Application of artificial intelligence for resilient and sustainable healthcare system: Systematic literature review and future research directions

Abstract

Recent years have witnessed increased pressure across the global healthcare system during the COVID-19 pandemic. The COVID-19 pandemic, a disaster, has shattered efficient healthcare operations and taught the importance of a resilient and sustainable healthcare system. The adoption of Artificial Intelligence (AI) has positively contributed to developing the best healthcare systems. To understand how AI contributes to building a resilient and sustainable healthcare system, we undertook a systematic literature review of 89 articles extracted from Scopus and Web of Science databases. The study is organized around several key themes under applications, benefits, and challenges of using AI technology in healthcare, offering a valuable synthesis of the relevant key literature. It is observed that AI has wide applications in radiology, surgery, medical, research, and development department of healthcare. Based on the analysis, a research framework is proposed using an extended Antecedents, Practices, and Outcomes (APO) framework. This framework comprises AI applications' antecedents, practices, and outcomes for building a resilient and sustainable healthcare system. Consequently, three propositions are drawn in this study. Furthermore, our study has adopted the theory, methodology, and context (TMC) framework to provide future research directions which can be used as a reference point for future academicians and practitioners.

Keywords: *Artificial intelligence, Disaster, Healthcare, Resilience, Sustainability, Systematic literature review*

1. INTRODUCTION

The healthcare system across the globe is changing drastically to deal with new life-threatening diseases such as COVID-19. Seddighi (2020) considers COVID-19 a natural disaster. Global healthcare is under pressure to prepare and respond to emergencies during uncertain environments (Chee et al., 2021; Dwivedi et al., 2018). The recent COVID-19 pandemic has tested even the best healthcare system and has brutely eroded many healthcare systems across nations (KPMG, 2022; UN, 2022). While the impact of the COVID-19 pandemic has devastated multiple global economies (Ardolino et al., 2022). Other natural disasters such as floods, wildfires, and hurricanes have caused global economic losses of $270 billion in 2021 (Bloomberg, 2022). The organizations had undergone such monster damages mainly because they were unprepared to bear the magnitude of the COVID-19 pandemic (Ardolino et al., 2022), showing the importance of organizations being resilient. Not only economic damages, but these disasters have also led to several tangible and intangible damages. Disasters lead to a shortage of drugs, disturb medical supplies, and interrupt basic nutrition facilities (drinking water, food, toilets) and essential healthcare facilities (Pourhosseini et al., 2015). Therefore, Healthcare management is one of the most crucial parts of any disaster management. Rapid advancements in medical technologies have inspired global health pioneers to work during catastrophic situations (Hadley et al., 2020). The recent improvements in the healthcare system apply AI as a powerful technology to positively contribute during the unprecedented time (Ghasemi et al., 2021). Dohale et al. (2022) and Lerch et al. (2022) highlighted that adopting AI technology help the firm to gain proactive and reactive capabilities. These capabilities further contribute towards building resilience by helping the firms to better resist and recover during the unprecedented time.

Disasters harm many people's health, cause loss of lives and cause psychological disorders (Pourhosseini et al., 2015). Any rise in disaster creates a heavy burden on the entire healthcare services. Improper transfer of victims can lead to injuries such as cardiac arrest, spinal cord injury, or even death. Hence a well-equipped emergency vehicles are necessary during disasters (Eliiyi, 2022). As a result, the demand for healthcare and medical needs increases. Meeting this high demand is important for any healthcare system. Healthcare organizations suffer a high level of uncertainty and chaos during disasters. The negative impacts of disasters on the environment stress the need for sustainability.In this context, the adoption of AI helps in preventing the huge destruction caused by disasters (Forbes, 2022). AI technologies are highly used in shaping the healthcare system (Chattu, 2021; Klumpp et al., 2021). AI technology is considered one of the significant pillars of Medical 4.0 (Haleem and Javaid, 2020) and has brought paradigm shifts in the healthcare industry (Awotunde et al., 2021; Yu et al., 2018).

Radanliev et al. (2022b) and Straw (2020) encore that AI is an opportunity for the healthcare industry through which companies can escalate their stake to a higher level and make a positive impact. According to Fortune Business Insights (2022), the global AI in healthcare market size was valued at USD 10.54 billion in 2021 and is projected to increase to USD 164,10 billion by 2029. Many healthcare organizations are getting benefited from the adoption of AI. For example, Microsoft Azure collaborated with Truveta Inc to develop a data-driven platform to work on a high scale globally. Alphabet Inc. collaborated with Isomorphic Labs to detect different ailments of multiple diseases using AI technology. Hewlett Packard Enterprise Company collaborated with Ayar Labs to open a data-based innovation center (Fortune Business Insights, 2022).

With the effective implementation of AI technology, there is a continuous improvement in the global healthcare system's quality, reach, access, and affordability (van der Schaar et al., 2021; Yigitcanlar and Cugurullo, 2020; Sarbadhikari and Pradhan, 2020; Haleem and Javaid, 2020). Therefore, in a highly uncertain and dynamic environment, AI technology provides many benefits (Hoppe et al., 2023; Ahsana and Siddique, 2022; Leimanis and Palkova, 2021). AI helps to provide primary and advanced treatment and medicines to the victims (Chee et al., 2021). In addition, it supports restoring normality. However, there are many challenges to the adoption of AI technology. The emergence of cyber risks threatens the adoption of AI technology (Radanliev et al., 2022a). Other challenges, such as lack of quality data, ethical issues, and lack of physicians understanding the AI-based systems, are observed by many past researchers (Beltempo et al., 2023; Joshua et al., 2022). But, looking at many benefits over challenges, the adoption of AI technology is increasing in the healthcare industry. Radanliev et al. (2022a) aim to promote the adaption of AI systems by creating a complementary between AI and cybersecurity.

The adoption of AI technology in healthcare has been highly observed during the recent COVID-19 pandemic for developing reliable healthcare systems (Shringare et al., 2023; Khamis et al., 2022; Kalina, 2022; Joshua et al., 2022; Zainal and Hamdan, 2022; ElGohary et al., 2022; Uddin et al., 2021). The healthcare system highly relies on accuracy and intelligence; therefore, implementing AI technology mitigates multiple problems (Shringare et al., 2023). Richie (2022) and Hadley et al. (2020) revealed that the application of AI to build a resilient and sustainable healthcare system goes beyond developed cities and extends healthcare support even to remote areas during disasters. AI technology deals with a large amount of healthcare data speed-up processes, and recognizes intricate patterns. AI contributes toward making the healthcare system to be resilient and sustainable. Therefore, AI helps in managing healthcare resources optimally, uses low energy consumption, reduces carbon footprints, saves energy, reduces losses, and saves more and more lives (Richie, 2022; Badidi, 2022; Sood et al., 2022; Hsu et al., 2021; Yigitcanlar and Cugurullo, 2020; Jung et al., 2018).

The importance of AI in healthcare management has drawn many researchers' interests across the globe (Capasso and Umbrello, 2022; Chee et al., 2021; Secinaro et al., 2021; Satpathy et al., 2021; Straw, 2020). The previous literature on AI applications in the healthcare sector is given in Appendix 2. Though these studies were conducted during different periods, the applications of AI in building resilient and sustainable healthcare systems were not the central ideas of these studies. Having seen a rise in disasters, we identify a clear gap in the AI literature to build a resilient and sustainable healthcare system. Since earlier literature did not address this dimension, providing a comprehensive understanding of the evolution of studies, nature of the analysis, research methodologies used, major publication outlets, and geographical orientation of the studies. Based on this context, our first research question is:

RQ1: How has the literature on AI application for the resilient and sustainable healthcare system evolved over the years?

Further, given the wide application of AI in healthcare, the extent of literature on AI technology in the context of a resilient and sustainable healthcare system is minimal and under-researched (Dasgupta et al., 2022; Chattu, 2021; van der Schaar et al., 2021; Milne-Ives et al., 2020). The recent literature has either only focused on the resilient healthcare system (Abdel-Basset et al., 2021; Sitharthan and Rajesh, 2021; Wang and Alexander, 2021; Leimanis and Palkova, 2021; Pascu-Gabara and Cepoi, 2021; Bansal et al., 2020) or the sustainable healthcare system (Richie 2022; Elavarasan et al., 2021; Rahman et al., 2021a; Mishra et al., 2021a; Ahmed et al., 2021; Hsu et al., 2021; Ahad et al., 2020; Yigitcanlar and Cugurullo, 2020). As a result, a combination of resilience and sustainability in the context of AI in healthcare is not yet discussed in any single work. To close this gap, our work aims to provide a research framework by addressing the research question as given below:

RQ2: How do AI applications contribute to building a resilient and sustainable healthcare system?

