

# Multi-Agent System as a New Approach to Effective Chronic Heart Failure Management: Key Considerations

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**Objectives:** Given the importance of the follow-up of chronic heart failure (CHF) patients to reduce common causes of re-admission and deterioration of their status that lead to imposing spiritual and physical costs on patients and society, modern technology tools should be used to the best advantage. The aim of this article is to explain key points which should be considered in designing an appropriate multi-agent system to improve CHF management. **Methods:** In this literature review articles were searched with keywords like *multi-agent system*, *heart failure*, *chronic disease management* in Science Direct, Google Scholar and PubMed databases without regard to the year of publications. **Results:** Agents are an innovation in the field of artificial intelligence. Because agents are capable of solving complex and dynamic health problems, to take full advantage of e-Health, the healthcare system must take steps to make use of this technology. Key factors in CHF management through a multi-agent system approach must be considered such as organization, confidentiality in general aspects and design and architecture points in specific aspects. **Conclusions:** Note that use of agent systems only with a technical view is associated with many problems. Hence, in delivering healthcare to CHF patients, considering social and human aspects is essential. It is obvious that identifying and resolving technical and non-technical challenges is vital in the successful implementation of this technology.

**Keywords:** Heart Failure, Multi-Agent Systems, Disease Management

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## I. Introduction

In recent years, heart disease has been a major widespread public health problem in most countries [1]. According to Centers for Disease Control and Prevention reports heart failure is the primary cause of more than 55,000 deaths each year. One out of nine deaths in 2008 was due to heart failure. About half the patients who have heart failure die within 5 years of diagnosis [2], and 40% of patients with chronic heart failure (CHF) die after hospital admission or within one year after they are admitted [3]. CHF is costly for healthcare systems in many countries. In the United States, it is estimated that this disease has cost more than \$20 billion [4]. The global cost of heart disease is estimated at \$863 billion in 2010 and it is

estimated to rise to \$1,044 billion by 2030 [5]. In spite of pharmacologic advances and mechanical therapies, prevalence of CHF is rising [6]. However, studies have shown that delay in symptom diagnosis, nonconformity with diet and medication instructions, as well as lack of knowledge and skills of patients for self-management are common causes of re-hospitalization of CHF disease [7-9]. Obviously, improving the monitoring of these patients, the use of self-management programs by patients, providing appropriate treatment based on clinical guidelines, educating patients and helping them pursue their care plans lead to improved treatment and prevention of deterioration of the status of these patients, decreasing hospital re-admission and reducing the use of healthcare resources [10-12]. Given the importance of the follow-up of CHF patients to reduce common causes of re-admission and deterioration of their status that lead to imposing spiritual and physical pressures on patients, their families, healthcare centers, and society, modern technology tools should be used to the best advantage. Use of information technology tools would be helpful to improve the monitoring of patients through continuous assessment of symptoms and signs of disease and checking compliance with self-management programs, thus, improving treatment, and resource use [13]. One innovation in the field of information technology in healthcare is the application of artificial intelligence and intelligent systems to facilitate, accelerate, and improve health services, especially in home care and telemedicine. Agents are one of the strongest artificial intelligence areas, especially in the generation of practical solutions for real problems. An agent is a computer system situated in a dynamic and unpredictable environment that is capable of flexible autonomous action to meet its design objectives [14]. One characteristic of agents is mobility, which is suitable for telemedicine and e-Health systems [15]. Multi-agent systems (MASs) are computational systems in which a collection of loosely coupled autonomous agents interact in order to solve a given problem [14]. Surveys have demonstrated the benefits of using multi-agent technologies in healthcare systems. Agents can provide suitable infrastructure for follow-up data analysis and CHF management due to their many advantage, such as autonomy, proactiveness and social ability as well as their ability to manage information located in different places and to handle communication and cooperation between independent elements [16-19]. The aim of this article is to explain key points which should be considered in designing appropriate MAS to improve CHF management. In this literature review articles were searched with keywords like *multi-agent system*, *heart failure*, *chronic disease management* in Science Direct, Google Scholar and PubMed databases without regard to the year of publications.

## II. General Key Factors in CHF Disease Management through MAS Approach

### 1. Organization

There are many factors in an organization that can have an impact on multi-agent-based information systems, such as organizational culture, which is an important factor in the success of new technology implementation [20]. Leadership behavior and commitment and providing relationship between the information system and organization performance, and tasks are influence on moving towards technologies [21]. The implementation of a CHF disease management system based on an agent approach requires the organizational culture to accept the need to use this system and high-level management support in healthcare organizations.

### 2. Human Resource

Some of the important considerations in the design and implementation of an agent-based system in CHF management include the use of skilled personnel in the field of information technology at healthcare centers [22]; user perspective and user knowledge [23,24]; and user characteristics, such as age, economic, social, and educational status [25]. User training is important to increase user acceptance and to maximize the use of information systems [26]. Staff must be involved in all steps from planning to implementation. Also, clear and effective communication between managers and all personnel involved in the project, describing the advantages and challenges of agent technology and change management are important to increase user acceptance [27].

