Study Protocol
http://mjiri.iums.ac.ir
Medical Journal of the Islamic Republic of Iran (MJIRI)

Med J Islam Repub Iran. 2025 (16 Jul);39.95. https://doi.org/10.47176/mjiri.39.95

A Study Protocol for the Macro-analysis of Iran's Health System with System Dynamics Approach

Mozhgan Emami[1], AliAkbar Haghdoost[2], Vahid Yazdi-Feyzabadi[3,4], Esmaeil Khedmati Morasae[5], Mohammad Hossein Mehrolhassani[6,7]*

Received: 25 Dec 2024 Published: 16 Jul 2025

Abstract

Background: The health system (HS) is characterized by its complexity and the interconnectivity of its various components, which can lead to unpredictable outcomes when faced with changes in the environment. Understanding these interactions is crucial for effective management and improvement of the system. To navigate this complexity, this study emphasizes the importance of adopting a real-world perspective and utilizing system modeling techniques. These approaches allow for a thorough analysis of the current state of the HS and enable the testing of different policy alternatives to identify potential improvements. Ultimately, the aim of the research is to pinpoint the key components and drivers within the HS. By modeling the dynamics of these elements, the study aims to provide insights that can inform better decision-making and enhance the overall effectiveness of health care delivery.

Methods: We designed a mixed methods study in 4 phases, consisting of sequential quantitative and qualitative analyses. In the first phase, to create a comprehensive and holistic view, we will identify key variables and indicators in the HS within the framework of the Balanced Scorecard framework (BSC), which includes population & population health; service delivery; financing; growth & development; and governance & leadership, through a review of documents and a scoping review. In the second and third phases of the study, using a foresight and systemic approach, expert opinions will be purposefully gathered through cross-impact analysis (CIA) and scenario writing to identify key drivers and levers of Iran's HS and obtain compatible future scenarios. Finally, in the quantitative phase of the study, based on the outputs of the previous phases, a dynamic model of the HS will be designed in the Vensim software, and the current situation along with other possible scenarios for the system will be examined for a period of 10 years.

Conclusion: It is anticipated that the results of this study could offer a methodological foundation for formulating the health component of the Islamic Republic of Iran's economic, social, and cultural development plan, intended for use by the Ministry of Health, Treatment, and Medical Education.

Keywords: Systems Analyses, Systems Approach, Systems Thinking, System Dynamics Analysis, Complexity Analyses

Conflicts of Interest: None declared
Funding: *This study is part of a doctoral dissertation funded by an internal grant from Kerman University of Medical Sciences. The study did not receive any external financial support.*

This work has been published under CC BY-NC-SA 4.0 license.
Copyright© Iran University of Medical Sciences

Cite this article as: Emami M, Haghdoost AA, Yazdi-Feyzabadi V, Khedmati Morasae E, Mehrolhassani MH. A Study Protocol for the Macro-analysis of Iran's Health System with System Dynamics Approach. *Med J Islam Repub Iran.* 2025 (16 Jul);39:95. https://doi.org/10.47176/mjiri.39.95

Corresponding author: *Dr Mohammad Hossein Mehrolhassani, mhmhealth@kmu.ac.ir*

1. Health Services Management Research Center, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran
2. Modeling in Health Research Center, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran
3. Social Determinants of Health Research Center, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran
4. Department of Health Management, Policy and Economics, Faculty of Management and Medical Information Sciences, Kerman University of Medical Sciences, Kerman, Iran
5. Department of Management Science, Strathclyde Business School, University of Strathclyde, Glasgow, Scotland
6. Health Foresight and Innovation Research Center, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran
7. Department of Health Management, Policy and Economics, Faculty of Management and Medical Information Sciences, Kerman University of Medical Sciences, Kerman, Iran

↑What is "already known" in this topic:
Health systems (HS) are intricate social constructs that respond unpredictably to changes in their environment. To effectively predict their behavior, a thorough analysis of both the HS and its external factors is essential. Numerous studies have systematically examined each of the various HS issues.

→What this article adds:
This study emphasized the importance of employing the BSC framework, which takes into account various dimensions of the HS.
The cross-impact analysis method plays a crucial role in this framework by assessing the dependencies and influences among key components of the system. By visualizing these relationships in a diagram, it becomes easier to understand how different elements interact and affect one another.
Dynamic system modeling further enhances this understanding by creating stock and flow diagrams that quantify the HS's dynamics. By equating these diagrams, the model can predict the system's state over time. This comprehensive modeling approach allows for better forecasting and management of HSs, ultimately leading to improved outcomes.

[Downloaded from mjiri.iums.ac.ir on 2025-08-11]
[DOI: 10.47176/mjiri.39.95]

Introduction

Improving public health is the primary goal of government policy in every country, regardless of its level of economic development, although public health significantly impacts economic competitiveness; healthier individuals possess greater physical and mental capabilities, are more productive and creative, and contribute to the economic growth of society (1).

A health system encompasses a wide array of organizations, institutions, resources, and individuals dedicated to enhancing health outcomes. This system operates through a blend of public health strategies and healthcare facilities that cater to personal health needs, involving both governmental and nongovernmental entities. To effectively deliver health services, the system must provide preventive, promotional, curative, and rehabilitative care. These interventions should be accountable and equitable, ensuring that individuals are treated with dignity. The success of a health system relies on its ability to integrate various components, including staff, funding, information, supplies, and transportation, while maintaining effective communication and overall strategic direction (2).

