Palliative Care and Multi-Agent Systems

Subjects: Others

Contributor: Kimberley C. Brondeel , Sheina A. Duncan , Patrick M. Luther , Alexandra Anderson , Pranav Bhargava , Chizoba Mosieri , Shahab Ahmadzadeh , Sahar Shekoohi , Elyse M. Cornett , Charles J. Fox , Alan D. Kaye

Palliative care is intended to relieve caregivers of physical, psychological, and even spiritual elements of care. One of the most prevalent issues facing this form of care is a lack of healthcare resources and structures to deal with an aging population. This aging population is placing a strain on the healthcare system, prompting a need for a shift in system management. A potential answer to this issue may be the Multi-Agent System (MAS). This category of computerized networking system was created by programmers to gather relevant health information on a patient and allow for the system to act with other agents to decide the best course for disease management. It can also allow for a multidisciplinary healthcare team to make more informed plans of actions for their patients by providing accurate and up-to-date information resulting from a greater synergetic mesh. MASs could fulfill the demands of a rising chronic illness population and deliver high-quality care, indicating a major paradigm shift within the US.

palliative care chronic disease multi-agent systems

1. Introduction

Palliative care is a healthcare specialty developed in the 1960s to provide quality care and comfort to patients with serious and terminal diagnoses and has since become a staple for healthcare across the world ^[1]. It is designed to ease the burden of care on family members or friends, by providing for physical, psychological, and even spiritual aspects of care ^[1]. It can accompany the healthcare provided to those with diagnoses such as kidney disease, HIV, and cancer. A team consisting of physicians, nurses, mental health experts, and clergy or other religious professionals work together to address the patient's needs ^[1]. With increased quality of life and greater symptom management, the usefulness of palliative care is widely recognized ^[2]. The US suffers from a chronic illness epidemic that may be remediated in part through expanded palliative care to those who suffer from it ^[3]. This expansion of palliative care will no doubt incur costs and require the need for increased palliative care workers. The Multi-Agent System (MAS) is designed to meet the needs of an expanding population of individuals with chronic illness and provide high-quality care by utilizing various agents to monitor the health of patients and make decisions independent of human intervention ^[4]. This model is designed to compensate for the increased resource cost, and thus could mitigate those with expansive palliative care. In planning to improve and expand palliative care in the US and worldwide, this model and other clinical considerations must be evaluated. The relationship of these various factors is displayed below (**Figure 1**).



Figure 1. The increased prevalence of chronic disease from factors that contribute to greater longevity via vaccination and antibiotics, poor lifestyle, and genetic factors leads to increased mortality and stress on the healthcare system. The use of palliative care to treat and remediate chronic disease can lead to decreased mortality and greater management of symptoms than the current system can account for. Unfortunately, the increased volume of patients through palliative care would increase overall costs and need for more palliative care professionals; however, the use of multi-agent systems can mitigate these costs by providing the changes necessary to correct health course without need for human intervention and by providing a level of synergy to the healthcare system that is currently lacking.

2. Chronic Disease and Contributing Factors

The prevalence of chronic disease within the United States has seen marked increases in the last few decades. In 2007, nearly half the population suffered from at least one chronic disease ^[5]. Data from 2022 suggests this number now encompasses almost 60% of Americans ^[6]. The staggering growth of an almost 10% increase in only 15 years' time is related to multiple factors that have harmonized to produce a cacophonous dilemma, which is to say that the United States is facing a chronic disease epidemic. The contributing factors to this epidemic include increasing sanitation/vaccines/antibiotics. longevity due to improved poor lifestyle choices in the form of overeating/sedentation/smoking, and genetic factors that predispose one to chronic disease.

Another contributing factor to increasing chronic disease is the poor lifestyle seen within the US. Some of the high-risk factors for chronic disease that the CDC recommends avoiding are smoking, drinking, and a sedentary lifestyle ^[Z]. Smoking habits within the US have seen decreases, from 20.9% in 2005 to 12.5% in 2020 ^[8]. The incidence of drinking

within the US is nearly 50% with binge drinking at nearly $17\% \frac{9}{2}$. The prevalence of obesity in the US from 2017–2020 was 41.9%, with the prevalence in non-Hispanic black adults as high as 49.9% $\frac{10}{2}$.