Our work focuses on how AI applications can help the healthcare system to be resilient and sustainable during disasters. Our study elaborates on the applications of AI in health services, health workforce, health information, medical technology, health financing, and health leadership and governance. Our work provides an extensive and detailed review of the state-of-the-art research conducted in AI technology and healthcare. In addition, we offer the extensive use of AI technology/techniques for the healthcare domain. Finally, our work examined the benefits of AI in building a resilient and sustainable healthcare system. The paper presents a multidimensional review of the factors that create significant technological, organizational, ethical, data, policy, political and legal challenges for AI adoption. Unlike the previous systematic reviews (Parviainen and Rantala, 2021; Wang and Alexander, 2021; Pascu-Gabara and Cepoi, 2021; Ahad et al., 2020; Haleem and Javaid, 2020; Angioni, and Musso 2020; Sonnessa et al., 2017), the authors use the extended antecedents, practices, and outcome themes to provide a novel research framework drawn from the systematic literature review. We also observed that past studies lack in proving future research directions using any framework (Elavarasan et al., 2021; Hsu et al., 2021; Wang and Wu, 2021; Islam et al., 2021; Haleem and Javaid, 2020; Sarbadhikari and Pradhan, 2020; Berquedich et al., 2020). Therefore, to fill this gap, our study uses the theory, methodology and context framework for providing future research directions. Hence, our study stands different from past literature by conducting an in-depth investigation of the applications of AI to build a resilient and sustainable healthcare system. Our study provides fresh insights into AI adoption in healthcare literature. Further, the manuscript has been organized into four sections. Section 2 discusses the research methodology. Section 3 examines the research findings. Section 4 presents the research framework, current trends, and future research directions. Section 5 provides the conclusion and implications of the study.

2. RESEARCH METHODOLOGY

Following the guidelines of Behera et al. (2019), our study has used a systematic literature review approach. The systematic literature review is selected because it helps in carefully identifying and synthesizing the relevant literature (Palmatier et al., 2018). We aim to initially understand how AI technology in the healthcare industry has evolved over the years and then examine how AI technology contributes to a resilient and sustainable healthcare system. Our study has conducted a three-step systematic literature review suggested by Behera et al. (2019). Step 1 focuses on planning and performing the review protocol. Step 2 highlights practical screening criteria. Step 3 focuses on reporting the findings.

Step 1: Planning and Conducting the review protocol

Our study begins with a wide range of literature searches in databases such as Scopus and Web of Science (WoS). Pranckutė (2021) highlights that the Web of Science and Scopus are the two most trusted and reliable extensive databases in the field of academia. Web of Science is one of the largest database platforms, with a collection of more than 21,100 peer-reviewed and high-quality scholarly journals across multiple disciplines (WoS, 2022). Scopus also has a high-quality research coverage of more than 84 million records published worldwide across various disciplines (Elsevier 2022a, 2022b). The WoS and Scopus databases provide relevant literature from different domains and cover the highest cited literature annually (Pranckutė 2021).

According to Sassanelli et al. (2019) and Merli et al. (2018), Scopus and WoS are the most used databases in management studies.

To get a broader perspective of the topic, different keywords were used, such as "Artificial Intelligence," "AI," "healthcare supply chain," "healthcare industry," "healthcare sector," "resilience," "sustainability," and "COVID19", "COVID-19", "Pandemic," both in the Scopus and WoS databases using "OR" and "AND" string commands in the title, abstract and the keywords section. The same string commands were used in the Scopus and WoS databases. We wanted to cover the widespread application of AI; hence we have used AI and artificial intelligence as the keywords during the search rather than using the keywords such as "deep learning," "machine learning," and "neural networks." However, our study summarizes the studies using the technologies coming under the umbrella of AI. The selection of subject areas was essential to focus on business management and the healthcare domain. Therefore, the subject areas selected from the Scopus database are Social Science, Business Management, and Decision Science. In contrast, the WoS database's assigned subject areas are Health Care Science Services, Computer Science, Operations Research Management Science, and Social Science Other Topics. Although no filter was used for the time frame, considering the discussed keywords and limitations, the study's time frame comes up to 26th September 2022.

Step 2: Practical Screening Criteria

Newbert (2007) highlighted that peer-reviewed journals were selected to maintain the quality control of search results and enhance the rigorous process. This eliminates the fewer rigorous articles, excluding, thus, the conference papers, book chapters, and grey literature (Tranfield et al., 2013). Furthermore, only documents published in the English language were considered. We used Zotero online tool to remove duplicate files. We initially combined the two different database files in the Zotero online tool, and then 23 duplicate entries were eliminated. Further, to maintain the scope and boundary of the research, documents were eliminated after reading the articles' abstracts, which did not focus on healthcare, sustainability, or resilience. The articles not discussing much AI technology were also eliminated. We included only those articles focusing on artificial intelligence and resilience or artificial intelligence and sustainability in the healthcare domain. The articles discussing the applications, benefits, or challenges of AI during the COVID-19 pandemic were also considered. The COVID-19 pandemic is a recent disaster (Seddighi, 2020) that disrupted many lives and severely affected the global healthcare system (KPMG, 2022; UN, 2022). Finally, (n=89, Appendix 1) documents were regarded as "fit for the purpose" of our study and "relevant" to the subject matter. The detailed selection criteria are presented in Figure 1.

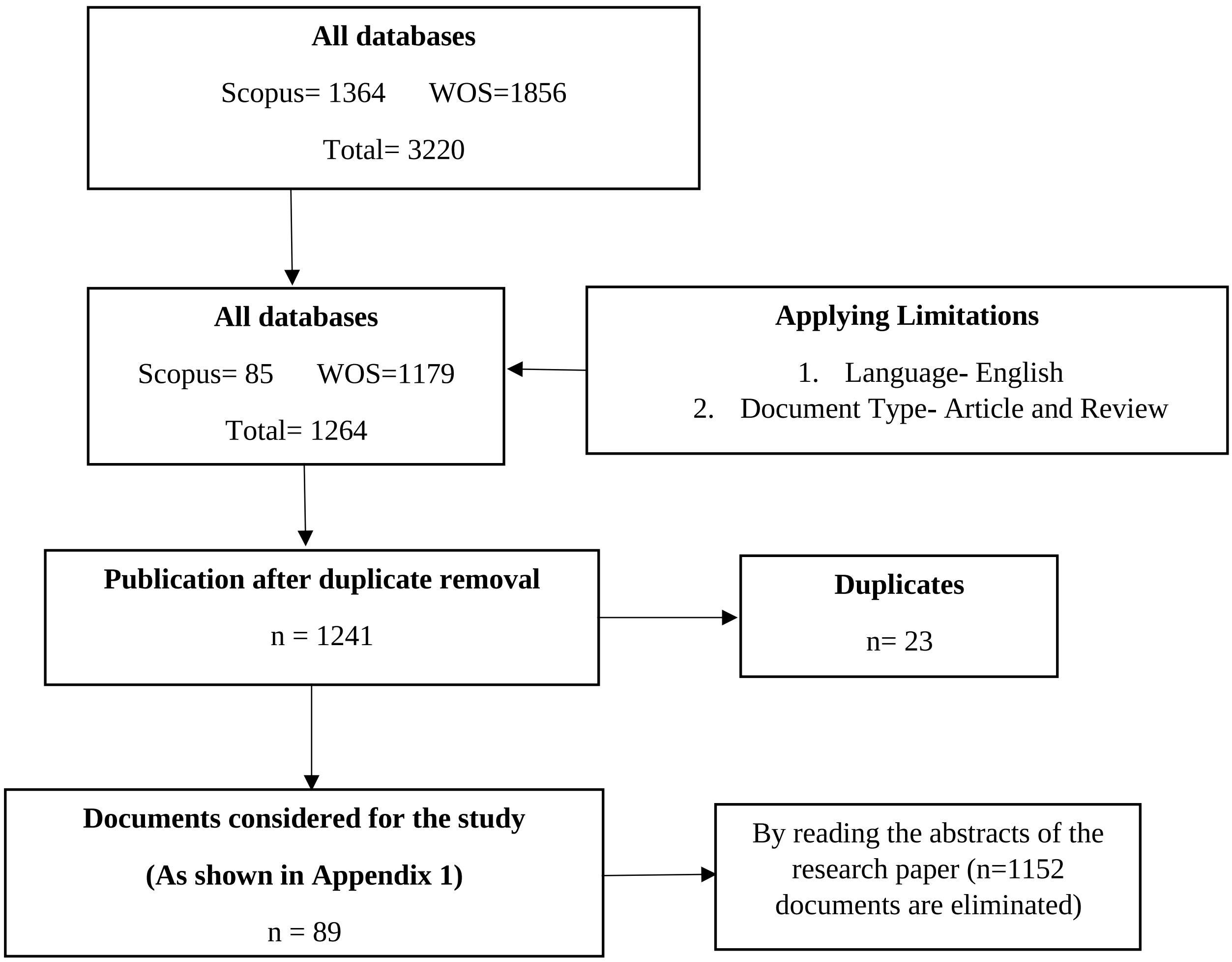

FIGURE 1: Search criteria for systematic literature review (as of September 26th, 2022)

3. RESEARCH FINDINGS

3.1 Descriptive Analysis

Descriptive analysis along with a systematic literature review, helps to present the knowledge in a comprehensive yet in-depth manner. The analysis-synthesis the knowledge that encapsulates the journey of AI in the healthcare domain and explores how AI applications can help build resilient and sustainable healthcare. The 89 documents were deeply analyzed for the present systematic literature review. In the first part, specific characteristics such as year-wise classification, the type of the study, research methods used, the count of authors, the geographical location based on the first author's institutional location, and the data collection method followed in the reviewed articles were extracted from the papers. The second part aimed at looking at more in-depth content and focusing on the reviewed papers. Hence, it discusses the themes of AI's applications, benefits, and challenges to building a resilient and sustainable healthcare system. The articles published in the AI, resilient, sustainable, and healthcare system drew initial attention in 2017 and have shown a markable growth after 2019 (see Appendix 4). 31.46% and 47.19 % of the reviewed articles were published in 2020 and 2021, respectively. Only 10.11% of the reviewed articles were published till 26th September 2022, with prospects for more studies to occur soon. The 2020 and 2021 results highlight an increase in papers published on the topic; the result could be due to the COVID-19 pandemic and the possibility of the study in the resilient healthcare system. However, the results of 2022 are partial, as only the initial eight months of the year are considered. The type of publication (see Appendix 5) was mainly a literature review (constituting 51.80%) followed by 42.16% quantitative study, 2.40% mixed study consisting of both qualitative and quantitative research, and 3.61% following the qualitative analysis.