Health systems (HSs) face issues such as sharply rising costs associated with safety, quality, and equity; an aging population; epidemiological changes; and increased public awareness and expectations (3). Therefore, this sector must continuously strive to improve performance, provide services, and operate according to community needs to sustain itself (4). Enhancing the performance of HSs requires systematic examination of information-based performance and thorough analysis of these systems to design effective strategies (3). Consequently, many countries at various levels of development interact with the World Health Organization (WHO) to improve their HS performance by exchanging ideas and experiences in key areas to refine and adjust their development programs (5). In this context, the WHO states that although no HS is perfect, understanding the system in its current form allows us to gain a comprehensive picture of how it functions and the interactions of its components in maintaining health (6).

The foundational structure of Iran's HS was initiated in 1905 and underwent formal institutionalization with the establishment of the Ministry of Health in 1941. This structure evolved further with the creation of the Ministry of Health and Welfare in 1975. In response to persistent public health challenges and suboptimal health indicators compared with international standards, the Iranian government implemented a nationwide health network in 1983, grounded in the principles of primary health care (PHC). Subsequently, in 1985, stewardship of the national health system was officially assigned to the Ministry of Health, Treatment, and Medical Education (MoHME), consolidating health service delivery with medical education and policy oversight.

At the provincial level, medical sciences universities are responsible for both delivering health services and training human resources in the healthcare sector. Iran's HS is structured around a network of urban and rural health centers, each serving designated populations and providing services across the 3 levels of disease prevention. When necessary, patients are referred from these centers to specialized and subspecialty hospitals. Although this network was originally designed to address the country's major health issues, it has faced ongoing challenges related to its structure, processes, and overall performance since its inception (7). Key issues include limited economic access to healthcare for certain population groups, a lack of applied data and research to support policy-making, insufficient intersectoral coordination, and weak management at both the network and referral system levels (8). Conducting a thorough review and analysis of the system presents a valuable opportunity to identify emerging needs and effectively address existing gaps (7).

HSs represent prototypical human organizations that integrate diverse professional roles and disciplinary domains within highly complex and dynamic operational contexts. Their behavior is shaped by nonlinear interactions, adaptive self-organization, and emergent properties, all of which underscore the inherent complexity of managing such systems (9). To examine the complexity of the HS and its changes in accordance with community needs and environmental conditions, comprehensive and evidence-based understanding and analysis of the HS is essential to evaluate all functions and operations concerning objectives in a holistic and coherent view. Various frameworks, methods, and tools have been proposed, among which the Balanced Scorecard framework (BSC) is an effective tool for considering and comprehensively evaluating performance while taking into account different dimensions and parameters (10). To put it differently, the BSC is the superior and most thorough framework across four dimensions: financial, internal processes, growth and learning, and customer. It provides crucial insights into both internal and external factors affecting the organization and its success (11).

While the BSC offers a holistic framework for assessing performance and exploring causal linkages among organizational dimensions, its application within HSs presents greater complexity due to their dynamic and multifaceted nature. As a result, there has been a notable surge in scholarly interest over the past 2 decades in areas such as systems thinking, complex adaptive systems, and systems science within the HS. Despite this growing body of literature, the majority originates from high-income countries, highlighting a significant gap in the application and exploration of these concepts in low- and middle-income settings. Most existing studies emphasize conceptual development or the use of systems thinking as a means to enhance HS performance (12).

Beyond the importance of adopting a comprehensive performance framework such as the BSC and embracing a systems-oriented perspective, strategic decision-making and foresight planning have also emerged as critical areas of focus among HS stakeholders (13). In HSs, a set of

[DOI: 10.47176/mjiri.39.95] [Downloaded from mjiri.iums.ac.ir on 2025-08-11]

factors that are not always predictable influences outcomes. Therefore, to understand the future and create a sense of control and stability, scenario analysis and the use of other predictive tools for strategic planning are recommended (14).

Creating scenarios allows for the reexamination of the structure and boundaries of the existing HS and also helps understand the nature and role of stakeholders in pursuing sustainable HSs. By synthesizing the results of key uncertainties, a set of scenarios emerges that indicates that future HSs may differ significantly from current states, thereby enhancing policymakers' and stakeholders' understanding of this area. Consequently, scenarios can elevate the understanding of policymakers and planners regarding the HS's governance uncertainties and provide insights for managing these uncertainties through the transformation of existing systems (15).

A growing body of research in Iran has applied the system dynamics (SD) approach to various domains within the HS, highlighting the relevance and versatility of this methodology. For instance, Mehrjerdi (2012) conducted a study exploring the interrelated effects of body weight, dietary behavior, physical activity, body fat percentage, medication use, and associated health conditions (16). Another investigation focused on modeling the dynamic interactions between production and pricing mechanisms in the pharmaceutical sector (17). In addition, Baibordy et al developed a SD-based model to evaluate and enhance human resource productivity within the HS of East Azerbaijan province (18). Bastan et al (2018) examined occupational health and safety management, uncovering complex feedback mechanisms through causal loop analysis (19). Yousefinejad et al analyzed the insurance sector, highlighting potential future deficits in insurance funds and challenges in financing medical expenses (20).