### 3. Confidentiality and Privacy

Because of increasing dependence on information and communication technology (ICT) at healthcare centers in gathering, transfer, storage and evaluation of health data, the application of security and privacy guidelines is essential [28]. Respecting confidentiality and integrity while preventing the manipulation of data in MASs is possible through the application of many security measures. These include encryption methods to protect access to data that are transmitted by agents, levels of authentication mechanisms, to use of your usernames and passwords for login, identification of algorithms used to protect licenses and to determine the date of validity of licenses, limiting the levels of access to resources for agents, preserving of wireless communication security and access to health information or update information by authorized users [29,30].

#### 4. Legal, Ethical and Administrative Issues

To advantages of MASs enable them to be used beyond borders on local, national, and international levels [31]; thus, they can provide citizens with healthcare services in different areas, with speed, accuracy, and quality. Obviously, implementing an agent-based system is successful when it is done in accordance with the principles of legal, ethical, and social rules.

#### 5. Appropriate ICT Infrastructure

Providing appropriate ICT infrastructure (especially information, technical, and communicational infrastructure) is important for the successful implementation of agent-based systems. Also, sufficient investment in the purchase, design, implementation, maintenance, and updating of information systems is necessary [32-34].

### III. Special Key Factors in CHF Disease Management through MAS Approach

#### 1. Design

Designing an agent-based system in CHF management must be aligned with organizational goals and compatible with health personnel tasks [35]. Some of the most important factors that have been identified in designing such a system include the following: defining e-Health service content exactly [36], responsibility in all parts identified [37], and designing based on standard methods in a way that satisfies user needs. The first step in designing an agent-based system is studying the scenario in the domain of the usage system carefully and identifying all of the actors and the main tasks. In the next phase, the role of each actor must be defined and their activities in the area must be studied to determine all of their interactions in the agent-based system [38]. Furthermore, defining a proper strategy to select the best actions is very important [39]. In designing an agent-based system, items, such as robustness, efficiency, and communication challenges in cooperation between agents must be considered and suitable plan for them must be provided [40].

#### 2. Architecture

Several important points must be considered in the architecture of a CHF disease agent-based management system. Knowledge management based on MAS should be used to ensure knowledge currency, and a flexible, extensible, and open architecture platform should be developed [41]. The Java agent development framework is a middleware developed and standard platform for MASs. This software is based on Java and Foundation of Intelligent Physical Agent standards. It is easy to use and has advantages, such as the capa-

bility of interoperating with other agents, uniformity, and portability [42]. Use of this middleware as a standard platform can be useful. Another important element that should be considered in the architecture of agent-based systems in CHF management is the application of an appropriate ontology, such as GALEN, UMLS, or SNOMED, to facilitate and accelerate the retrieval and integration of health information and support effective communication in systems based on agent technology. Ontology is the official, exact, and complete description of implications and relationship between concepts and individuals (often but not always) that enables the generation of interoperability standards and provides a common vocabulary [43-45]. Standards for data exchange between MAS and related tools and system interoperability with Electronic Health Records and other IT tools are key factors [46,47]. Also, using Web services to interact with different systems and providing various needs of all users is necessary [17].

### IV. Conclusion

Chronic diseases like CHF leads to reduced productivity and increased healthcare costs. The prevalence of CHF is rising. Educating patients and helping them to use self-management programs can decrease hospital re-admission. The use of modern ICT tools is the best way to prevent CHF and thus provide, appropriate healthcare management, and increase people empowerment. The architecture of agent-based systems allows high interoperability, and efficient information management, and appropriate sharing data sharing. Clearly, identifying and resolving technical and non-technical challenges are vital to the successful implementation of this technology. Thus, in the design and implementation of agent-based systems many issues should be considered. Information confidentiality and privacy issues and reduced face-to-face communication between patients and doctors can lead to increased stress for in some CHF patients. System must be designed using an appropriate architecture and following communication standards and protocols. The mode of communication between agents, ethical and legal aspects, feedbacks, user attitudes, appropriate readiness, stakeholders supports to use technology, budgeting, motivations, coverage healthcare costs based on MASs by insurance company, hierarchy, cost afford, identification opportunities and barriers, designing and creating a database that is rich in order to provide support of various formats and training and tasks and backup of database.

It should be noted that the use of agent systems only with a technical view is associated with many problems, such as

lack of user acceptance. Hence, in delivering healthcare to CHF patients, considering social and human aspects and the involvement of end users and consideration of their needs in all phases of a project is essential. Also, for users, especially elderly people, special attention should be paid to ease of use and user friendliness.

## Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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