Several research methodologies (Appendix 6) were exhibited in the 89 articles. Out of the 89 articles, 51.80% of the studies followed a review methodology, 14.45% followed conceptual methods, 9.63% conducted experimentation and modelling, 8.43% completed case studies, and 6.02% followed a survey method. A good percentage (92.1%) of the reviewed articles result from the collaboration between several authors (papers with more than one author). Rest, 7.86% of studies are single-authored. Our study's geographical orientation (see Appendix 7) is built on the first author's institutional location. 15.73% of reviewed articles were published in India, followed by 14.61% and 6.74% of articles from the USA and China, respectively. The data collection method (see Appendix 8) used in the reviewed articles shows that 51.804% of review papers have collected data from various databases such as Scopus or WoS, etc., 39.75% uses secondary databases (such as government data, industry datasets, etc.), and 4.81% uses questionnaire and 3.61% uses interview method. The significant publications- 7.87% coming dedicatedly from the journal "Sustainability" followed by 6.74% from "Sustainable Cities and Society" and "Healthcare" each.

3.2 Thematic Analysis

This section highlights the major themes and is divided into three sub-sections. First, section 3.2.1 discusses the applications, sections 3.2.2 and 3.2.3 elaborate on the role of AI for resilient and sustainable healthcare systems respectively, and section 3.2.4 illustrates the challenges of AI technologies for a resilient and sustainable healthcare system.

3.2.1 Applications of AI in Healthcare Systems

The traditional healthcare systems are now changing and aiming to provide complete care to the patient's physical, economic, social, emotional, and spiritual needs (Capasso and Umbrello, 2022). In our study, AI applications in the healthcare system have been observed across the six-health system building blocks. These building blocks of the healthcare system are adapted from the WHO conceptual framework (KPMG, 2022; WHO, 2010). The six- health system building blocks are: 1) Health services, 2) Health workforce, 3) Health information, 4) Medical technologies, 5) Health finance, and 6) Leadership and governance. The application of AI under these six building blocks is discussed in Table 1. The application of AI in health services has been observed as meeting patients' needs and improving health services delivery. The health workforce discusses providing the resources and reducing the burden on healthcare stakeholders using AI applications. AI in health information encore in shifting the traditional reactive healthcare models to proactive models using medical data and technology advancements. AI in medical technology discusses the recent developments in the healthcare systems to meet medical needs. Health finance examines healthcare schemes in a subsidized manner using AI applications to get the maximum benefit and ensure transparency. AI in leadership and governance describes the application of AI for a better understanding of medical needs from citizens' perspectives. It further elaborates on how AI can be used to fulfil healthcare goals and provide positive results.

Table 1: Application of AI in Healthcare System

Application of AI across the six-healthcare system building blocks	**Descriptions**	**References**
AI in Health Services	• Telemedicine	Wang et al., (2021a); Wang and Alexander (2021); Mishra et al., (2021a); Tan et al., (2020); Sarbadhikari and Pradhan, 2020; Scott et al., (2020)
	• Online consultations	Klumpp et al., (2021); Parviainen and Rantala, (2021); Li et al., (2021)
	• Automating healthcare services	Wang and Wu, (2021); Babic et al., (2021); Parviainen and Rantala (2021); Umbrello et al., (2021); Ahuja et al., (2020); Saba et al., (2019)
	• Replaces the routine tasks- digital assistance	Mishra et al., (2021a); Rahman et al., (2021b); Klumpp et al., (2021); Sharma et al., (2020);

		Parviainen and Rantala, (2021); Li et al., (2021)
	• Communication improvement- healthcare stakeholders	Klumpp et al., (2021); Battineni et al., (2020)
	• Personalized treatment and care	Chattu (2021); Hsu et al., (2021); Wang and Wu (2021)
	• AI-based robots- Transferring essential and non-essential items	Rahman et al., (2021a); Wang and Wu (2021); Umbrello et al., (2021); Adly et al., (2020)
	• AI-based robots- Assistance during critical surgeries	Richie (2022); Klumpp et al., (2021); Secinaro et al., (2021); Zemmar et al., (2020); Haleem and Javaid, (2020); Coombs (2020)
	• Improves service execution accuracy and time	Shankar et al., (2021); Ahuja et al., (2020); Adly et al., (2020); Loey et al., (2020)
AI in Health Workforce	• Automates the repetitive tasks (reduces the unnecessary burden in the healthcare workforce)	Rahman et al., (2021a); Sharma et al., (2020); Vaishya et al., (2020); Naseem et al., (2020); Sun et al., (2019)
	• Updates the healthcare and medical information instantly	Popkova and Sergi, (2022); Secinaro et al., (2021); Elleuch et al., (2021); Islam et al., (2021); Scott et al., (2020)
AI in Health Information	• The electronic record of medical data (including past health records)	Chattu (2021); Sun et al., (2019)
	• Remote access of the health information to the doctors, patients, and administration	Chattu (2021); Leimanis and Palkova (2021); Mishra et al., (2021a); Gunasekeran et al., (2021); Hoffman (2020); Angioni and Musso (2020); Sarbadhikari and Pradhan (2020); Phillips et al., (2018)
	• Improves knowledge management activities	Wang and Wu, (2021); Jung et al., (2018)
	• Health risk alerts	Klumpp et al., (2021); Adly et al., (2020)
	• Clinical decisions	Chattu (2021); Secinaro et al., (2021)
	• Meaningful healthcare information to government officials and healthcare staff	Khan et al., (2021) Haleem and Javaid, (2020); Ahuja et al., (2020); Szolovits, (2019); Sun et al., (2019)
AI in Medical Technology	• Real-time information	Popkova and Sergi (2022); Islam et al., (2021); Elleuch et al., (2021); Haleem and Javaid (2020)
	• Health outcomes prediction	Dasgupta et al., (2022); Chattu (2021); Klumpp et al., (2021); Naseem et al., (2020)
	• Drug discovery and development	Peng et al., (2022); Dasgupta et al., (2022); Chattu (2021); Vaishya et al., (2020); Adly et al., (2020); Naseem et al., (2020)
	• Vaccine development	Rahman et al., (2021b); Sarbadhikari and Pradhan (2020); Ren et al., (2020); Vaishya et al., (2020); Haleem and Javaid, (2020); Coombs (2020); Bansal et al., (2020)
	• Timely health data processing and analysis	Rahman et al., (2021a); Klumpp et al., (2021); Secinaro et al., (2021)
	• It makes the tasks more effective and robust in terms of computational speed and efficiency	Alahmari et al., (2022); Klumpp et al., (2021); Hsu et al., (2021); Baker et al., (2021); Rahman and Hossain, (2021); Tan et al., (2020); Sun et al., (2019); Brunetti et al., (2018)
	• AI-based Chatbots- digital assistance to the patients (booking appointments, making the payment process smoother, answering queries)	Milne-Ives et al., (2020); Parviainen and Rantala, (2021); Battineni et al., (2020); Coombs, (2020)
AI in Health Finance	• Helps the patients in finding the best public or private insurance providers	Aerts and Bogdan-Martin (2021); Ho et al., (2020); Sonnessa et al., (2017)

	• It helps to combine the reimbursement schemes to get the maximum benefit	Aerts and Bogdan-Martin (2021); Ho et al., (2020)
AI in Leadership and Governance	• It helps the government to cope with the complex changing environment	Kankanhalli et al., (2019); Sun et al., (2019)
	• Encourages innovative practices in the healthcare system	Pascu-Gabara and Cepoi (2021); Wang and Wu (2021)
	• Manages individual data on government databases	Rahman et al., (2021a); Khan et al., (2021)
	• It helps the government for surveillance purposes	Badidi (2022); Sood et al., (2022); Chattu (2021); Angioni and Musso (2020); Ho et al., (2020); Scott et al., (2020); Naseem et al., (2020)
	• AI chatbots help in improving communication between citizens and governments	Secinaro et al., (2021); Battineni et al., (2020)
	• It helps to streamline the government's administrative burden in the healthcare system	Klumpp et al., (2021); Battineni et al., (2020); Sun et al., (2019)
	• AI-based statistical models help government authorities to conduct decision-making processes	Wang and Wu, (2021); Islam et al., (2021); Nasseef et al., (2021); Ahad et al., (2020); Lalmuanawma et al., (2020); Sun et al., (2019); Jung et al., (2018)

AI is an umbrella of technologies consisting of machine learning, deep learning, expert systems, computational intelligence, robotics, neural networks, and decision support systems. Reviewed articles (see Appendix 3) provide an in-depth purpose of using AI technology and techniques in different healthcare segments. For example, chat bots were highly used during the COVID-19 pandemic as social distancing was followed. It has also been found that AI is widely used for radiology and healthcare data management. Most AI models revolved around detecting, diagnosing, treating, forecasting, monitoring, and tracking COVID-19 infections.