Collectively, the reviewed studies highlight the increasing recognition of systems thinking within health research, with dynamic modeling emerging as a vital tool for analyzing, understanding, and addressing complex health-related challenges. By utilizing data and identifying key variables, researchers have been able to conduct experiments and evaluate policy options, leading to the development of scenarios aimed at improving health outcomes. This methodological rigor underscores the potential of SD to inform decision-making in the HS.

What sets the current project apart is its integration of the BSC framework, which allows for a comprehensive examination of the HS's dimensions. As a result, considering the role of governance in achieving health on the one hand, and the complex nature of HSs and the necessity of adopting a comprehensive, systemic, and forward-looking perspective to enhance HS performance on the other hand, it is suggested to use a combination of CIA scenario writing methods based on SD within the framework of the fourth generation BSC. This approach would not only allow for macro and systemic analysis of the HS but also facilitate future-oriented decision-making, strategy formulation, and its operationalization, thereby laying the groundwork for developing HS programs in each country.

Methods

Study Design

This study adopts a sequential transformative mixed-methods design, structured into 4 distinct phases.

In the initial phase, key macro-level variables pertinent to the HS are identified through a comprehensive scoping review and document analysis. These variables are subsequently classified using the BSC framework to ensure systematic categorization.

During the second phase, the previously identified variables are transformed into a structured questionnaire format and distributed among academic experts and professionals with specialized knowledge in HS-related issues and dimensions. Concurrently, by utilizing the CIA method within the MICMAC software environment, the driving forces and uncertainties influencing Iran’s HS are determined, alongside mapping their interdependencies.

In the third phase, potential and desirable future scenarios are constructed based on the level of significance and uncertainty associated with leverage and driving variables. This is achieved through the application of Scenario Wizard software, which facilitates scenario development grounded in expert input and systemic relationships.

Finally, in the fourth phase, a system dynamics model is developed using Vensim software. This quantitative modeling process incorporates causal relationships between variables derived from earlier phases and aligns them with the objectives outlined in the sixth national health development program. The model aims to simulate both current and ideal states of the HS across various plausible scenarios over a 10-year horizon (see Figure 1 and Appendix 1 for further details).

Research Methods

In this study, the BSC framework has been used to identify and categorize key components in each of the dimensions of the HS while considering the causal relations between them.

The BSC, introduced by Kaplan and Norton in 1992, has been the most important tool for strategy implementation over the past decade and has evolved through 4 generations over time. In the first generation, the multitude of defined indicators was the main challenge of this model, which was addressed in the second generation. The abundance of indicators and the lack of dependency and causal relationships between them posed a challenge in the second generation of the BSC, which was resolved with the introduction of the third generation and the emergence of strategy-oriented concepts, strategy maps, and strategic alignment. However, the biggest challenge organizations faced in implementing the BSC was the inability to operationalize and somehow link strategies with organizational operations, a challenge that was also addressed in the fourth generation. The strategy map in the fourth generation defines a coherent architecture of strategies and solutions across different perspectives, along with illustrating the causal relationships between them (21).

According to the BSC framework and dimensions of the HS, a proposed comprehensive model for monitoring and

[Downloaded from mjiri.iums.ac.ir on 2025-08-11]

[DOI: 10.47176/mjiri.39.95]

