

Multi-agent Artificial Intelligence Systems in Health care: Applications, Challenges, and Future Prospects

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Abstract

The Multi-agent Artificial Intelligence (AI) systems adoption in the healthcare sector is an innovative way for addressing the natural complexities, efficiency of the field. Various applications of the multi-agent systems in the health care environment are explored in this narrative review, including decision support, medical data management, resource management, remote patient care, etc. These systems promise the efficient utilization of resources, improved decision-making, and efficient health care process through efficient communication among autonomous agents. The primary goal of this narrative review is to address the different applications, the future and current aspects of Multi-Agent Artificial Intelligence (AI) Systems in the healthcare sector. There are several problems related to Multi-agent AI, for example, integrating the systems with the existing clinical workflow, data quality, minimizing algorithmic bias, the ethical problems related to the privacy of the patient and data protection in the healthcare system, etc. To achieve the confidence of the patient and healthcare professionals, the key issue of the understanding of AI-driven decision making also needs to be addressed. The gaps highlighting and the scope for the research findings are also explored in this review. Addressing these issues may assist in enhanced operational effectiveness, enhanced patient outcomes, as well as a more versatile healthcare environment. Overall, the continued growth in the research of the multi-agent AI systems may have a significant impact on the healthcare development in the future in terms of propelling the move to more individualized, effective, as well as accessible care.

Keywords: Multi-agent Systems (MAS), Artificial Intelligence (AI), Healthcare Applications, Decision Support Systems, Data Privacy and Security, Explainable AI (XAI),

I. Introduction

Health care is a crucial aspect of human societies, as it directly influences the quality of life for individuals. Enhancing health care efficiency, both in terms of time and cost, involves digitizing administrative and support processes. Nevertheless, health care remains one of the most challenging fields to address due to its inherent

complexity. Traditional computational models struggle to effectively represent an environment characterized by diverse users and intricate processes and interactions (1).

Agent-Based System: A Solution to Health-Care Challenges

Artificial Intelligence is comprised of agent based systems, which have become a considerable area of solving simple and complex issues. A user software or an owner is called agent. Principal features of an agent are as follows a) autonomy, b) pro activity, c) reactivity, d) bargaining e) cooperation, f) communication, and g) learning. These characteristics assist agents to be productive in executing specific tasks. An autonomous agent is able to learn and adjust himself to the environment. It can choose to achieve their goals and adapt to the changes in the environment. When a set of agents are combined in relation to one another, a system that is known as a multi-agent system (MAS) will be developed. The main idea of MAS is to establish a communication and collaboration between agents in such a way that they are able to cooperate in order to perform certain task. MAS is primarily used in some areas such as telecommunication, robotics, the Internet, and the medical sector among others (2). Agents are applied in health care for various purposes like providing distributed data sources with access, assisting professionals in decision-making, and coordinating healthcare activities (3). To assist patients address and overcome obstacles during the COVID-19 pandemic, recent research has been effectively conducted (4). The ability of this technology to reduce direct interactions between patients and healthcare professionals is main advantage (5).