3.2.2 AI for the resilient healthcare system

Due to the unpredictable nature of disasters, healthcare systems need to be resilient. Resilience helps to cope with the uncertainties of a complex environment. After any disaster, resilience determines the time to come back to normalcy. Wiig et al. (2020) highlighted that resilient healthcare is expected to withstand disruptive events and consistently deliver high-quality care. Nasseef et al. (2021) and Munawar et al. (2021) observed that AI techniques reinforce and complement resilience strategies. For building a resilient healthcare system, detecting the early warning of uncertainty is essential, and AI-based models help identify those early warning signals. In the recent wake of the COVID-19 pandemic, AI technology allows for the early detection, diagnosis, classification, treatment, and prevention of diseases (Peng et al., 2022;

Ogiela and Ogiela, 2021; He et al., 2021; Al-antari et al., 2021; Xue et al., 2021; Greenspana et al., 2020; Vaishya et al., 2020).

Disasters like floods, virus outbreaks, and earthquakes shatter internal and external healthcare stakeholders. Managing and coping with internal and external shocks is essential to build a resilient healthcare system. AI technology reduces the process execution time for multiple operations (Loey et al., 2020), thereby identifying the process execution loopholes (Sharma et al., 2021; Li et al., 2021). AI techniques stress developing adaptive systems to meet the changing requirements over time. Disaster causes significant loss of lives; therefore, meeting medical needs during disaster becomes necessary. AI applications help in the effective management of medical drugs and medical equipment and identify and fulfil the supply and demand signals (Ying et al., 2020; Lai et al., 2020). AI devices help to keep track of the patient's medical history (Chattu, 2021; Berquedich et al., 2020).

Managing relief operations requires coordination and collaboration among different parties to provide the necessary items to the disaster victims. AI positively contributes to factors that affect resilience and helps in knowledge sharing, information sharing, collaboration, transparency, and increasing responsiveness (Abdel-Basset et al., 2021; Secinaro et al., 2021; Ahad et al., 2020; Lalmuanawma et al., 2020). Because of AI's dynamic capabilities, it helps in enhancing the healthcare decision-making process (Wang and Wu, 2021; Islam et al., 2021; Lai et al., 2020; Jung et al., 2018). Improving the internal and external healthcare operations during disasters positively contributes to improving the overall efficiency of the healthcare system (Ahsana and Siddique, 2022).

3.2.3 AI for the sustainable healthcare system

The destruction caused by disasters teaches the importance of sustainability. Disasters and sustainability are directly or indirectly linked to each other. Alahmari et al. (2022) observed that climate change, a threat to the environment, is proof that the planet's condition is deteriorating daily. The rise in temperatures, increasing pollution, growing populations, and increasing urbanization are decreasing sustainability and parallel giving rise to different types of global disasters. These threats are simultaneously deteriorating the citizens' psychological and physical health. In order to reduce the damage to the environment, there is a need for innovation among the healthcare stakeholders to understand and provide solutions, information, services, and community support structure for timely disease prevention and cure (Yigitcanlar and Cugurullo, 2020).

Ahad et al. (2020) highlighted that AI technology is one of the sustainability-enabled technologies. Muhammad et al. (2021) encore the importance of a sustainable city as it is directly related to providing many health-related benefits. A highly polluted city, especially in a densely populated urban town, causes adverse effects on people's lives and leads to chronic related diseases (Alahmari et al., 2022). Sustainability has different dimensions and can be analyzed through different modes and channels. For example, from a social perspective, sustainability can be achieved by developing a healthcare system that benefits all stakeholders, such as healthcare institutions, doctors, government, and patients. The abnormal conditions, emergencies, and extreme conditions caused by disaster demolishes the traditional healthcare information flow. But, recent AI technological developments have made it possible to share the sensory data from the health sensors with remote doctors, to get the results and feedback of the reports or diseases in a few milliseconds (Alahmari et al., 2022; Rahman et al., 2021a).

AI algorithms support healthcare services by providing accurate results in the healthcare ecosystems, irrespective of geographical distances and locations (Hossain et al. 2019). AI offers remote access and control to doctors and patients (Gunasekeran et al., 2021; Sarbadhikari and Pradhan, 2020) and improves the accessibility of healthcare data and healthcare services (Wang and Wu, 2021; Khan et al., 2021). Richie (2022) and Zahid et al. (2021) highlighted that sustainable healthcare focuses on boosting and restoring public health parameters, thereby reducing the negative impacts on a sustainable city's social, environmental, and economic elements. Chattu (2021) revealed that AI technology has a lot of potential to improve the healthcare system, especially in low-resource areas. AI helps in accurate forecasting (Serte et al., 2022; Comito and Pizzuti, 2022; Tariq et al., 2021), which further leads to resource optimization (Peng et al., 2022; Sood et al., 2022; Haleem and Javaid, 2020; Adly et al., 2020). Remote care access to doctors and resource optimization contributes to building a sustainable healthcare system.

3.2.4 Challenges of AI in Healthcare Systems

The adoption of AI technology in the healthcare system comes with significant challenges. These challenges are discussed in this section. Chattu (2021) highlighted that the healthcare system adopting AI technology is still in the infancy stage, and many difficulties must be tackled. Not all healthcare organizations have adopted AI technology, and the reason behind the low adoption rate is the challenges faced by healthcare firms (Dasgupta et al., 2022;

Klumpp et al., 2021; Greenspana et al., 2020; Sun et al., 2019). The significant challenges faced by the firms are the top management support regarding the IT infrastructure, low investments, the mismatch between the human goals and machine output, and lack of accountability (Ahsana and Siddique, 2022). In addition, there are multiple technological challenges during the adoption, such as the difficulty in algorithm readiness and the lack of technology vendors (Secinaro et al., 2021; Aerts and Bogdan-Martin, 2021; Ahad et al., 2020). Zahid et al. (2021) highlighted that the digital healthcare environment demands transparency, data privacy, compatibility, data manipulation, user-centric design, data security, scalability, and interoperability. Mishra et al. (2021a) highlighted that the traditional manual procedures and delays in functionalities hinder AI technology adoption. The lack of a skilled workforce is one of the significant challenges in adopting AI technology. Previous literature encores the need for proper training and education for the rapid adoption of AI technology (Haleem and Javaid, 2020; Sarbadhikari and Pradhan, 2020; Laudanski et al., 2020). Lack of government support, policies, regulatory framework, and incentives is another major challenge the organization faces in adopting AI (Leimanis and Palkova, 2021; Aerts and Bogdan-Martin, 2021; Hoffman, 2020; Sarbadhikari and Pradhan, 2020). Further, the challenges of AI in the healthcare system are discussed in depth in Table 2.

Table 2: Challenges of AI applications in Healthcare Systems

Challenges of AI in Healthcare Systems	Description of challenges	References
Technological Challenges	• Interoperability and Scalability issues	Zahid et al. (2021); Hoffman (2020); Scott et al. (2020)
	• Complex interconnected systems	Straw (2020); Sarbadhikari and Pradhan (2020)
	• Lack of technology vendors	Aerts and Bogdan-Martin (2021)
	• Misuse of Technology	Unberath et al., (2020)
	• Difficulty in readiness of algorithms	Secinaro et al., (2021); Unberath et al., (2020)
Organizational Challenges	• Lack of Top Management Support	Alahmari et al., (2022); Klumpp et al., (2021)
	• Lack of investments	Ahsana and Siddique (2022); Alahmari et al., (2022); Aerts and Bogdan-Martin (2021); Klumpp et al., (2021); Naseem et al., (2020)
	• Lack of stakeholder engagements	Rahman et al., (2021a,b); Sun et al., (2019)
	• Lack of innovation, research, and development	Ahsana and Siddique (2022); Klumpp et al., (2021)
	• Lack of accountability	Sun et al. (2019)
	• Lack of skilled workforce	Mishra et al., (2021a); Aerts and Bogdan-Martin (2021); Angioni and Musso, (2020)