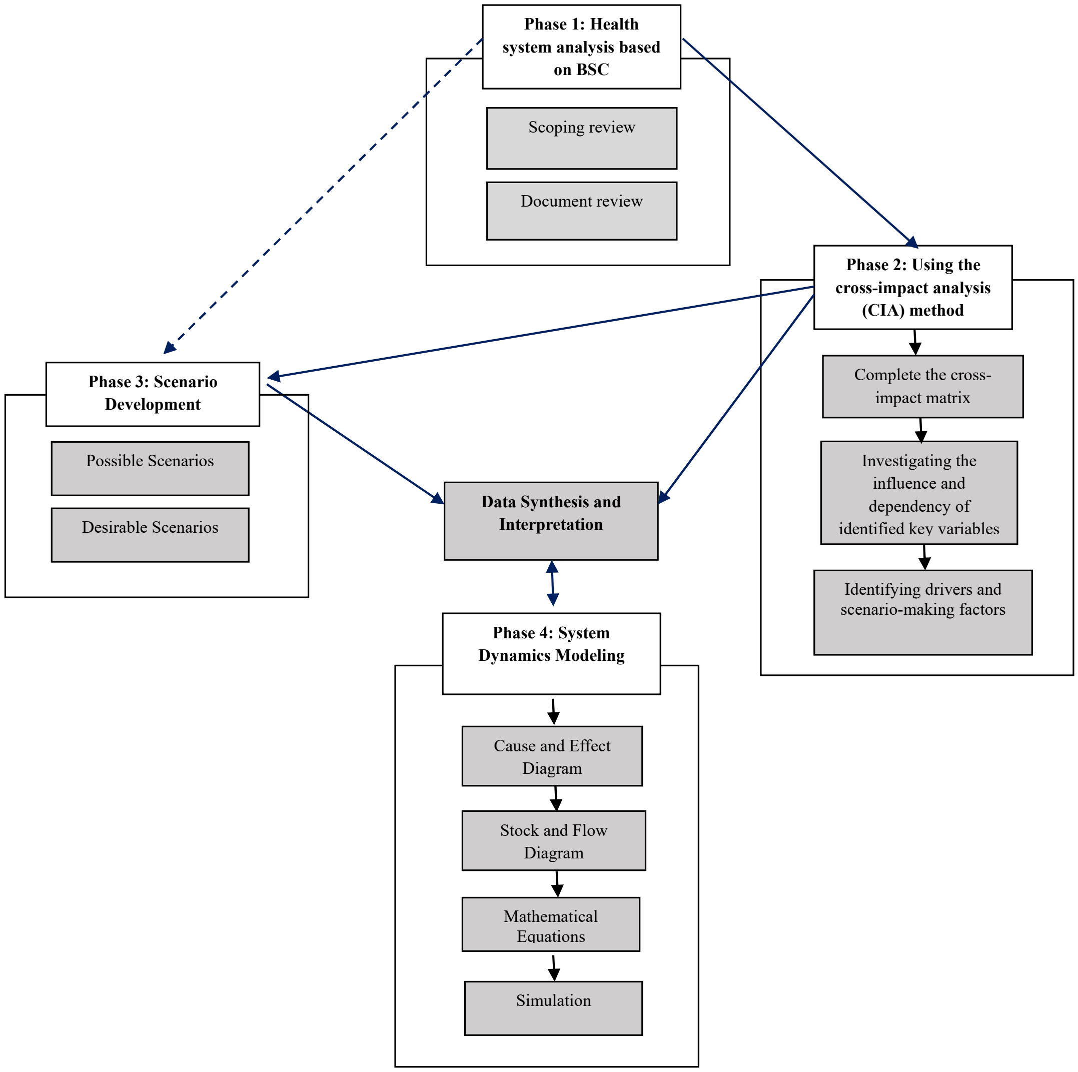

Figure 1. Study phases according to different stages of dynamic system design

evaluation of the system was extracted, aiming to enhance communication and provide a clear context for planning, implementation, and supervision within the HS. The model comprises 5 key components: governance and leadership, population health, service delivery, financing, and infrastructure (growth & development). Each component plays a crucial role in the overall functionality and effectiveness of the HS (10).

The method is designed based on phases and stages of study, beginning with a document review stage. During this stage, relevant documents, laws, regulations, reports, and programs related to the operational domain of the HS are examined to identify the influencing variables and indicators in each dimension of the BSC, which are then analyzed content-wise.

During the scoping review stage, articles are retrieved from selected databases using predefined search strategies (Appendix 2). The process of identifying keywords begins with selecting highly relevant terms, which are then expanded by incorporating synonyms and related concepts associated with SD in HSs, informed by expert input and supplementary online searches. Following the initial search within the defined time frame, duplicate records are removed using EndNote, and irrelevant studies are excluded based on title and abstract screening. The remaining articles are classified into 3 categories based on their relevance to the research topic: fully relevant, partially relevant, and irrelevant. Full texts of the fully and partially relevant articles are reviewed to confirm their alignment with the study objectives, and key insights from each are extracted and organized. To ensure consistency and minimize inter-rater variability, the initial screening and review process is conducted by a single reviewer. Each selected article is then carefully analyzed to identify key concepts. Data from the included studies are analyzed using a framework analysis approach. A 2017 study, for instance, offers a BSC framework for HS performance monitoring, adapted from the WHO's global model (10).

[DOI: 10.47176/mjiri.39.95] [Downloaded from mjiri.iums.ac.ir on 2025-08-11]

After completing the data extraction table, two researchers independently code the data and identify emerging themes. Any disagreements in coding or thematic classification are resolved through group discussions with the full research team to achieve consensus.

In the second phase of the study, experts with significant experience in systemic health management will be selected through purposive sampling. These individuals will be selected based on academic experience (more than ten years of experience, academic rank of associate professor or higher) and executive experience (employment at the national and provincial levels in various departments of the system). The aim is to gather diverse perspectives from 12 knowledgeable experts who are willing to participate in the research.

In this phase, the CIA method will be used to collect and analyze data, which is considered part of soft systems thinking approaches. CIA is a very useful tool for qualitatively analyzing complex issues and identifies those variables that play a significant and notable role in the system's future development (22). Thus, the application of systems thinking—through the analysis of interrelationships among health system components and their contextual influences, as well as the assessment of cross-impacts—enables a comprehensive evaluation of the potential outcomes of policies and interventions (23).

This phase will be designed and implemented in three stages. In the first stage, a list of key variables derived from the scoping review and examination of documents is compiled. In the second stage, the identified variables will be presented to experts in the form of a questionnaire for scoring. The questionnaire will be designed to include criteria such as “data reliability,” “measurability,” “data availability,” and “clarity of the factor,” aimed at facilitating the selection and prioritization of key components. These will be rated using a 5-point Likert scale (1 = very low, 2 = low, 3 = moderate, 4 = high, 5 = very high). In addition, two other dimensions— “level of importance” and “degree of ambiguity or unpredictability of the factor”—will be assessed on a 10-point scale, in order to evaluate their influence on the future achievement of community health in Iran and the associated uncertainty surrounding these factors.

In parallel with the completion of the questionnaire, and based on the number of identified key variables, a cross-impact matrix will be constructed in Excel. This matrix will be populated through a series of structured expert meetings conducted in multiple rounds. During these sessions, participants will be asked to assess the influence of each variable (row) on every other variable (column) by assigning a score ranging from 0 to 3. In this scoring system, 0 indicates no impact, 1 denotes a weak impact, 2 reflects a moderate impact, and 3 represents a strong impact.