System Design and Agent Roles

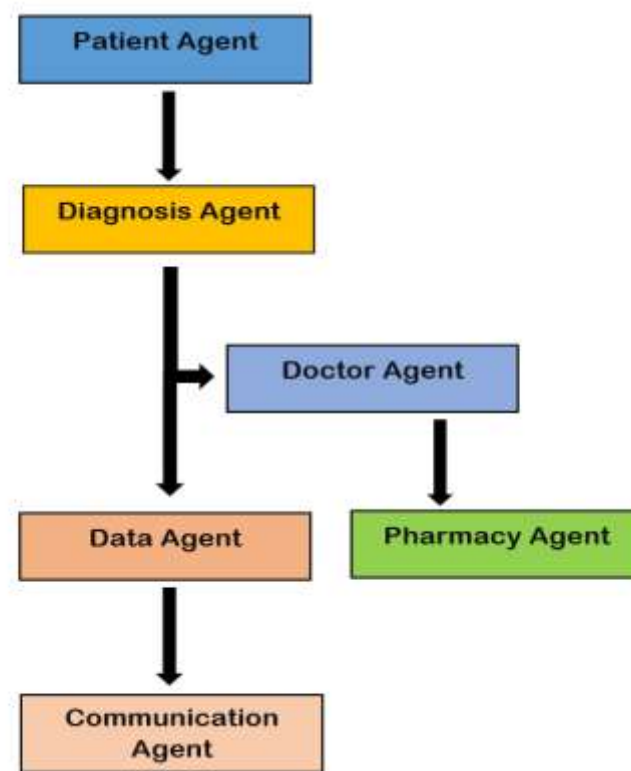


Figure 1: Flow Chart of Multi-Agent AI System for Patient Care

Patient Agent: Collect patient's personal information and symptoms.

Diagnosis Agent: Diagnose the disease based on of patient's symptoms

Doctor agent: Analyze the diagnosis of the patient and make treatment plan.

Pharmacy Agent: Agent are in charge of supervising medicine dispensing, verifying prescriptions, and informing patients about drugs.

Data Agent: Handles Storage and privacy of Patient's data.

Communication Agent: Sends alerts and messages to doctor and patients about the disease and its cure

Addressing Health Care Interconnections

Hospitals consist of independent wards and support units that are closely interconnected. The challenges arise from the interactions among patients, facilities, nursing staff, healthcare providers, the complexity of illnesses, treatment options, medications, and more. Emphasis should be placed on enhancing the triptych of cost, quality, and time. The objective is to identify the optimal balance among these three factors. Consequently, a patient-focused multi-agent system for health care is proposed to achieve this aim. This system serves as a decision support tool to assist both medical personnel throughout the health care process and management staff by offering dynamic decision-making scenarios with improved resource allocation. It becomes essential to model this intricate reality. The multi-agent paradigm indeed enhances the capacity to model, design, and implement complex systems that are inherently distributed, highly adaptable, and cooperative (6).

Technical Architecture and Agent Coordination

The timely interaction of agents in Multi-Agent System (MAS) in healthcare rests with communication protocols and decision-making architectures (that make the interaction seamless and task execution). The typical use of structure agent communication languages like FIPA protocol, or SOAP and JSON message formats are used so that real-time transmission of structured data may be sent between agents. Such protocols make it possible to secure the effective interaction of heterogeneous agents which are typically built based on different frameworks or languages within the healthcare domain. The paradigms of decision-making in MAS systems may differ according to the use case. An example of these rule-based systems is ideal in structured diagnostic paths where a given logic tree is used and others such as machine learning (ML)-driven agents utilize supervised learning models to train on data about past patients to predict a given condition or prescribe treatments. Reinforcement learning has also been found promising in situations where the agents need to adjust dynamically e.g. optimization of treatment plans as the patient responds to treatment over time.

They usually have learning mechanisms within them that are designed to change. To take an example, diagnosis agents can be worked on by using supervised learning with labeled datasets to increase the classification accuracy of symptoms or diseases. Unsupervised methods on the other hand can be useful in grouping patients profile to

enable individual care strategy. Even though the MAS architectures have its own benefits, they encounter technical issues. Scalability would become another dominant issue with a larger number of agents interacting, thus keeping a risk of latency in the message transit or the decision-making process. The conflicts between agents (example, contradictory diagnosis, resource conflicts) need conflict-resolution mechanisms, which may be parallel (e.g., implemented with the help of priorities rules or by using arbitration agents). The real-time performance is also a matter of infrastructure capacity that can require optimization to operate on low latency in the context of emergency care. Future research can center around hybrid systems that mix edge and cloud integration in order to diminish latency as well as enhance fault tolerance in decentralized systems.

II. Applications

The potential economic and social advantages of accurately forecasting medical outcomes are substantial. Clinical data are inherently complex due to factors such as the genetic and biological diversity among individuals, the variability of disease markers, differences in drug combinations administered to each person, and the presence of missing data, among others. Traditionally, the analysis of clinical data has predominantly depended on conventional methods like logistic regression (7) for uncovering knowledge or predicting medical outcomes. However, these methods often fall short when addressing highly complex problems.