As the US struggles to treat these individual factors, the incidence of chronic disease is ever increasing. This places high demand on the healthcare system in the form of reactive rather than proactive care. When untreated, chronic illnesses progress gradually and thus individuals with chronic conditions require more long-term treatment. One such long-term treatment is palliative care, which is a branch of medicine that involves multidisciplinary care for the symptoms associated with advanced chronic illnesses. In the context of the US, palliative care is high-level care from a multidisciplinary team with efforts focused on curative ends [11]. Hospice care shares the same aspects as palliative care; however, it differs fundamentally in terms of comfort measures only because curative efforts have been largely abandoned [11]. Palliative and hospice care have been proven to improve the quality of life and medical care in end-oflife treatment [12]. With improved life expectancy and the contributing factors therein, the question of how these patients suffering from chronic illness will be cared for is of increasing import. The current medical system allots over 80% of its expenses to chronic disease treatment per year ^[13]. Despite the magnitude of the expenditures devoted to the treatment of chronic illness, data projects that the prevalence of chronic illness will continue to increase ^[5]. Therefore, the need for a new medical system, or one bolstered with a more powerful synergistic factor, is of great necessity in order to combat this growing epidemic. A potential candidate for this position may be the Multi-Agent System (MAS). With MASs, a system of agents can make predictions on the steps needed to improve the patient's health and can be updated in real time at a central location, and thus may allow for an additional layer of synergism to be added to the healthcare schema ^[4]. The use of this system could greatly expand and make efficient the resources that are already present, mitigating the increased costs of instituting palliative care as a healthcare standard in the treatment of chronic disease.

3. Multi-Agent Systems and Palliative Care

Multi-agent systems are computerized networks that use agents to cross-reference and monitor relevant health data on a patient and then proactively or reactively make changes to benefit the patient without the need for human intervention ^[4]. The "agents" referred to in this framework are individual programs that can use artificial intelligence techniques in order to act on and correct course to a desired goal or range, as programmed ^[4]. These agents are highly variable in their specified capability as interpreted by their given programming; however, all agents must have three aspects: sociability, pro-activeness, and responsiveness ^[14]. Sociability refers to the interaction of the agent with other agents, physicians, and patients in an effort to solve a problem. Pro-activeness is the ability to predict the need for action before prompted and make efforts to mitigate that eventuality. Responsiveness refers to the ability to perceive the directed environment and make changes ^[14]. The principal advantage and usefulness of multi-agent systems is the ability to have multiple entities that will interact with differential capacities to reach a solution to a proposed problem through cooperation, coordination, and negotiation ^[14].

Multi-agent systems exist to combine the efforts of these agents to provide a more wholistic spectrum of care, make efficient use of existing resources, and reduce costs to the system they are engaged in. MASs enhance complex problem-solving capabilities amongst healthcare system collaborators to provide effective care to various patient populations. By 2030, approximately 20% of the U.S. population will be older than age 65. Therefore, there is a growing

need for a more cost-effective healthcare decision-making platform ^{[15][16]}. Multi-agent systems provide solutions for multiple healthcare sectors, such as organ transplantation and palliative care, due to the number of stakeholders required to make a shared medical decision ^{[17][18]}. Different stakeholders in healthcare include, but are not limited to, patients, doctors, medical institutions, governments, and medical insurance agencies ^[19]. MASs address a significant barrier within healthcare systems: interoperability ^[20]. In healthcare, solving problems requires the coordination of numerous individuals with different skills and functions, and the required knowledge is spatially distributed in different places ^[17]. To provide the best treatment possible, it would be of great benefit for all agents and knowledge to be significantly coordinated. This coordination begets a level of interoperability that the current systems do not have. Interoperability implements a space for the coordination of actions and the exchange of information ^[21]. The application of MASs within healthcare can monitor and coordinate all stakeholders who perform different tasks based on distinct information in order to devise a comprehensive solution to a patient's problem. This makes them a viable solution in the managing, coordinating, controlling, and modeling of many different healthcare problems ^[22]. It quickly becomes more of a requirement than an option, particularly in health information systems ^[20].