	• Lack of performance evaluation standards while using AI technology	Secinaro et al., (2021); Laudanski et al., (2020)
Ethical Challenges	• Privacy and Security Breaches	Badidi (2022); Rahman et al., (2021b); Ghayvat et al., (2021); Sarbadhikari and Pradhan (2020); Haleem and Javaid, (2020); Min et al., (2019); Kankanhalli et al., (2019)
	• Lack of trust and transparency	Ahsana and Siddique (2022); Klumpp et al., (2021); McGreevey et al. (2020); Hoffman (2020); Kumar et al., (2020); Unberath et al., (2020); Laudanski et al., (2020); Sun et al., (2019)
Data Challenges	• Lack of quality data	Peng et al., (2022); Popkova and Sergi (2022); Zahid et al., (2021); Yigitcanlar and Cugurullo (2020)
	• Lack of data integration	Larsson and Heintz (2020); Sun et al., (2019)
Policy, Political and Legal Challenges	• Lack of government support for the adoption of new technologies	Capasso and Umbrello, (2022); Kumar et al., (2020); Sun et al., (2019)
	• Lack of Government Policies and Incentives	Alahmari et al., (2022); Klumpp et al., (2021); Mrówczyńska et al., (2019)
	• Lack of government-defined industry standards for using AI	Babic et al., (2021); Laudanski et al., (2020)
	• Political influences	Mrówczyńska et al., (2019); Sun et al., (2019)

4. Research Framework, Current Trends, and Future Research Directions

4.1 Research Framework for AI applications

This section presents a research framework based on the findings of thematic analysis of AI applications in building a resilient and sustainable healthcare system in detail. Our study has adopted the extended Antecedents, Practices, and Outcome (APO) framework to analyze the key themes. The APO framework originated from the Antecedent-Behaviour-Consequence (ABC) model, derived from the behavioural analysis branch of Psychology. The ABC model is used to understand the general and organizational behaviour induced by the antecedents, behaviours, and consequences (Nijhof and Rietdijk, 1999). In addition, the ABC model is widely used in management research as it helps to discover the functional relationship between the behaviour and control variables (Skinner, 1966). In AI adoption, Yu et al. (2022) study the antecedents and consequences. Furthermore, Baabdullah et al. (2021) examine antecedents and consequences to understand AI-based business-to-business practices.

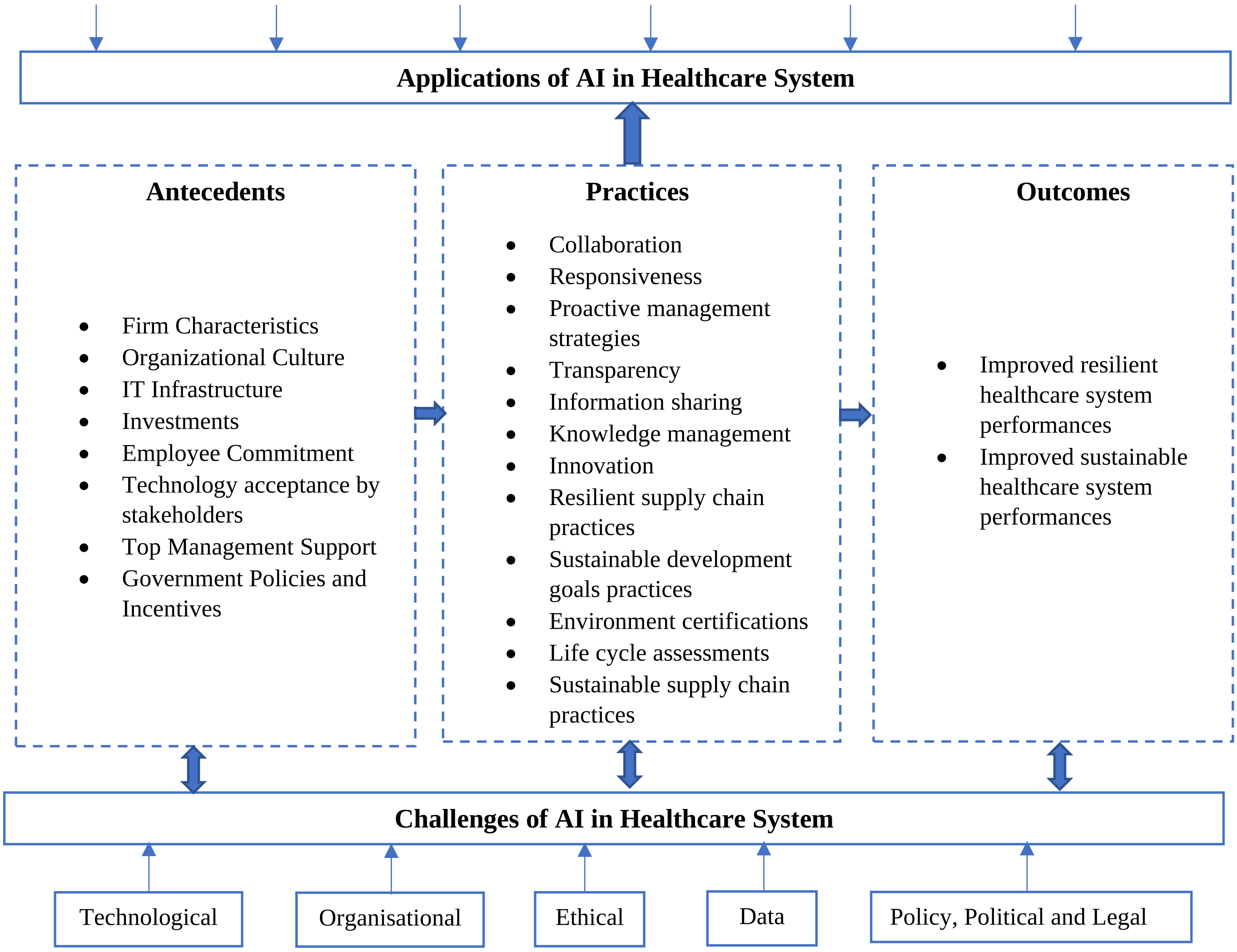

Figure 2: Research Framework based on extended APO for AI Application for building a resilient and sustainable healthcare system

Our study has extended the APO framework using applications and challenges for the adoption of AI in the healthcare system. Based on this study, we propose a research framework based on extended APO for AI applications to build a resilient and sustainable healthcare system (Figure 2). The framework describes the antecedents, practices, and outcomes of the application of AI in the healthcare system. Antecedents are driving factors for practices, leading to the outcomes. The framework elaborates on the applications and challenges of AI in the healthcare system. According to the literature discussed, the main antecedents include the top management support needed for adopting AI technology in a healthcare firm (Alahmari et al., 2022; Klumpp et al., 2021). IT infrastructure facilities must adopt AI technology, including hardware and software support. The infrastructure should support the timely information flow across the healthcare system. Lack of information sharing results in the rise of uncertainty during any disaster. Information sharing helps in making operations more efficient and effective. It further helps to gain a competitive advantage for many healthcare firms. The IT infrastructure should secure the environment and maintain privacy and security (Kumar et al., 2020). Organizational culture, firm characteristics, and employee commitments highlight how AI technology is accepted at the organizational level (Ahsana and Siddique, 2022; Alahmari et al., 2022; Aerts and Bogdan-Martin, 2021). Investments and government policies motivate the adoption of AI technology in a healthcare system (Capasso and Umbrello, 2022). Klumpp et al. (2021) encore making research and development investments encouraging firms to adopt AI. The adoption of AI in firms provides a competitive advantage (Rahman et al.,2021b). However, at the same time, it creates pressure on the firms lacking behind this adoption. Thus, top management support is essential to facilitate the adoption of AI practices in the healthcare system. Therefore, in this context, the following proposition is established:

Proposition 1: Pressure from the market will motivate top management to support antecedents such as IT infrastructure development and investments in R&D to facilitate the adoption of AI practices in the healthcare sector.

As stated by the literature review results, it is found that the adoption of AI across different functions of the healthcare system, such as health service, health workforce, health information, medical technology, health finance, health leadership, and governance, changes the working pattern of the traditional healthcare system. However, various healthcare processes still lack the adoption of AI (Ahsana and Siddique, 2022). During any disaster, any healthcare system's primary responsibility is to save more individuals and speed up its operations. AI technology helps in speeding up healthcare operations. The practices such as collaboration, responsiveness, transparency, and knowledge management can contribute to adopting AI across different processes, which further contributes to the resilience and sustainability of a healthcare system (Wang and Wu, 2021; Jung et al., 2018). Collaboration among firms is essential to building a resilient and sustainable healthcare system. Collaboration and Knowledge sharing help increase visibility and decrease uncertainty, which results in a resilient healthcare system. Collaborating with firms focusing on sustainable practices, working towards sustainable development goals, practising life cycle assessments, and having environment certifications positively contribute towards a sustainable healthcare system. In addition, Sun et al. (2019) revealed that AI applications are the enablers for increasing the efficiency and effectiveness of different processes. These processes are believed to contribute positively to the resilience and sustainability of the healthcare system. Proposition 2 is thus outlined in the context:

Proposition 2: Adopting AI across different processes will improve the resilience and sustainability of the healthcare sector.