System Evaluation

Multi-agent Artificial Intelligence Systems (AI) in Healthcare play a crucial role in enhancing the diagnosis and treatment of the diseases by healthcare professionals. In a recent study, a group of specialized AI agents was incorporated for sepsis care using MATEC (Multi-Ai Agent Team Care) framework. The sepsis AI agent team included five doctor agent, four health professional agent and a risk prediction model agent, with 33 more doctor agents available for consultation. Ten attending physicians assessed this framework by completing a 5 point Likert scale survey (ranked from 1 = unfavorable to 5 = favorable) and spent about 40 minutes on web based MATEC program. The results showed the high acceptance, with median score for both accuracy ($P < 0.01$) and helpful ($P = 0.01$) being 4 out of 5 as rated by the doctors.(8) This study highlights that how MATEC might help healthcare professional, particularly in hospitals with limited resources

Leveraging Machine Learning in Clinical Settings

In an attempt to enhance the performance, ease of implementation, and seamless incorporation in clinical practice, researchers have now focused on Intelligent Data Mining (DM) and Machine Learning (ML) techniques as alternative techniques of data modeling and prediction. (9). Based on research, ML algorithms are applicable in healthcare environments where automatic processes must manage dynamic conditions, process uncertain and incomplete medical data, improve performance based on prior data, and draw conclusions from examples in the database. (10). ML techniques are being applied to various clinical applications like detection of microcalcifications in the mammogram (11), diagnosing thyroid diseases (12) and the analysis of sudden infant death syndrome (SIDS) (13). Intelligent multi-agent system is to be applied for the following: developing e-

health systems to predict the outcomes of kidney transplant operation (14). Moreover, to show the potential of the e-health systems, this strategy is also to be implemented for developing the e health system for the management of chronic diseases like diabetes. With the aim to provide the healthcare service and consulting to the patient, e health system has the potential for reducing the barrier of distance and time (15).

This review aims to:

- Identify and explore the different applications of multi-agent systems utilized in healthcare, including medical data management, resource management, clinical decision support, and remote patient monitoring, highlighting the ways these systems enhance operations effectiveness and healthcare provision.
- Analyze the potential for the future: Research possible future advancements in multi-agent systems for healthcare environments, including the adoption of innovative technologies like blockchain, the emergence of specialized medical approaches, and the formulation of ethical standards and norms.

Ensuring Privacy and Security in E-Health

"Electronic health systems are utilized to record information about the patient at every stage of the medical process. Medical staff and other consuming users have thus been provided with medical records containing extremely sensitive and confidential information. A number of measures have been proposed to maintain the privacy and security of Electronic Health Records (EHR) (16). However, these solutions demand stronger data distribution security measures. Therefore, it is essential to create a system that maintains the privacy and security of the EHR data. A Multi-Agent System has been put forward to provide efficient and secure e-health security services. These intelligent agents provide user-friendly and effective communication among the users and service providers. The multi-agent system manages various functions like the generation of the interface, user registration, user login, establishing connections, and maintaining the connections. Moreover, it uses a database for the storage and retrieval of health information in the form of electronic health records (17).

Concept of AI-Driven Hospitals

The concept of AI hospitals, or virtual hospitals or agent hospitals, is a model where multi-agent systems imitate the workflow of real hospitals and labs. These settings allow for the systematic observation of LLM behaviors, thorough evaluation of the reliability and efficiency of models/agents, and controlled simulations to produce high-quality training data. Although there is increasing research interest in AI-driven hospitals, current studies are disjointed and lack a cohesive framework that systematically links various AI hospital simulations to real-world scenarios. While numerous studies investigate specific multi-agent applications, they often do so independently, failing to offer a comprehensive view of how these systems interact and contribute to a unified AI hospital ecosystem (18).