MAS interoperability promotes other important characteristics, such as proactivity and autonomy, that are applicable to healthcare services ^[17]. These services include locating medical centers with certain specifications (i.e., palliative care in Houston, TX), accessing and/or updating medical records, and making an appointment to be evaluated by a specific physician ^[17]. Suppose a MAS is aware a patient has a specific medical condition and is traveling. In that case, it can proactively search for information regarding medical centers in town that can address their medical condition in case of an emergency ^[17]. The proactive behavior of agents allows actions that are not directly requested to be performed by rapidly retrieving, analyzing, and selecting required information for healthcare providers while also simultaneously integrating access to huge online information services ^[22]. Regarding autonomy, each stakeholder operates based on its knowledge and information retrieved from its domain ^[17]. However, MASs permit independent, autonomous entities to communicate and coordinate succinctly for pertinent determinations about patient care and thrive in dynamic and unpredictable environments ^{[17][23]}.

There are multiple advantages to MAS implementation in healthcare. MASs perform well at addressing the goals of complex healthcare systems, including correct health data management, providing users with appropriate information to enhance the integrity and quality of healthcare, timely and accurate access to information, and minimizing medical errors ^[23]. They can be useful in monitoring patients through continuous assessment of symptoms and signs of disease, checking compliance with self-management programs, allowing improvement of treatment and patient outcomes, resource use, and effectively decreasing the cost of healthcare ^[24]. For example, the importance of follow-ups in patients with chronic heart failure (CHF) resides in reducing common causes of re-admission and deterioration of health status, which ultimately, if not mitigated, will impose physical and spiritual costs on both patients and society ^[24]. The continuous monitoring and appropriate application of proactive, effective, and affordable resources can decrease the burden on both patients and society. MASs can also address barriers to access to healthcare by minimizing unnecessary physical medical appointments through the provision of real-time data on patient statuses to healthcare providers. The obvious streamlining that this system would provide warrants study of the downstream effects it could potentiate amongst healthcare worker satisfaction and burnout rates.

4. Conclusions

The aging population within the US is growing and will continue to cause greater strain on the healthcare system. If instituted as a healthcare standard for patients with chronic illness, palliative care services powered by MASs could satisfy the requirements of an ever-growing chronic illness-stricken population, while also providing high-quality healthcare. The use of MASs may prove to be a necessary paradigm shift in healthcare as the chronic disease patient population continues to expand. While many efforts have been made to prevent chronic disease before it begins, it is imperative that greater care be offered to those already suffering from it. Given the success of several studies that have shown the advantageous nature of MASs as a healthcare standard, this system is worthy of further investigation and potentially implementation as a staple healthcare system that may vastly improve our health as a nation.

References

- 1. Al-Mahrezi, A.; Al-Mandhari, Z. Palliative Care: Time for Action. Oman Med. J. 2016, 31, 161–163.
- Palliative Care Improves Quality of Life. Available online: https://newsinhealth.nih.gov/2017/01/palliative-care-improves-quality-life (accessed on 6 January 2023).
- 3. Palliative Care and Disease Types|Get Palliative Care. Available online: https://getpalliativecare.org/whatis/disease-types/ (accessed on 6 January 2023).
- Alva, H.; Sequeira, A.H.; Narayana, V.N. Proactive Approach to Palliative Care through Routine Monitoring by Home Caregivers Using Multiagent Systems: A Conceptual Framework. Rochester, NY. 2017. Available online: https://papers.ssrn.com/abstract=3022771 (accessed on 6 January 2023).
- 5. 071204_H4L_FocusonWellness.pdf . Available online: https://www.aha.org/system/files/content/00-10/071204_H4L_FocusonWellness.pdf (accessed on 6 January 2023).
- Hoffman, D. Commentary on Chronic Disease Prevention in 2022. National Association of Chronic Disease Directors. Available online: https://chronicdisease.org/wpcontent/uploads/2022/04/FS_ChronicDiseaseCommentary2022FINAL.pdf (accessed on 6 January 2023).
- 7. How You Can Prevent Chronic Diseases|CDC. Available online: https://www.cdc.gov/chronicdisease/about/prevent/index.htm (accessed on 6 January 2023).
- CDC Current Cigarette Smoking Among Adults in the United States. Centers for Disease Control and Prevention. 2022. Available online: https://www.cdc.gov/tobacco/data_statistics/fact_sheets/adult_data/cig_smoking/index.htm (accessed on 6 January 2023).
- 9. Data on Excessive Drinking|CDC. Available online: https://www.cdc.gov/alcohol/data-stats.htm (accessed on 6 January 2023).
- 10. CDC Obesity is a Common, Serious, and Costly Disease. Centers for Disease Control and Prevention. 2022. Available online: https://www.cdc.gov/obesity/data/adult.html (accessed on 6