The wide applications of AI provide several benefits to the healthcare stakeholders such as patients, medical experts, doctors, pharmacists, and hospital healthcare professionals in numerous ways. For example, in the sample of articles studied, it is found that using AI creates new experiences for healthcare stakeholders (Dasgupta et al., 2022; Parviainen and Rantala, 2021; Battineni et al., 2020; Berquedich et al., 2020; Milne-Ives et al., 2020). This may be because the application of AI is cost-effective (Khan et al., 2021; Aerts and Bogdan-Martin, 2021); provides remote access to health data (Leimanis and Palkova, 2021; Mishra et al., 2021a; Gunasekeran et al., 2021); remote care to the patients (Angioni and Musso, 2020; Sarbadhikari and Pradhan, 2020); automates the repetitive tasks (Rahman et al., 2021a; Sharma et al., 2020); reduces the administrative burden (Klumpp et al., 2021; Sun et al., 2019); reduces medical and human error (Peng et al., 2022; Islam et al., 2021; Yigitcanlar and Cugurullo, 2020); saves time (Li et al., 2021; Loey et al., 2020). Thus proposition three is defined as:

Proposition 3: Healthcare firms adopting AI technology can create better experiences for healthcare stakeholders.

4.2 Current Trends and Future Research Directions

The present section reveals the current trends and identifies relevant questions which can be taken up in future studies. The result of the present study highlights significant marking trends that have emerged from the systematic literature review conducted to understand the role of AI technology in building a resilient and sustainable healthcare system. Given the field's recency, the majority of the early work focused on conceptualizing the AI models for monitoring (Rahman et al., 2021a), detection (Mishra et al., 2021; Pathan et al., 2021; Dutta et al., 2020), controlling (Sim and Cho, 2021), creating awareness (Jung et al., 2018), classifying (Xu et al., 2021), diagnosis (Sait et al., 2021; Lorencin et al., 2021; Almalki et al., 2021; Battineni et al., 2020) of diseases. The possible reason behind this trend is the emergence of the COVID-19 pandemic. The havoc and life-threatening disease of COVID-19 have made the need for the development of AI models for monitoring, controlling, detecting diagnoses, and creating awareness of the diseases.

Many studies have conducted reviews to understand the role of AI in different healthcare domains. The AI technology applications (Table 1) can be observed across the healthcare system. The benefits of AI technology can be experienced by all the healthcare stakeholders, such as patients, doctors, hospital administration, and medical departments. The multiple benefits of AI technology in healthcare have drawn the attention of many researchers in this field. Hence, a significant increase in research is observed in this area (Figure 2). One of the possible reasons behind this is the increasing number of medical emergencies and the initial stage of AI adoption in the fourth industrial revolution. The adoption of AI is changing the working patterns of the healthcare system by revolutionizing daily healthcare operations. Our study reveals that the adoption of AI is observed mainly across healthcare departments such as Radiology, Surgery, Medical, Research, and Development. On the other hand, many healthcare firms lack the adoption of AI technology, mainly because of the organizational, technical, ethical, data, policy, political and legal challenges (Table 2).

4.2.1 Future Research Directions

Our study aims to provide a foundation for researchers focusing on AI in the healthcare system. Furthermore, our research findings in the AI field open up new avenues for future researchers. In particular, our study uses the Theory, Methodology, and Context (TMC) framework to provide the future research direction. The TMC framework was previously adopted by various past researchers (Mishra et al., 2021b; Paul, 2019).

4.2.1.1 Future Directions- Theory

The existing literature review highly lacks using the theory for the adoption of AI to build a resilient and sustainable healthcare system. Based on our findings, out of 89 reviewed articles, only one article used the theory in their work. Neutrosophic Theory is used by Sonnessa et al. (2017). Hence future work must adopt theories that can focus on how more healthcare firms can adopt AI technology. Our attention is limited to the current theoretical underpinnings in the area focused on this study. There is a need to establish the link with traditional theories. Therefore, future researchers can work on using resource-based, dynamic capability, game, technology advancement, and systems theories. For example, we couldn't identify a single work that links AI adoption in healthcare firms using the resource-based or dynamic capability theory. The adoption of a resource-based, dynamic capability or game theory is important because disasters are unprecedented events, and therefore, healthcare organizations must maintain their resources over time to gain a competitive advantage. The applications of AI in health services, workforce, information, medical technologies, finance, leadership, and governance are the central themes under AI in healthcare literature. Therefore, future studies can answer how might a dynamic capability or a resource-based approach be used throughout a healthcare firm's different functional areas, especially during any disaster. In addition, and further study is needed to build theories connected to AI technologies research to comprehend and handle a variety of difficulties under these themes from either customer's perspective, which in this case is majorly the patient's, or the organization's perspective.

Future studies can build a strong foundation of well-established theories to understand "how" and "why" organizational resources or market competition encourages the adoption of AI technology across the healthcare sector. Diffusion of innovation theory, for example, can provide more insights into the current context, explaining the factors that impact the customer's or organization's behaviour and motivation, respectively. Furthermore, future researchers can focus on how AI technology can be initially adopted in one healthcare segment and further can be expanded to other healthcare segments. It is also suggested that a longitudinal study be conducted to confirm the phenomenon behaviour over time. For example, has the adoption of AI technology in healthcare increased after the COVID-19 pandemic? Was the adoption helped the firm to build a resilient and sustainable healthcare system? It is also recommended that the results obtained should be compared with different economic segments.

Further, future studies can test, modify and advance the information systems model to explain the patient's intention to use AI-based healthcare services. Additionally, the decision-making process, performance improvement, innovation, and technological improvements are the elements that can be examined to offer further information to ensure a seamless experience. For example, how can the organization information processing theory be linked with the AI technology adoption behaviour with enhanced firm performance?

4.2.1.2 Future Directions- Context

As discussed, the applications of AI to build a resilient and sustainable healthcare system, its benefits, and challenges. The findings of our study reveal that despite having numerous applications and benefits of AI, its adoption is still significantly less among healthcare firms. Therefore, the factors impacting the AI adoption strategies for the healthcare industry can be studied further. Future studies should focus on how the technical, organizational, ethical, data, policy, political and legal challenges should be minimized. Future studies can conduct qualitative and quantitative analyses to drill down the applications and benefits discussed in this work. Case studies can be undertaken to understand the healthcare firms already adopting AI technology. Such used case scenarios will be helpful for healthcare firms yet to adopt AI technology. Future studies can enhance the cooperation between AI and human physicians to benefit from adopting AI technology. Future studies can focus on how adopting AI helps gain a competitive advantage.

Future studies can also conduct on how healthcare firms can achieve Sustainable Development Goals (SDG). Future studies can address how healthcare systems might be redesigned using AI technology to promote SDG goals. The propositions derived from the application of AI using the extended APO framework for building a resilient and sustainable healthcare system are developed to guide future research, which can be further tested in future works. Our study reveals that AI technology can improve healthcare service quality and customer satisfaction remains unexplored. Therefore, Future researchers can answer how the new AI business models in the healthcare sector can be used to improve service quality and customer satisfaction. Our findings state that the government sector's AI is still nascent. Future studies can be conducted to understand what values the adoption of AI technology adds to the healthcare sector. The value adoption can be studied in general and in the context of unprecedented times. Future studies can also focus on different AI technologies, such as machine learning, deep learning, and artificial neural networks, to understand how these technologies can increase the efficiency of the healthcare system.

4.2.1.3 Future Directions- Methodology

Findings from our study reveal that the current literature lacks qualitative study. Only three out of 89 studies have conducted qualitative studies (see Appendix 5). Hence, qualitative studies should be given importance by the coming researchers. Under the quantitative research, only Elavarasan et al. (2021) and Abdel-Basset et al. (2021) have used the MCDM technique-TOPSIS. Therefore, MCDM techniques can be focused on more. Findings from our study further reveal that just two studies have adopted the mixed methodology.

Consequently, we also highly recommend using the mixed method for understanding the role of AI in the healthcare system for future researchers, as it will provide an in-depth analysis of the topic. For example, mixed-method research can be answered to deepen the understanding of AI adoption across diverse business functions in the healthcare sector. In addition, future researchers can understand the numerous trade-offs of implementing AI technology using the mixed-method approach. More quantitative and qualitative studies can be conducted to answer how using different data sources from multiple healthcare stakeholders such as patients, medical experts, doctors, pharmacists, and hospital healthcare professionals can help better grasp our research questions. Also, mixed-method studies can be conducted to validate the results using a single analytical method.

5. CONCLUSION AND IMPLICATIONS

By conducting a systematic literature review of articles, we find that the AI literature for either resilience or sustainability is available in the healthcare domain. As a result, a combination of resilience and sustainability in the context of AI in healthcare is not yet discussed in any of the past single works. We contribute to the literature by focusing on this gap. Our study initially provides a descriptive analysis of the reviewed articles to analyze the evolution of the literature on AI applications for the resilient and sustainable healthcare system. Interestingly, the articles published in this context have shown significant growth after 2019. The reason behind this can be the wake of the COVID-19 pandemic, shattering even the world's best healthcare systems. Based on the analysis of several papers, we developed themes under the AI applications for building a resilient and sustainable healthcare system, its benefits, and challenges.

Our study reveals that AI technology is a powerful tool during disasters. The AI application in the healthcare sector is saving many lives by improving image analysis, quick decision-making, drug discovery, automated data collection, automated experiments, and executing priority-based treatments, thereby improving the quality and care of the patients. AI technology plays an essential role in healthcare by providing therapy, customized treatment, and successful surgeries. It further offers innovative solutions in the healthcare domain and its associated fields. When combined with other technologies, AI helps connect all the devices and systems used in the healthcare domain. These enable real-time capabilities and improve decision-making processes by healthcare policymakers and professionals. The integration further enhances the implementation of new techniques in the local, national and international healthcare systems efficiently and swiftly.