The integration of AI Agents into healthcare offers a chance to transform patient care, enhance administrative efficiency, and aid in intricate clinical decision-making (19).

Table 1: Analyzed fields of application of agent-based approaches (20).

Field	Description
Medical data management	Systems designed for accessing and handling medical information, such as electronic health records
Decision support systems	Methods intended to aid professionals in carrying out healthcare tasks like treatments or diagnostics
Planning and resource allocation	Systems focused on organizing and scheduling both human and material resources
Remote care	Methods designed to monitor patients' conditions from a distance, enabling continuous care
Composite systems	Systems that provide comprehensive and integrated healthcare management solutions for a specific organization, often incorporating multiple elements from the aforementioned areas

Although multi-agent AI systems hold promise for health care, several obstacles must be overcome for successful implementation. These problems include minimizing bias and ensuring high-quality data, improving the interpretability of AI, incorporating these systems into clinical work flows, performing rigorous clinical validation and handling ethical and legal dilemmas, and. To address these issues, strategies such as focusing on thorough user experience studies, implanting stringent data validation protocols, creating hybrid models that blend deep learning with more approachable techniques, carrying out multicenter randomized controlled trials are recommended and setting up ethics boards to supervise system development and deployment (21).

III. Challenges and Limitations

Although Multiagent AI Systems (MAS) have promising applications in healthcare but their implementation in healthcare faces numerous hurdles resulting in their limited adoption. These h include technical, ethical, legal, and infrastructural domains.

Integration and interoperability

Interoperability is arguably one of the biggest challenges to the implementation of MAS in health care. Most protocols to share and communicate agent-to-agent, or agent-to-provider, information, which can result health care institutions depend on heterogeneous electronic health record (EHR) systems that are not standardized, making it difficult to integrate with AI systems (22). Health systems have inconsistent in ineffective, inefficient, and inaccurate clinical decision-making. In addition, integrating AI models into clinical workflows must also align with the current infrastructure and training requirements for stakeholder buy-in, which today, many health systems are not prepared for (23). Multiagent systems have not been supported by universal communication protocols for agent-to-agent interactions, which complicates the capacity for real-time coordination between agents and systems.

Data privacy and security

Because MAS systems are decentralized, where multiple agents interact and share data, the risks to patient data security will be enormous. The privacy of health data has to be ensured when utilizing distributed systems and, while patients can consent to the use of their sensitive and personally identifiable information, the issues of privacy and misuse are monumental (24). Use of MAS systems can result in severe implications for patients, and providers, if there are data breaches. Moreover, agents in a MAS will require large datasets for training and continual learning, but as we just discussed in the context of big data management, it raises ethical issues when consents, ownership, and anonymizing datasets in this context are considered (25) and presents on-going challenges to aligning innovative progress with compliance obligations under data protection, like GDPR, or privacy, like HIPAA.

Legal and ethical considerations

Ethical dilemmas created by MAS systems are amplified because decisions relating to patient care are undertaken by numerous autonomous agents. Notably, accountability is a major issue—when something goes wrong (i.e., an adverse event), identifying who is liable (i.e., when asked to provide the information, all you get are blank stares) will become increasingly complex given the multitude of agents and stakeholders involved in patient care (24). Further, research suggests algorithmic bias present in AI systems being implemented in healthcare systems will perpetuate existing inequities in health services use (26). Besides their benefits, MAS systems can also undermine the patients' control over their own data if implemented without transparency or informed consent processes. Right now, laws like the EU AI Act are still catching up—there aren't strong enough rules in place to make sure these systems are used ethically and responsibly in medicine (23).

Technical Challenges

The multi-agent systems (MAS) clearly pose a complicated technical problem which can pose barriers to the trust and debency of clinical use. One major issue is that commonly, the decisions made by AI agents are not explainable, especially if deep learning algorithms are used (27). Even in a multi-agent environment, an agent

can adopt a different model, thus explaining the systems decisions can be even more difficult. Other factors adversely impacting real-time performance in MAS include computational capacity and latency in agent-agent communications and scalability of the model (25). A major challenge for real-world implementation is that validating and certifying the safety and efficacy of multi-agent interactions in clinical environments (22).