January 2023).

- Palliative Care vs. Hospice: Which to Choose. CaringInfo. Available online: https://www.caringinfo.org/types-of-care/what-is-the-difference-between-palliative-care-and-hospicecare/ (accessed on 6 January 2023).
- 12. Cruz-Oliver, D.M. Palliative Care: An Update. Mo. Med. 2017, 114, 110–115.
- 13. Chronic Disease in the United States: A Worsening Health and Economic Crisis. AAF. Available online: https://www.americanactionforum.org/research/chronic-disease-in-the-united-states-a-worsening-health-and-economic-crisis/ (accessed on 6 January 2023).
- A Roadmap of Agent Research and Development. Available online: https://www.researchgate.net/publication/220660843_A_Roadmap_of_Agent_Research_and_Development (accessed on 6 January 2023).
- 15. Bureau, U.C. Older People Projected to Outnumber Children for First Time in U.S. History. Census.gov. Available online: https://www.census.gov/newsroom/press-releases/2018/cb18-41population-projections.html (accessed on 6 January 2023).
- 16. Anderson, L.A.; Goodman, R.A.; Holtzman, D.; Posner, S.F.; Northridge, M.E. Aging in the United States: Opportunities and Challenges for Public Health. Am. J. Public Health 2012, 102, 393–395.
- Moreno, A. Medical Applications of Multi-Agent Systems. 12 April 2003. Available online: https://www.researchgate.net/publication/2901914_Medical_Applications_of_Multi-Agent_Systems (accessed on 6 January 2023).
- 18. Shakshuki, E.; Reid, M. Multi-Agent System Applications in Healthcare: Current Technology and Future Roadmap. Procedia Comput. Sci. 2015, 52, 29–34.
- Yu, W.; Liu, X.; Zhao, F.; Li, M.; Zhang, L. Control of unreasonable growth of medical expenses in public hospitals in Shanghai, China: A multi-agent system model. BMC Health Serv. Res. 2020, 20, 490.
- 20. Cardoso, L.; Marins, F.; Portela, F.; Santos, M.; Abelha, A.; Machado, J. The Next Generation of Interoperability Agents in Healthcare. Int. J. Environ. Res. Public. Health 2014, 11, 5349–5371.
- 21. Pollard, A.J.; Bijker, E.M. A guide to vaccinology: From basic principles to new developments. Nat. Rev. Immunol. 2021, 21, 83–100.
- 22. Safdari, R.; Shoshtarian Malak, J.; Mohammadzadeh, N.; Danesh Shahraki, A. A Multi Agent Based Approach for Prehospital Emergency Management. Bull. Emerg. Trauma 2017, 5, 171–178.
- 23. Mohammadzadeh, N.; Safdari, R.; Rahimi, A. Multi-agent systems: Effective approach for cancer care information management. Asian Pac. J. Cancer Prev. APJCP 2013, 14, 7757–7759.
- 24. Mohammadzadeh, N.; Safdari, R.; Rahimi, A. Multi-Agent System as a New Approach to Effective Chronic Heart Failure Management: Key Considerations. Healthc. Inform. Res. 2013, 19, 162–166.

Retrieved from https://encyclopedia.pub/entry/history/show/100057