learning and deep learning must strive to advance to explainable AI and make the inner working open and transparent. Futher, regulatory compliance may restrict AI applications in smart health until the working processes are transparent (Zednik, 2021).

Research Direction 1: Because AI and data science using machine learning are opaque, it is difficult to explain and understand how they work and what they do. Research on explainable AI is key for the subsequent development and adoption of AI.

Challenge 2: Relationship Between Patients and Hospitals

Another inherent challenge in a medical hospital environment is the complex relationship between patients and hospitals. While AI and data science technologies may save money and waiting time for patients (Stefanini *et al.,* 2021), patients may still feel dissatisfied due to a variety of factors, such as health outcomes, unmet expectations, and unclear communication. Patients arguing about their rights, doubting results, and not trusting doctors will take up valuable time of healthcare professionals that can be better spent on servicing the patients.

Research Direction 2: As most patients do not possess medical knowledge on disease diagnosis and treatment, intelligent chatbots can help to explain some of the medical symptoms, causes, treatment options, and treatment processes. For example, virtual worlds such as metaverse can be used to depict hospital schematics, and metaverses can be used to simulate operation theatres and procedures. Telemedicine and aftercare services can also be greatly facilitated and enhanced with metaverse, AI, and data science. Healthcare education program that uses AI to tailor and deliver health education to patients is another important research area (Siau, 2018).

Challenge 3: Trust

The lack of human emotions such as empathy and compassion in AI systems and health robotics also makes them appear less trustworthy in the eyes of patients (Siau and Wang, 2018). For this reason, patients often trust their doctors and not the more accurate AI systems (Bedué & Fritzsche, 2021). Healthcare providers, therefore, must take on the extra challenge of earning patients' trust whenever AI is involved (Von Eschen bach, 2021). Further, improving the quality of diagnoses and treatments, reducing misdiagnoses and wrong diagnoses, and building trusting relationships between humans and AI are important to the development of smart health.

Research Direction 3: How can we develop or emulate human feelings such as empathy and compassion in AI systems? True empathy and compassion may be difficult to achieve in the short term by AI, but emulation of such feelings is achievable. AI with "emotional" intelligence is important in a healthcare context. Nevertheless, such emulation should not cross the threshold of becoming unethical and deceiving.

Challenge 4: Data Security and Privacy

Many AI systems rely on machine learning using a large database. Data science also relies on a huge set of data. Building the database may include collecting many personal and private data. Data security and privacy become major issues in such situations. Informed consent, privacy, and data protection need to be practiced and regulated (Gutierrez, 2020). Furthermore, these databases are prone to hacking and attacks. Many personal and private data are at stake (Sohn *et al.,* 2020). The bad news is that these attacks and hacking are going to be more advanced and sophisticated. Patients' data and information are highly valued on the dark web. Data security needs at hospitals and medical institutions require advanced and state-of-the-art security tools.

Research Direction 4: Data security and privacy are continuous improvement items, especially for healthcare. AI and data science can assist in enhancing security and privacy and preventing data breaches. Research in these areas is critical to the development of smart health.

Challenge 5: Ethical Issues

In addition to using the data collected legally, the ethical use of data in AI and data science needs to be considered. Further, the AI systems developed should behave ethically, and ethical principles need to be practiced by developers as well (Siau & Wang, 2020). For legal issues, new laws need to be introduced to regulate AI data protection, responsibility determination, and supervision. Similar laws that resemble HIPAA should be formulated for the use of AI and data science in the healthcare environment. Laws, regulations, and guidelines related to the ethical use of AI are urgently needed (Golbus *et al*., 2020; Gerke *et al*., 2020).

Research Direction 5: The ethical dimension in the development of the metaverse, AI, and data science cannot be ignored. In fact, the ethical use of AI is considered of paramount importance by many in the AI community. The use of AI in educating AI professionals about ethical issues is another critical research area. AI ethics is urgently needed.

CONCLUSION

Metaverse, AI, and data science offer many advantages over traditional analytics and clinical decision-making techniques. The development and use of AI in healthcare will continue despite some of the existing challenges. The amount of data in healthcare will, of course, continue to grow and will grow at an increasing rate. Data science can contribute to analyzing and making sense of these data to enhance healthcare development and services. AI and data science are two key pillars of smart health. Metaverse provides a new dimension to consider for smart health and intelligent healthcare systems. Metaverse is very new, and its potential will continue to enhance. This means that its importance in healthcare will continue to grow and evolve.

Smart health has the potential to provide better healthcare outcomes and improve the productivity and efficiency of healthcare delivery. In this article, we study and discuss how metaverse, AI, and data science are used and can be used in different areas of hospital management. AI and data science are equipping more doctors, nurses, and healthcare workers with many management and decision-making tools, enabling them to take better care of their patients. Metaverse is a new kid on the block with tremendous potential. Several research directions are listed in this article, and these research directions will be important to the continuing advancement and development of smart health and intelligent healthcare systems.

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