Subsequently, the completed cross-impact matrix will be imported into the MicMac software. This tool allows for the analysis of both direct and indirect relationships among variables. In addition to mapping direct interactions, MicMac utilizes a specialized algorithm to determine the strategic positioning of each variable within maps of direct and indirect influence. In the third stage of the analysis, variables exhibiting both high significance (with a Likert score >7) and considerable uncertainty (with a score above or near 5) will be identified. Specifically, variables located in the upper-left quadrant and above the diagonal in the lower-left quadrant of the MicMac influence map—often referred to as secondary levers—will be selected. These key driving forces will then be transferred into the Scenario Wizard software for scenario development in the next phase of the study.

Within the Scenario Wizard software, the mutual influence of different uncertainty/driving force alternatives is evaluated, and through statistical analysis, coherent and plausible future scenarios for the system under study are generated. The software utilizes a Cross-Impact Balance (CIB) matrix, which is populated using expert input from the health sector. Experts assign scores ranging from -3 to +3, where -3 represents a strong constraining influence, -2 indicates a moderate limiting effect, -1 reflects a weak negative influence, 0 denotes no influence, +1 signifies a weak positive effect, +2 represents a moderate reinforcing effect, and +3 indicates a strong reinforcing impact. Ultimately, the final scores from the participants will yield compatible future scenarios in the health domain, and the validity of the outputs will be assessed by referring to expert opinions. In writing the scenarios, efforts will be made to utilize qualitative insights from experts to systematically analyze the status of each driver and the key factors related to that driver within the context of each identified scenario, utilizing the qualitative opinions and insights of experts.

In the fourth phase of the study, system thinking and dynamic systems modeling methods will be used. Data collection for this model will involve secondary data from surveys, articles, and expert meetings, with the analysis conducted using Vensim software.

Systems thinking offers a novel perspective for analyzing complex phenomena and integrates a diverse array of tools and methodologies. In the health sector, certain system-oriented practices—such as cross-sectoral and interdisciplinary collaboration—have already been adopted to some extent and institutionalized to varying degrees. Consequently, systems thinking serves as a valuable framework for enhancing HSs and evaluating strategic interventions (24). Among the most important systems thinking approaches that have significant applications in the health sector is complexity theory (25, 26). Within this framework, dynamic systems modeling emerges as an appropriate approach for tackling the dynamic complexity inherent in numerous public health challenges. The dynamic systems approach involves developing computer simulation models that depict accumulation and feedback processes, allowing for systematic testing of effective policies (27). The goal of dynamic systems is to provide a conceptual model with the structure of complex systems for managers so they can intervene to ensure behavior aligns with objectives (28). Given that the complexity of interactions among all dimensions of the HS is evident to everyone today, addressing these challenges is essential for achieving an efficient and effective HS. Modeling systems with

[Downloaded from mjiri.iums.ac.ir on 2025-08-11]

[DOI: 10.47176/mjiri.39.95]

new dynamic modeling techniques that consider many key variables in measurement and analysis is of great importance (29).

In this study, the findings from the second and third phases, along with indicators associated with the health development program, will serve as the basis for constructing stock-and-flow diagrams and developing the dynamic systems model. Once the stock-and-flow structures are established, mathematical equations corresponding to the variables will be formulated using the general structure outlined below. Subsequently, the HS dynamic model will be implemented.

$X_i(t+dt)= X_i(t)+(R_i(t)-R_o(t))dt$

In other words,

$X=INTEG(R_i-R_o, X(0))$

- X: stock variable
- R_i: input rate variable to the stock variable
- R_o: output rate variable from the stock variable
- X(0): initial value of the stock variable

The study will explore various simulations, considering both desirable and undesirable scenarios to assess potential changes in health indicators during a decade. These changes will be informed by existing research and discussions held during Focus Group Discussions (FGDs).

Finally, the model will project the future state of Iran's HS during ten years, comparing the current situation with various scenarios. The outcomes will be presented through tables and graphs, providing a clear visualization of the expected changes in health indicators based on the simulations conducted.

Quality Assurance

This study focuses on establishing trustworthiness by adhering to Lincoln and Guba's assessment criteria, which emphasize the importance of credibility and dependability in research. The researchers are committed to executing the four phases of the study meticulously to ensure that the findings are reliable and valid.

To maintain objectivity, the researchers strive to gather information without bias or personal influence, aligning their efforts with the overarching goals of the research. This commitment to impartiality is crucial for producing credible results that can be trusted by stakeholders.

The outcomes of this study will culminate in the development of information software and a dashboard that can be utilized across various levels, including national, provincial, and regional. This practical application underscores the significance of the research in contributing valuable tools for decision-making and analysis.

Discussion

This study sought to develop a comprehensive, analytical, and forward-looking framework for Iran's HS strategy and methodology by encompassing all key components and functions—namely, financing, resource generation, service provision, and governance. Recognizing the complex, ambiguous, and uncertain nature of the HS and the necessity for a holistic perspective, the research adopts a futures-oriented and systems-based approach. Its objective is to generate concrete representations and credible, diverse narratives of plausible and coherent future scenarios for Iran's HS. With the necessary features for adopting a futures-oriented and systemic approach to the research topic, including complexity, ambiguity, uncertainty, and the need for holism, the study aims to provide tangible images and credible, diverse narratives of potential and consistent future scenarios for the HS in Iran. Thus, it is expected that this study will identify the driving variables and key uncertainties in Iran's HS within the BSC framework, and based on this, extract probable and desirable scenarios in the system. Subsequently, by designing a dynamic system model, the current and ideal states will be illustrated over 10 years. It is hoped that the output of this study will provide a roadmap for changing and improving the performance of the HS for the MoHME. In addition, the status of each component in each diagram, while being influenced by other system components, can help the policymaker to obtain policy alternatives to improve the system status, or the dynamic environment produced in this software can act as an information dashboard to measure the indicators and policies considered by the policymaker.