Ethical Consideration in Multi agent System (MAS)

Protecting patient’s personal data and preserving decision making transparency are essential to ensuring ethical use of AI in healthcare. Multi-AI agent health care systems must adhere to the regulations of HIPAA (USA) and GDPR (EU) to protect the electronic health records (HER). To prevent data breaches and misuse, these system must implement strong encryption, anonymization and informed consent. Additionally, to maintain accountability, protect patient autonomy, and prevent algorithmic bias, AI agents should never make life-altering decisions without human review, particularly in diagnosis and treatment.

Table 2: Ethical and Legal Considerations in Multi-Agent Healthcare Systems

ISSUE	DESCRIPTION	RECOMMENDED ACTION
ALGORITHMIC BIAS	Discriminatory outcomes due to non-representative training data	Use diverse datasets; implement fairness audits
DATA PRIVACY (GDPR, HIPAA)	Risk of unauthorized data sharing across agents	Apply encryption, anonymization, access controls
LIABILITY	Unclear responsibility when AI makes clinical errors	Define legal frameworks assigning shared accountability
TRANSPARENCY (XAI)	Difficulty in understanding AI decisions	Use explainable AI techniques and decision rationale
ACCOUNTABILITY	Lack of traceability in agent decisions	Maintain audit logs of agent actions
HUMAN OVERSIGHT	Risk of autonomous decisions without clinical review	Implement human-in-the-loop for high-risk decisions

IV. Emerging Emerging Debates and Design Considerations

The recent upward trend of bringing foundational large language models (LLMs) to completion has led to speculations as to whether large language models have the potential of replacing decentralized Multi-Agent Systems (MAS) in the healthcare sector eventually. Due to generalized reasoning ability, natural language comprehension and even dynamic task management abilities across domains, LLMs are able to. Nevertheless, because of their flexibility and followability, LLMs in many instances act as monolithic systems without any specialized modularity. They also have issues of context preservation during a long session, explicitness and intensity. On the contrary, MAS architectures are in their nature modular, scalable, and suited to complex

healthcare environments where there is a need to simultaneously perform task-specific operations across distributed agents. The fact that this is a decentralized nature helps in ensuring robustness, especially in dealing with various clinical workflows, specialized diagnostic operations or patient specific adjustments. Therefore, although they could be helpful in individualizing agents or adding smartness to layers of communication, LLMs would not become a total replacement of MAS frameworks in more than low-stakes, steady state clinical settings.

The second critical point would be the user who interacts with MAS, namely, clinical users. To enable the use of agent-based systems, they should be easy to use, and their applications must fit into the daily routine of the work of healthcare professionals. Nonetheless, there is a group of clinicians who lack the basic knowledge in terms of which they can interpret or communicate with AI recommendations with confidence. This shows that there is an increasing necessity of AI literacy training so that clinical users can work together with intelligent agents in a meaningful way and question the results of the automated system critically. by incorporating users into co-design and feedback looping mechanisms, the usability and trust of the system will be enhanced further.

Also, it is more desirable to discuss the granularity of agents in MAS. Instead of using general diagnostic agents, systems must be developed to contain special agents against popular disease, uncommon disorders or comorbidities. Greater specificity could be achieved using hierarchical or modular MAS architectures, in which supervisory agents on a higher level allocate tasks to a more focused sub-agents depending on the clinical situation. As an example, a case where a general diagnostic agent triggers a cancer-specific sub-agent or rare disease module will lead to better accuracy and efficiency.

V. Case Study Examples

The unnatural pairing of MAS with healthcare has evolved and presented us with interesting use cases and applications radically effacing the inherent complexity of managing a pandemic, the exact role of privacy with health records, and intelligent diagnostics. The rich literature suggests that a blizzard of work has been done theoretically and practically in development of MAS, especially within the more recent work associated with COVID-19, moving MAS models and EHR systems forward with use of AI, and thinking about aiding clinical decision-making.