Drawing broadly on the literature, we developed an extended APO framework on the applications of AI in healthcare to build a resilient and sustainable healthcare system. The antecedents and practices discussed in this work contribute to understanding the state of technology in industry and academia. Our study identifies the top peer-reviewed journal publishing in the context of AI in healthcare. Our study highlights that very few mixed methods are conducted in this domain. Hence, providing a research framework and proposing propositions that enriches the AI literature can be tested in future work. Our study highlights specific gaps in the literature and suggests promising future research directions using the TCM framework.

Our study provides some interesting AI applications for the practitioners engaged in managing disaster operations. However, many healthcare firms have not yet adopted some of these applications. Our study will help healthcare professionals understand AI's role in building a resilient and sustainable healthcare system. Our study will help healthcare firms planning to adopt AI. The antecedents and practices discussed in this work will help the healthcare firm to understand the requirements for AI adoption. In addition, our study will allow them to draw the link and maintain the fine line between the antecedents, practice, and outcome for AI applications. Furthermore, our analysis will help organizations formulate AI adoption strategies in healthcare systems during different disaster phases and during normal conditions.

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Appendices

Appendix 1: Research Papers considered for the SLR

Capasso and Umbrello (2022); Popkova and Sergi (2022); Alahmari et al., (2022); Comito and Pizzuti (2022); Peng et al., (2022); Dasgupta et al., (2022); Sood et al., (2022); Richie (2022); Serte et al., (2022); Badidi (2022); Ahsana and Siddique (2022); Chattu (2021); Babic et al., (2021); Al-antari et al., (2021); Pascu-Gabara and Cepoi (2021); Wang and Wu (2021); Satpathy et al., (2021); Ghayvat et al., (2021); Secinaro et al., (2021);

Nasseef et al., (2021); Parviainen and Rantala (2021); Sim and Cho (2021); Wang and Alexander (2021); Munawar et al., (2021); van der Schaar et al., (2021); Li et al., (2021); Aerts and Bogdan-Martin (2021); Ogiela and Ogiela (2021); Elleuch et al., (2021); Xue et al., (2021); Tariq et al., (2021); Umbrello et al., (2021); Sait et al., (2021); Almalki et al., (2021); Zahid et al., (2021); DeGrave et al., (2021); Xu et al., (2021); Shankar et al., (2021); Islam et al., (2021); Khan et al., (2021); Gunasekeran et al., (2021); Klumpp et al., (2021); Pathan et al., (2021); Lorencin et al., (2021); Elavarasan et al., (2021); Mishra et al., (2021); Ahmed et al., (2021); Abdel-Basset et al., (2021); Rahman et al., (2021a); Rahman et al., (2021b); Leimanis and Palkova (2021); Hsu et al., (2021); Sitharthan and Rajesh (2021); Chee et al., (2021); Kumar et al., (2020); Naseem et al., (2020); Vaishya et al., (2020); Sharma et al., (2020); Berquedich et al., (2020); Ahad et al., (2020); Ho et al., (2020); Hoffman (2020); Tan et al., (2020); Laudanski et al., (2020); Alanazi et al., (2020); Greenspana et al., (2020); Straw (2020); Zemmar et al., (2020); Bansal et al., (2020); Haleem and Javaid (2020); Angioni and Musso (2020); Sarbadhikari and Pradhan (2020); Yigitcanlar and Cugurullo (2020); Coombs (2020); Unberath et al., (2020); Liu et al., (2020); Lai et al., (2020); Mohamadou et al., (2020); Scott et al., (2020); Battineni et al., (2020); Santosh (2020); Dutta et al., (2020); Adly et al., (2020); Milne-Ives et al., (2020); Loey et al., (2020); Mrówczyńska et al., (2019); Sun et al., (2019); Jung et al., (2018); Sonnessa et al., (2017)

Appendix 2: Comparisons of the similar literature review conducted on AI and healthcare

Article	Journal	Focus	Review Type	Sample Size	Database Selected	Time Frame for the study
Peng et al., (2022)	Artificial intelligence review	Describes the applications of AI to combat the COVID-19 pandemic	Literature Review	NA	Web of Science, ScienceDirect, IEEE Xplore Digital Library, China national knowledge infrastructure, EiCompendex, and Google Scholar	NA
Comito and Pizzuti (2022)	Artificial Intelligence in Medicine	Illustrates the application of AI for forecasting and diagnosing the COVID-19 pandemic	Literature Review (Focused Review)	146	ScienceDirect (SD), IEEE Xplore, Web of Science (WoS), Google Scholar, Scopus, PubMed, ACM Digital Library, arXiv and medRxiv	February 2020 to March 2021
Secinaro et al., (2021)	BMC Medical Informatics and Decision Making	Conducts cluster analysis for AI applications in healthcare	Bibliometric Analysis and Literature Review	288	Scopus	1992-January 2021
Islam et al., (2021)	Healthcare	Provides an overview of current research trends of AI application to the COVID-19 pandemic	Bibliometric Analysis	729	Web of Science	2020-February 2021

Khan et al., (2021)	Expert Systems With Applications	Discusses the applications of AI-based techniques for the COVID-19 pandemic	Literature Review	NA	ScienceDirect, Google Scholar, and Preprints from arXiv, medRxiv, and bioRxiv	NA
van der Schaar et al., (2021)	Machine Learning	Examines how Ai is used to mitigate the challenges during the COVID-19 pandemic	Literature Review	NA	NA	NA
Chee et al., (2021)	International journal of environment al research and public health	Describes the applications of AI to combat the COVID-19 pandemic in intensive care and emergency settings	Literature Review (Systematic Review)	14	PubMed, Embase, Scopus, CINAHL, IEEE Xplore, and ACM Digital Library	August 2020- October 2020
Chattu (2021)	Big Data and Cognitive Computing	Highlighted the application of AI, blockchain, and big data in medical and global health	Literature Review	NA	Web of Science, Scopus, MEDLINE/PubMed, and Google Scholar	NA
Bansal et al., (2020)	Journal of medical systems	Analyses application of machine learning techniques to battle the COVID-19 pandemic	Literature Review	NA	NA	NA
Milne-Ives et al., (2020)	Journal of medical Internet research	Assess the usability and effectiveness of AI-based conversational agents in healthcare	Literature Review (Systematic Literature Review)	31	PubMed, Medline (Ovid), Excerpta Medica dataBASE, Cumulative Index to Nursing and Allied Health Literature, Web of Science, and the Association for Computing Machinery Digital Library	2008- November 2019
Naseem et al., (2020)	Journal of Primary Care & Community Health	Discusses the applications of AI to combat the COVID-19 pandemic	Literature Review (Focused Review)	13	PubMed	December 2019 - April 2020
Vaishya et al., (2020)	Diabetes & Metabolic Syndrome: Clinical Research & Reviews	Describes the applications of AI to combat the COVID-19 pandemic	Literature Review	NA	Pubmed, Scopus, and Google Scholar	NA

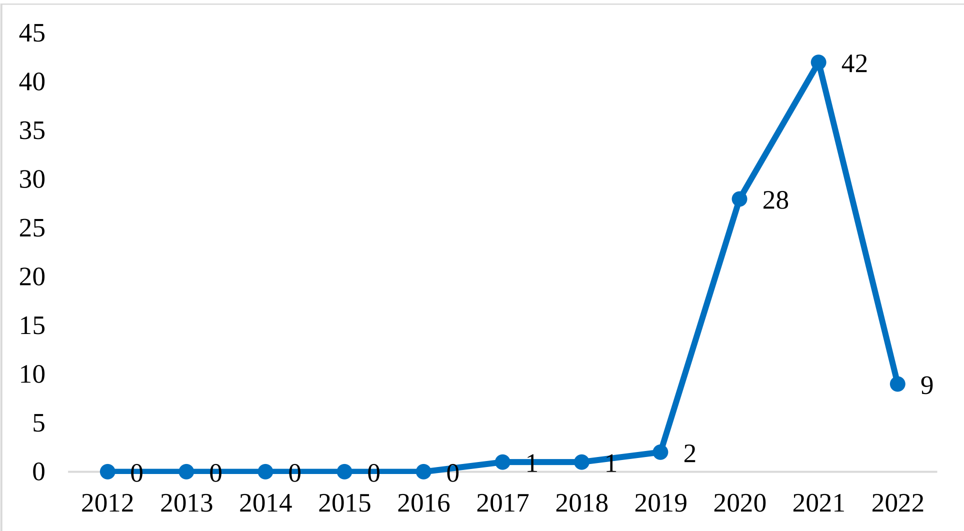
Appendix 3: Different AI technologies and applications in healthcare segments

AI Technologies	Applications	References
Computational Intelligence-based Heuristic Greedy Best First Search (GBFS) algorithm and Random Forest Classifier (RFC)	Optimizing the lung cancer dataset	Mishra et al., (2021a)
Deep neural network (DNN) -based object detection technique and Gaussian YOLOv3 algorithm	Human Detection	Ahmed et al., (2021)
Deep learning convolutional neural network (DLCNN)	Detecting COVID-19 infection using chest X-ray images	Sait et al., (2021)