This study emphasizes the importance of ethical considerations, particularly in protecting the intellectual property of the researchers during the scoping review phase. The authors have adhered to ethical standards by avoiding plagiarism, dual publication, and ensuring the integrity of data without distortion or fabrication in the initial phase of the study.

Ethical Considerations

This study emphasizes the importance of ethical considerations, particularly in protecting the intellectual property of the researchers during the scoping review phase. The authors have adhered to ethical standards by avoiding plagiarism, dual publication, and ensuring the integrity of data without distortion or fabrication in the initial phase of the study.

Coordination efforts were made to schedule meetings and secure consent from participants for recording sessions, highlighting the importance of transparency and participant involvement. This process is crucial for fostering trust and ensuring that participants are fully informed about the research's purpose and nature.

Confidentiality is a key focus, with measures in place to protect participants' personal details and opinions. The researchers are committed to maintaining respect for participants' rights and ensuring that their information remains confidential throughout the study.

Study Limitations

The research on identifying influential components and their interrelationships within the HS is currently lacking both nationally and internationally. To address this gap, the study will involve a thorough review of the existing literature on each dimension of the HS, followed by focus group discussions to explore the relationships among these components using the BSC framework.

Access to relevant research may be limited due to potential restrictions on databases and journals not included in the MoHME's subscriptions. This limitation could hin-

[Downloaded from mjiri.iums.ac.ir on 2025-08-11]
[DOI: 10.47176/mjiri.39.95]

der the ability to obtain critical articles that are essential for a comprehensive understanding of the HS components and their interactions.

The complexity of the study's fourth phase, which involves modeling a dynamic system, may lead to challenges such as errors and interruptions in the work process. To mitigate these issues, the research team plans to consult with experts in SD and seek online training to enhance their understanding and execution of the modeling process.

Conclusion

This study aims to identify the key drivers and their complex interrelationships within Iran's HS, while considering national contextual factors and developmental goals. Using system dynamics modeling via Vensim software, the research provides policymakers with a robust analytical tool to assess, prioritize, and implement targeted health interventions and policies in a systematic and informed manner.

Additionally, the integration of a real-time monitoring dashboard strengthens decision-making capacity by enabling continuous tracking of critical health indicators and simulating the potential impacts of various policy alternatives. This innovation promotes more agile, evidence-based, and adaptive HS planning, thereby enhancing the system's ability to respond effectively to evolving public health challenges.

Authors' Contributions

The study was conceptualized, designed, and the research team assembled by M.E., M.H.M., A.A.H., V.Y.F., and E.Kh.M. M.E. was responsible for drafting the initial manuscript. M.H.M., A.A.H., and V.Y.F. contributed to the review and editing of the manuscript. The methodology and quality assurance were supervised by M.H.M., M.E., and V.Y.F. MHM served as the head of the scientific committee, while M.E. led the executive committee.

Ethical Considerations

This study was approved by the Ethics Committee of Kerman University of Medical Sciences under the code IR.KMU.REC.1397.287.

Acknowledgment

The authors extend their sincere appreciation to the experts in health management and policy-making from the universities of medical sciences, whose contributions were instrumental in modeling the HS's dynamic structure and providing valuable insights into potential scenarios for its future improvement.

Conflict of Interests

The authors declare that they have no competing interests.