Recent studies emphasized the use of Multi AI Agent system in decentralized decision support and telemedicine environment. AI Hospital Simulation (28) presents a multi agent setting where simulated doctors, patients, and hospital staff interact with an Large Language Model (LLM powered system to replicate real clinical workflows. While the system performed well in single-step tasks, it struggled with multi-turn interactions, this demonstrates the need of MAS framework to support realistic care pathways and contextual consistency. A recent study presented the MATEC, framework used for sepsis care received outstanding ratings in both accuracy and utility from physicians (8). Similarly, in clinical diagnostic and treatment planning, Sulis et al (2023) surveyed agent based technology, observed significant improvements in early diseases detection and AI-assisted triage (29).

These advancements are part of a larger trend toward patient-centered, explainable AI systems in real-world healthcare settings

Case Study 1: MAS in Pandemic Management

Perhaps one of the most exciting and useful examples of the use of MAS was a program led by Sharma et al., 2020 (30) where they presented roles that have significance to pandemic management, one the pandemic of COVID-19 being on-going. Sharma and colleagues outlined the phases of MAS use of the AI and agent-based work for purposes of automating critical pandemic response activities such as; monitoring the spread of the COVID virus; resource allocation; and risk communication. With the project we can appreciate the value of applying intelligent agents over a wide geographic area where dynamic and localized data can be put captured and analyzed to inform decision making. For instance, cases of agent-based contact tracing undertaken by us reflects human participant time spent identifying and documenting chains of infection were replaced and minimized by MAS agents, thus less manual effort, less risk of transmission to human participants.

Technical Setup

The Multi-AI Agent Team Care (MATEC) framework was developed to support clinical decision-making in sepsis management. The system architecture consisted of multiple autonomous agents with clearly defined roles. Five doctor agents were designated to evaluate patient-specific clinical data and suggest potential diagnoses. These were supported by four health professional agents responsible for coordinating care activities, such as vitals monitoring and care prioritization. A central risk prediction agent employed machine learning models to assess patient risk levels based on inputs such as lab results and vitals. In addition, the system included a pool of 33 consultative doctor agents, which could be dynamically engaged for secondary opinions. All agents communicated through a web-based interface, allowing real-time simulation and collaborative care planning among AI and human participants.

Outcomes and Challenges

MATEC was evaluated by ten attending physicians who spent approximately 40 minutes interacting with the system in a controlled simulation. Using a 5-point Likert scale, the doctors reported high confidence in the system's accuracy and clinical usefulness, giving median scores of 4.0 for both metrics ($p < 0.01$ and $p = 0.01$, respectively). This indicates strong initial acceptance. However, several challenges were identified, including limited adaptability in patients with multiple comorbidities, dependency on static knowledge bases, and a lack of integration with existing electronic medical record (EMR) systems. These limitations restrict the scalability of MATEC in dynamic real-world settings, highlighting the need for continuous model updates and improved interoperability.

Case Study 2: AI Hospital Simulation with LLM Integration

The AI Hospital simulation was designed to evaluate the capabilities of large language models (LLMs) embedded within a multi-agent hospital framework. Agents simulated various stakeholders in a hospital (patients, doctors, nurses) in an environment to mirror real-time clinical workflows and decision pathways.

Technical Setup

The AI Hospital Simulation utilized a multi-agent framework powered by a centralized large language model (LLM), simulating real hospital operations and workflows. The agents included synthetic patient agents that generated symptoms and histories, doctor agents that queried the LLM for diagnostic and treatment reasoning, and hospital staff agents responsible for scheduling and logistics. The LLM acted as a shared intelligence layer across the system, supporting decision-making and enabling natural language exchanges between agents. This configuration allowed for dynamic and flexible simulations of clinical encounters, especially those requiring language-based interpretation and decision logic.