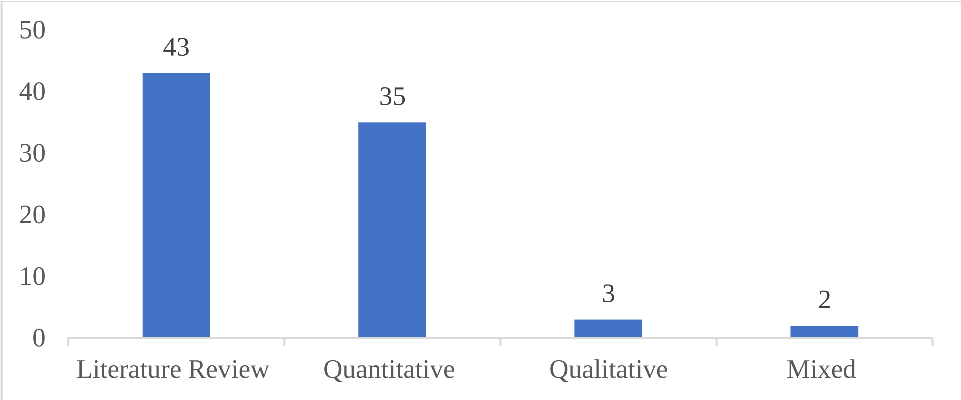
Deep Learning Models (DLM)	Detecting COVID-19 using the chest X-ray images	DeGrave et al., (2021)
Deep Learning Models	Detect, Diagnose and Classify COVID-19 using Xray images	Al-antari et al., (2021)
Agent-Based model decision support system	Comparison of co-payments rules	Sonnessa et al., (2017)
Deep learning-based Recurrent Neural Networks (RNN)	Analyzing hospitalized patients' data	Hsu et al., (2021)
Machine learning-based Latent Dirichlet Allocation (LDA) Algorithm	Contributes to the cancer treatment process - Surgical Therapy, Chemo, and Radiation Therapy	Alahmari et al., (2022)
Deep learning-based Classical data augmentation techniques along with Conditional Generative Adversarial Nets (CGAN) model	Detecting COVID-19 using chest X-ray images	Loey et al., (2020)
Logistic regression; Multilayer perceptron layer; Gradient boosting model; Bagging tree; Random Forest using machine learning and deep learning	Classifying and Assessing COVID-19 infections using chest X-ray images	Almalki et al., (2021)
Stimulus-response methods	Human Interactive experiences using an AI Chatbot	Battineni et al., (2020)
Cascaded recurrent neural network-based Barnacle Mating Optimization (BMO) algorithm	Diagnosis of COVID-19 infections using chest X-ray images	Shankar et al., (2021)
A harmony search algorithm, genetic algorithm, Particle swarm optimization algorithm, and K-means	Diagnosis the diabetes disease using combined AI algorithms	Li et al., (2021)
Artificial Neural Networks (ANN) and Fuzzy Interval Mathematical Modeling	Classifying, prioritization, and scheduling the COVID-19 patients.	Elleuch et al., (2021)
Convolutional Neural Network (CNN) Model	Classifying the clinical data for coronary heart disease.	Dutta et al., (2020)
Optimized CNN Model	Detect COVID-19 infection using X-ray images	Pathan et al., (2021)
Artificial Immune Decision Support System (AIDSS)	Drug prescription to the home quarantine patients.	Berquedich et al., (2020)
Machine Learning	Monitoring and tracking the COVID-19-infected patients.	Sitharthan and Rajesh (2021)
Machine Learning	Discusses how AI can help at different stages to battle the COVID-19 pandemic	Bansal et al., (2020)
CNN Architecture	Diagnosis and treatment of the COVID-19 infection using the lungs X-ray images.	Lorencin et al., (2021)
Supervised Learning Model	Assess the severity of COVID-19 infections using lung ultrasound and clinical information.	Xue et al., (2021)
Machine Learning	Chatbots for automated consultancy during the COVID-19 pandemic.	Parviainen and Rantala (2021)
Support Vector Machine (SVM) Networks	Analyzing noise pollution in protected areas	Mrówczyńska et al., (2019)
Machine Learning, Deep Learning, Natural Language Processing, Expert Systems, Robots, and Robotics Processes	Highlighting AI's importance during the COVID-19 pandemic.	Rahman et al., (2021b)
Active learning and Deep learning	Discusses AI-driven tools to test and train multitudinal or multimodal data	Santosh (2020)
Machine Learning and Deep Learning	Diagnosis and forecasting of the COVID-19 pandemic	Comito and Pizzuti (2022)
Machine Learning and Deep Learning	Discusses different applications for combating the COVID-19 pandemic	Khan et al., (2021)

Convolutional Neural Network	Detect COVID-19 infection using chest X-ray images	Pathan et al., (2021)
Machine Learning	Discusses different applications for combating the COVID-19 pandemic	van der Schaar et al., (2021)
Machine Learning	Uses the past susceptible, infected recovered data for combating the future COVID-19 infection	Alanazi et al., (2020)
Convolutional Neural Network and Deep Learning	Detecting the COVID-19 infections	Serte et al., (2022)
Natural Language Processing	Discusses multiple conservational AI-based agents	Milne-Ives et al., (2020)
Deep Learning	Detect COVID-19 infection using CT scan images	Dasgupta et al., (2022)

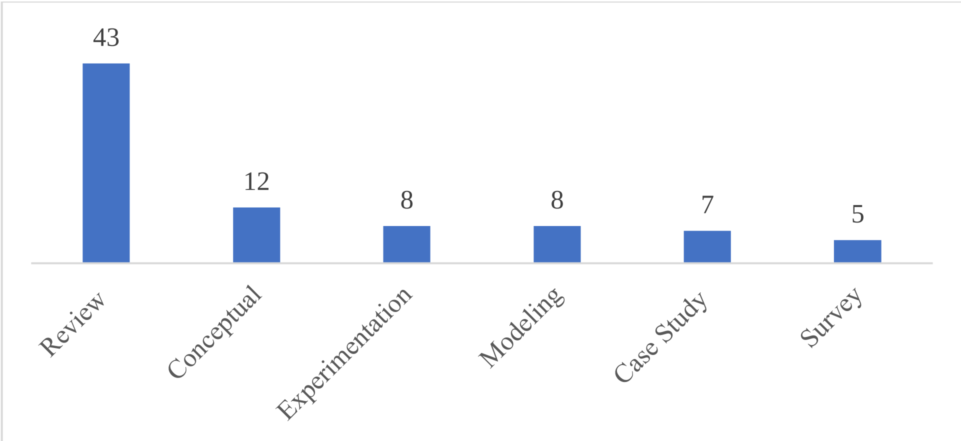
Appendix 4: Year-wise paper publication (As of 26th September 2022, N = 89)



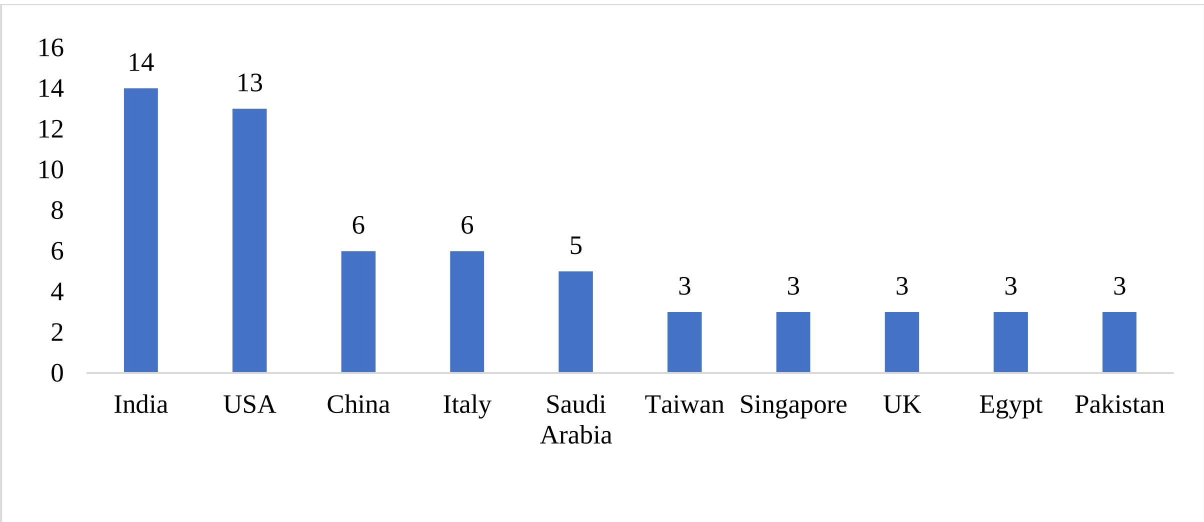
Appendix 5: Type of publication (N = 89)



Appendix 6: Research methods used in the research papers (N = 89)



Appendix 7: Top 10 geographical orientations of the reviewed papers



Appendix 8: Distribution of data collection method used in the research papers (N = 89)