References

1. Sigal AV, Bakumenko MA. The Level of the Country's Health Care as an Indicator of its Economic Development. Advances in Economics, Business and Management Research. 2020;128:1098-1103.
2. Indicators AH. Monitoring the building blocks of health systems. Geneva, Switzerland: WHO Document Production Services [serial online] 2010 [cied 2025 May 16]. Available from: https://iris.who.int/bitstream/handle/10665/258734/9789241564052-eng.pdf.
3. Kharazmi E, Bahrami MA, Bordbar Sh, Shayan Z, Gholampoor H. The Performance of Health Systems: An Assessment Framework and Comparison of Developed and Developing Countries. J Health Sci. 2023;11(2):342-350.
4. Mehrolhassani MH, Emami M, Haghdoost AA, Dehnavieh R, Amanpour S, Sabbah F, et al. Performance Assessment of Medical Universities using Balanced Scorecard and Analytical Hierarchy Process; 2013. Iran J Epidemiol. 2017;12(5), Special Issue (Efficiency and financial protection in the Health system of Iran):55-64. [In Persian]
5. World Health Organization. Strengthening Health Systems to Improve to Health Outcomes [serial online] 2007 [cited 2024 October 15]. https://iris.who.int/bitstream/handle/10665/43918/9789241596077_eng.pdf.
6. Zakus D, Bhattacharyya O, Wei X. Understanding Global Health. In: Markle W.H, Fisher M.A, Smego R.A, editors. Health Systems, Management, and Organization in Global Health. 2nd ed. The McGraw-Hill Companies; 2014. https://accessmedicine.mhmedical.com/content.aspx?bookid=710&sectionid=46796921.
7. Negarandeh R, Kamran A, Heydari H. Iran's Health System Performance in Achieving Goals Based on the World Health Organization's Framework: A Scoping Review. J Health Res. 2022;12(2):65-74.
8. Sedigheh Mirhashemi S, Kalantar Motamedi MH, Mirhashemi AH, Hamidreza Taghipour HR, Danial Z. Lancet. 2016;387:29-30.
9. Martínez-García M, Hernández-Lemus E. Health Systems as Complex Systems. Am J Oper Res. 2013:113-126.
10. Mehrolhassani MH, Haghdoost AA, Dehnavieh R, Abolhallaje M, Emami M. The Proposed Framework for Monitoring Health System. Iran J Epidemiol. 2017;12(5), Special Issue (Efficiency and Financial Protection in the Health System of Iran):92-96. [In Persian]
11. Rahimi H, Kavosi Z, Shojaei P, Kharazmi E. Key performance indicators in hospital based on balanced scorecard model. J Health Manag Inform. 2016;4(1):17–24.
12. Adam T. Advancing the application of systems thinking in health. Health Res Policy Syst. 2014;12(1):50.
13. Vollmar HCh, Thomas Ostermann Th, Redaèlli M. Using the scenario method in the context of health and health care – a scoping review. BMC Med Res Methodol. 2015;15:89.
14. Dennis C. Strategic planning—a health system operational perspective. J Hosp Manag Health Policy. 2019 Dec 13;3.
15. Esmaeili AK, Izadi M, Sanaei-Nasab H. Designing health system scenarios at the national level. Iran. J Health Educ Health Promot. Autumn 2021;9(3):296-310. [In Persian]
16. Zare Mehrjerdi Y. A system dynamics approach to healthcare cost control. International Journal of Industrial Engineering & Production Research. 2012 Sep 10;23(3):175-85.
17. Zare Mehrjerdi Y, Khani R, Hajimoradi A. System Dynamics Approach to Model the Interaction Between Production and Pricing Factors in Pharmaceutical Industry. J Qual Eng Prod Optim. 2020 Dec 29;5(2):163-88.
18. Baibordy L, Bafandeh Zendeh A, Aali S. Designing a human resource productivity model with a system dynamics approach in the health sector. Int J Nonlinear Anal Appl. 2022 May 23.
19. Bastan M, Azizi L, Groesser S, Sheikhahmadi F. Analysis of development policies in occupational health and safety management system: a system dynamics approach. InThe 2nd IEOM European International Conference on Industrial Engineering and Operations Management; 2018.
20. Yousefi Nezhad V, Izadbakhsh HR, Ghanbar Tehrani N, Ataeipoor S. Simulating the financial health system of Health insurance with System dynamics approach. Hakim Health System Research. 2016;18(4):306- 315. [In Persian]
21. Kaplan RS, Norton DP. The balanced scorecard –measures that drive performance the balanced scorecard – measures. Harvard Business Review; 1992. Pp. 71–9. Available from: http://libroweb.alfaomega.com.mx/book/385/free/data/Materiales/Capitulo01/TheBalancedScorecard.pdf.
22. Izadi A, Bahadori M, Teymourzadeh E, Yaghoubi M, Ravangard R.

[Downloaded from mjiri.iums.ac.ir on 2025-08-11]
[DOI: 10.47176/mjiri.39.95]

A foresight study of factors affecting the health system research and technology. J Educ Health Promot. 2019 Jan 1;8(1):219.
23. Atun R. Health systems, systems thinking and innovation. Health Policy Plan. 2012;27:iv4–iv8.
24. Swanson RC, Cattaneo A, Bradley E, Chunharas S, Atun R, Abbas KM, et al. Rethinking health systems strengthening: key systems thinking tools and strategies for transformational change. Health Policy Plan. 2012 27(suppl_4):iv54-iv61.
25. Thompson DS, Fazio X, Kustra E, Patrick L, Stanley D. Scoping review of complexity theory in health services research. BMC Health Serv Res. 2016;16(1):87.
26. Sturmberg JP, Martin CM, Katerndahl DA. Systems and complexity thinking in the general practice literature: an integrative, historical narrative review. Ann Fam Med. 2014;12(1):66–74.
27. Homer JB, Hirsch GB. System dynamics modeling for public health: background and opportunities. Am J Public Health. 2006 Mar;96(3):452-8.
28. Jackson M.C. Thinking-Creative Holism for ManAs. UK: University of Hull, John-Wiley-Sons.Systems; 2003.
29. Mehrjerdi YZ. A system dynamics approach to healthcare cost control. Int J Ind Eng. 2012;23(3):175–85.

[Downloaded from mjiri.iums.ac.ir on 2025-08-11]

[DOI: 10.47176/mjiri.39.95]

Appendix 1. Study protocol for macro analysis of the Iranian HS with a systems approach