Outcomes and Challenges

The AI Hospital model excelled in single-step tasks, such as symptom recognition, medication identification, and generating diagnostic suggestions. Its use of LLMs allowed for highly fluent and human-like interactions, making it effective for simulation, training, and testing purposes. However, the system faced limitations in multi-turn dialogue scenarios where contextual memory across interactions was crucial. Additionally, the high computational cost, lack of persistent context retention, and absence of integration with real-time patient data limited its current applicability in real hospital settings. These findings underscore the need for architecture improvements and domain-specific tuning to transition from simulation to deployment.

VI. Future Directions

The intersection of MAS, block-chain and AI means we are likely transitioning into a new era of health data management in real-time. One example of the merging of these technologies was the study conducted by Alruwaili, 2020 (31) where they explored a MAS and AI focus of decentralized ledger, offer security and privacy of EHRs. The systems use smart tools to automatically check, encrypt and save patient record on blockchain (a secure digital ledger that doesn't rely on just one server) making it more secure. This made the data to tamper or lose much harder while allowing the healthcare staff to mutually share the information safely.

Interoperability and Standardization

A recent study by Sulis et al., 2023 (29) found these smart systems can track how diseases develop, recommend personalized treatment options, and even help catch illnesses earlier by analyzing symptoms. In one cancer department, the system reviewed patient information instantly, comparing it with past cases to recommend the most effective treatments. This technology has not only made diagnoses more accurate but has also given doctors and nurses some much-needed support in their demanding work. A major technical challenge lies in the integration

of MAS with heterogeneous hospital information systems, electronic health records (EHRs), and medical devices. Future research should prioritize the development of common communication protocols and ontologies to ensure that agents developed by different vendors or institutions can interoperate seamlessly. Adopting standards such as HL7 FHIR or extending the FIPA framework could promote widespread adoption across healthcare settings.

Personalized MAS for Rare and Complex Diseases

One of the biggest goals now is to help these AI systems work smoothly with the technology hospitals already use. During COVID-19 pandemic, we saw how frustrating it was when different hospitals' systems couldn't share information due to lack of interoperable systems that makes communication across various healthcare institutions and regions possible (30). Most existing MAS applications are geared toward common clinical workflows. However, there is a pressing need to develop agent architectures tailored to rare or complex diseases, where patient-specific data, multidisciplinary coordination, and individualized decision-making are crucial. Research in this area should focus on modular MAS designs that allow dynamic creation or activation of condition-specific agents, thus enabling more granular and adaptive care pathways.

Integration with Blockchain and Secure Data Infrastructure

Security and trust in data sharing among agents remain key concerns. Integrating blockchain technology with MAS offers a promising solution for managing decentralized health records with greater transparency and immutability. Future projects should explore the development of blockchain-powered MAS where smart contracts govern agent behavior, audit trails are automatically generated, and patient consent is managed cryptographically. Building Doctors and clinicians interest on AI systems is important for making an impressive impact on healthcare. Recent research by Saraswat et al., 2022 (27) shows that when AI can clearly explain its reasoning—like showing its "work" the way a student does in math class—people are more likely to accept and depend on it. That's why researchers are now working to develop fully transparent AI systems, particularly for high-stakes areas like disease diagnosis and predicting health outcomes prediction.

Legal and Regulatory Frameworks for MAS Deployment

Responsible AI use in healthcare isn't just about simple technology - it's includes strong rules to protect patients. A recent study by Elendu et al., 2023 (24) warns that there's real risk of data misuse or detrimental actions going unchecked in the absence of clear regulations. Because of this, next generation of medical AI must have built-in "ethical compasses" - systems that automatically determine whether decisions are both medically, legally sound and morally right, particularly when lives are at stake. With increasing global interest in regulating AI systems in healthcare, legal frameworks such as the EU AI Act must be considered during MAS design and deployment. Future research should focus on aligning agent decision-making processes with emerging compliance standards and ensuring transparency, auditability, and ethical accountability. Establishing clear governance protocols for liability, informed consent, and algorithmic explainability will be vital for regulatory approval and public trust.

Hierarchical and Modular MAS Architectures

Future MAS systems should evolve beyond flat structures. Hierarchical agent designs—where top-level agents oversee and delegate to task-specific sub-agents—can improve scalability and clarity in clinical environments. For instance, a supervisory agent could trigger specialized diagnostic agents based on symptom clusters or escalate decision-making to human clinicians when ethical thresholds are crossed. Such modularity will improve both technical performance and trustworthiness.

Hybrid MAS and LLM Integration

With the rise of foundational large language models (LLMs), research should investigate how MAS can be augmented with LLM-based reasoning engines. While LLMs offer unmatched versatility in language tasks, MAS provide structured, task-oriented decision pipelines. A hybrid model—combining the dynamic contextual fluency of LLMs with the robustness and modularity of MAS—could transform intelligent clinical support systems. However, careful design will be needed to address context retention, hallucination risks, and accountability.

Combining AI systems with blockchain technology could revolutionize how we protect patient records. As demonstrated by researchers such as Alruwaili, 2020 (31), this powerful combination can ensure that health data shared between providers remains safe and private. The current aim to make these solutions more effective and faster so they can be used everywhere - from large metropolis hospitals to small rural clinics - without technical issues.

Future AI systems need to put personalization first—identifying each patient’s particular requirements, monitoring their health in real time, and making emergency modifications to treatment plans. According to Sulis et al., 2023 (29), the future of medical AI isn’t about strict regulations, but smart, flexible helpers that change with a patient’s health journey. The outcome? Better, more customized treatments.

Before these AI systems become widely used, we need conclusive evidence that they work in real hospitals - not only in lab settings. As reported by Juluru et al., 2021 (22), established, the answer is to incorporate them into the daily routine of doctors. The next step: Numerous studies done in various hospitals to check how effectively they standardize the treatment of all the patients, especially in the wake of research (26) highlighting this issue like unfair algorithm biases and missed diagnoses must be addressed first.

VII. Conclusion

Multi-Agent Artificial Intelligence (AI) systems in the healthcare environment offers a viable path for increasing the efficiency, quality, and access of medical care. This narrative overview identifies the versatile applications of multi-agent systems to illustrate how the same could transform the realms of decision-making, medical data management, resource management, and telemedicine. By achieving effortless communication and cooperation among independent agents, these advancements can advance patient outcomes and hasten the healthcare process. However, there are pitfalls in developing the Multi-agent AI system. Efficacy accompanied by the safety of these

innovations relies on the right management of data quality, algorithmic bias, interoperability, and ethics regarding patient confidentiality and accountability. Moreover, the development of trust among the patient group and healthcare staff is also crucial for the extensive adoption of Ai system in healthcare environments.

Multi-agent systems have much potential for future growth. Multi-agent systems have much potential for further growth. By emphasizing the importance of transparency in AI decision-making, developing strong ethics and regulation frameworks, and coupling this with leading-edge techniques like block chain for secure data storage, the next era of healthcare AI can move towards more customized, efficient, and transparency-fostering practice.

In conclusion, the healthcare industry can become more responsive and flexible with the continued development of multi-agent AI systems. A patient-centric strategy, stakeholder partnership, and continuous research will be the keys to achieving this. With the implementation of these innovative ideas, we can more effectively manage the intricacies of healthcare today and pave the way for a future with enhanced health outcomes and effective healthcare delivery system.

Abbreviations

AI-Artificial Intelligence, MAS-Multi-Agent system, MATEC-Multi-Ai Agent Team Care, DM- Data Mining
ML-Machine Learning and HER-Electronic Health Records

Author Contributions

Muhammad Rizwan Saeed contributed to conceptualization, study design, manuscript drafting, and supervision. Dur E Najoom Bazgha assisted in data collection, formal analysis, and critical revision of the manuscript. Hina Mukhtar was involved in investigation, resource acquisition, and data visualization. Maria Tahseen Akhtar contributed to validation, project administration, and manuscript editing. Sumaia Faizi participated in graphical presentations. Konstantin Koshechkin provided supervision, funding acquisition, and critical review of the intellectual content. All authors reviewed and approved the final version of the manuscript before submission.

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