Expected Output	Data analysis method	Data source and collection method	Theoretical Framework/General Research Methodology at Each Stage		
1 .Determining the main indicators of the HS in the Population and Population Health Dimension; 2 .Determining the main indicators of the HS in the Service Delivery Dimension; 3 .Determining the main indicators of the HS in the growth and development /infrastructures dimension 4 .Determining the main indicators of the HS in the financing dimension; 5 .Determining the main indicators of the HS in the dimension of governance and leadership (stewardship);	Content analysis method	Review of laws, regulations, reports and programs related to the functional area of health	Document Review	Stage one	Phase One
1 .Determining the main variables/components of the HS in the Population and Population Health Dimension; 2 .Determining the main variables/components of the HS in Service Delivery Dimension; 3 .Determining the main variables/components of the HS in the growth and development /infrastructures dimension; 4 .Determining the main variables/components of the HS in the financing dimension; 5 .Determining the main variables/components of the HS in the dimension of governance and leadership (stewardship);	Framework analysis method	Articles searched in the period 1975-2020 based on selected strategies from the sites in question	Scoping Review	Stage two	
1. Extraction of key drivers and uncertainties in the Iranian HS 2. Identification of the sustainability status of the Iranian HS	Questionnaire scoring based on Likert scale and completing the matrix based on the degree of influence and impact of variables and analyzing the output of the MicMac software based on the location of variables in the map of direct and indirect impacts	1. Developing a questionnaire and completing it based on a survey of experts 2. Completing the cross-impact matrix in Excel software based on a survey of experts and entering it in the MicMac software	Cross Impact Analysis)CIA(	Phase Two	
Extraction of compatible future scenarios in the HS	Completing the CIB matrix based on the degree of influence and impact of each of the uncertainty/driving alternatives on each other	Completing the cross-impact-balance (CIB) matrix in Scenario Wizard software based on a survey of experts	Scenario development	Phase Three	
1. Simulation of the current state of the Iranian HS in the next ten years and comparison with other possible situations/scenarios and, as a result, the possibility of changing and improving the situation	Dynamic modeling of the Iranian HS in each of the BSC dimensions in each view of the software, performing mathematical equations for each variable based on secondary data and a survey of experts and simulating the base state of the system between 2021-2031 and simulating different states of the system based on a survey of experts	Designing stock and flow diagrams in the Vensim software	Dynamic modeling of the Iranian HS	Phase Four	

[Downloaded from mjiri.iums.ac.ir on 2025-08-11]

[DOI: 10.47176/mjiri.39.95]

Appendix 2. Structured search method of databases and findings obtained in preliminary search based on the names of the studied databases

Keywords	Database name	Raw
(dynamic OR dynamics OR "system dynamics" OR "Dynamic model" OR "Nonlinear Dynamics" OR "Complex system") AND ("health center" OR "medical services" OR Hospitals OR "medical institution" OR "clinic" OR infirmary OR sanatorium OR "nursing home" OR "convalescent home" OR "Health system" OR hospice) AND (financing OR "financial performance" OR "financial ratio" OR "financial affairs" OR funding OR resource generation OR subsidy OR health information system OR financial OR "human resources" OR "financial state" OR "cash flow" OR budget OR cost OR payments OR "equipment & drugs" OR "leadership & governance" OR "health services delivery" OR "health provision" OR stewardship OR "consumer health" OR "population health")	Scopus	1
(dynamic OR dynamics OR "system dynamics" OR "Dynamic model" OR "Nonlinear Dynamics" OR "Complex system") AND ("health center" OR "medical services" OR Hospitals OR "medical institution" OR "clinic" OR infirmary OR sanatorium OR "nursing home" OR "convalescent home" OR "Health system" OR hospice) AND (financing OR "financial performance" OR "financial ratio" OR "financial affairs" OR funding OR resource generation OR subsidy OR health information system OR financial OR "human resources" OR "financial state" OR "cash flow" OR budget OR cost OR payments OR "equipment & drugs" OR "leadership & governance" OR "health services delivery" OR "health provision" OR stewardship OR "consumer health" OR "population health")	Web of Science	2
(dynamic OR dynamics OR "system dynamics" OR "Dynamic model" OR "Nonlinear Dynamics" OR "Complex system") AND ("health center" OR "medical services" OR Hospitals OR "medical institution" OR "clinic" OR infirmary OR sanatorium OR "nursing home" OR "convalescent home" OR "Health system" OR hospice) AND (financing OR "financial performance" OR "financial ratio" OR "financial affairs" OR funding OR ″resource generation″ OR subsidy OR ″health information system″ OR financial OR "human resources" OR "financial state" OR "cash flow" OR budget OR cost OR payments OR "equipment & drugs" OR "leadership & governance" OR "health services delivery" OR "health provision" OR stewardship OR "consumer health" OR "population health")	PubMed	3
(dynamic OR dynamics OR "system dynamics" OR "Dynamic model" OR "Nonlinear Dynamics" OR "Complex system") AND ("health center" OR "medical services" OR Hospitals OR "medical institution" OR "clinic" OR infirmary OR sanatorium OR "nursing home" OR "convalescent home" OR "Health system" OR hospice) AND (financing OR "financial performance" OR "financial ratio" OR "financial affairs" OR funding OR resource generation OR subsidy OR health information system OR financial OR "human resources" OR "financial state" OR "cash flow" OR budget OR cost OR payments OR "equipment & drugs" OR "leadership & governance" OR "health services delivery" OR "health provision" OR stewardship OR "consumer health" OR "population health")	Embase	4
Dynamic system (In Persian)+ health sector (In Persian)	Magiran	5
Simulation (In Persian)+ health sector (In Persian)		
System dynamics (In Persian)+ health sector (In Persian)		
Dynamic system (In Persian)+ health sector (In Persian)	SID	6
Simulation (In Persian)+ health sector (In Persian)		
System dynamics (In Persian) + health sector (In Persian)		

[Downloaded from mjiri.iums.ac.ir on 2025-08-11]

[DOI: 10.47176/mjiri.39.95]