Men's Health Journal. 2023; 7(1): e15

OPEN ACCESS

ORIGINAL RESEARCH

Designing the Infrastructural Model for Smart Hospitals in Iran; a Mixed-Methods Approach

Tayebeh Layeghi-Ghalehsoukhteh[1], Somayeh Hessam[1]*, Soad Mahfoozpour[1], Shaghayegh Vahdat[1]

1. Department of Healthcare Management, South Tehran Branch, Islamic Azad University, Tehran, Iran.

Received: September 2023; Accepted: October 2023; Published online: December 2023

Abstract: **Introduction:** The smartification of hospitals has the potential to enhance the quality of services, ensuring faster and more efficient healthcare delivery while improving the tracking and security of hospital equipment. We aimed to design an infrastructural model for smart hospitals in Iran. **Methods:** A mixed-methods approach was used combining qualitative Grounded Theory and quantitative descriptive-survey methods. The qualitative phase involved in-depth semi-structured interviews with 12 experts familiar with hospital smartification concepts. In the quantitative segment, 412 participants, including senior healthcare managers, IT specialists, hospital administrators, technology experts, and university faculty members, were surveyed using a structured questionnaire. Statistical analyses, including Kolmogorov-Smirnov and independent t-tests, were conducted, and a structural equation model was developed using SPSS 21 and LISREL 8.5 software. **Results:** In the qualitative phase, 135 initial codes and 22 subcategories were identified, eventually consolidated into six main categories: information and communication infrastructures, advanced medical technologies, hospital management, trained human resources, financial resources, and monitoring and control systems. The highest coefficient belonged to the information and communication infrastructures (F1) with a value of 94.3, while the lowest was related to monitoring and control (E5) with a value of 65.0, all indicating significant relationships among the dimensions of hospital smartification. **Conclusion:** Based on the findings, information and communication infrastructures; advanced medical facilities and technologies; human resources; management; monitoring and control systems; and financial resources were identified and validated as six main infrastructures of smart hospital in Iran.

Keywords: Hospital Design; Digital Technology; Information; Equipment; Infrastructure

Cite this article as: Layeghi-Ghalehsoukhteh T, Hessam S, Mahfoozpour S, Vahdat S. Designing the Infrastructural Model for Smart Hospitals in Iran; a Mixed-Methods Approach. Mens Health J. 2023; 7(1): e15.

1. Introduction

The rise in life expectancy, coupled with the increasing complexity of healthcare services, has substantially inflated healthcare costs globally. Smart healthcare, a product of technological advancement and connectivity, aims to enhance healthcare service quality (1).

The concept of a smart hospital emerged in 2009, envisioning a hospital reliant on optimized, automated processes, predominantly leveraging interconnected systems like the Internet of Things. This setup aims to enhance patient care methods and introduce novel diagnostic and treatment capabilities (2). Essentially, a smart hospital strives to provide optimal patient services through cutting-edge information and communication technology. This involves having immediate access to all pertinent information, tapping into internal and external expertise efficiently, and conducting surgical and diagnostic procedures with minimal errors and cost-effectiveness (3). The overarching goal is to implement global state-of-the-art technologies in all hospital sectors, including operating rooms, emergency units, intensive care, radiology, and pharmacies, among others (4).

Successful patient data collection in databases enables synchronized information exchange between patients and doctors, adhering to healthcare system regulations. However, for hospitals, merely collecting vast data amounts and tracking them isn't enough. Utilizing data systems based on Radio Frequency Identification (RFID) technology holds more value, enhancing efficiency (5). Smart technologies have the potential to alleviate numerous constraints in the healthcare

* **Corresponding Author:** Somayeh Hessam; Address: Department of Healthcare Management, South Tehran Branch, Islamic Azad University, Tehran, Iran. Email: somayehh59@yahoo.com, Tel: +989122268534.

sector, such as creating diverse intelligent diagnostic and treatment systems (6).

Information and communication technologies in healthcare are a means to bridge the gap between the supply and demand for healthcare services (7). Incorporating innovative smart technologies, a smart hospital can: enhance treatment conditions, ensuring higher satisfaction levels for both staff and patients, assure the security and comfort of staff and patients through clinical monitoring systems, boost patient awareness levels, improve energy efficiency through controlled monitoring of energy resources, provide an elevated level of comfort and security for patients through control and monitoring systems, encompassing services such as nurse call systems, lighting control, temperature regulation, curtains, and similar amenities (8). In recent decades, efforts have been made in Iran to implement smart hospital initiatives.

However, challenges like a high patient load, a shortage of skilled staff, inadequate infrastructure, a lack of advanced medical equipment, and limited financial resources have posed significant hurdles (9). Presently, the need for continuous communication between patients and doctors, ongoing patient and staff monitoring, efficient control over hospital spaces, reduced medical errors, enhanced patient safety, long-term economic savings, process automation in communication and information, and the internet of things technology are crucial aspects demanding the implementation of smart hospital solutions (10).

While research in Iran has predominantly focused on hospital information systems, the internet of things, smart building architecture, and the benefits of smartification, this study aims to comprehensively explore various facets of smartification. It seeks insights from experts and informed individuals to design a comprehensive infrastructural model for smart hospitals in Iran.

2. Methods

2.1. Study design and setting

This study employed a qualitative and quantitative approach, combining Grounded Theory for qualitative exploration and a descriptive-survey method conducted during 2021-2020. for quantitative data collection. Initially, qualitative data were gathered, followed by quantitative data collection. The qualitative phase involved in-depth analysis with limited participants to understand the research topic. Based on qualitative findings, the necessary tool was developed. To achieve the primary goal of creating an infrastructural model for smart hospitals in Iran and gain deeper insights into the topic and the factors influencing hospital smartening, theoretical foundations and interviews were used. Quantitative methods were then applied to validate the qualitative results. This approach was chosen as the qualitative phase aimed to identify key variables, establish a system classification, or formulate a new theory. The subsequent quantitative phase involved a more detailed evaluation of these results (Creswell & Plano Clark, 2007).

The thesis was registered at Islamic Azad University, South Tehran Branch, under ethics code IR.IAU.CTB.REC.1400.098, dated 11/06/2021, with registration number 1412229696993314001623657 65.

2.2. Participants

The study participants included hospital managers, physicians, medical equipment officials, university faculty members, health information technology experts, and implementers of smartening projects in governmental hospitals from Tehran, Isfahan, and Fars provinces. Twelve informed individuals and experts in hospital smartening participated. Purposeful and snowball sampling ensured diverse perspectives.

Qualitative findings regarding influential components of hospital smartening have been published in an article titled "Identification of Factors Influencing Hospital Smartening" in the Journal of Health Promotion Management (11). This paper primarily presents the quantitative findings and the infrastructural model.

2.3. Data gathering

In the quantitative section, stratified random sampling was used. The sample size, determined using the Cochran formula, was 412 individuals, considering the research population of hospitals. After identifying dimensions, components, and indicators, the hospital smartening questionnaire was developed based on expert opinions, underwent three stages of adjustment, and received approval. This questionnaire, utilized in the quantitative phase, was designed on a 5-point Likert scale (ranging from strongly agree to strongly disagree). The researcher-developed questionnaire's formal, content, and structural validity were confirmed through consultations with advisors, supervisors, and experts. Cronbach's alpha results indicated the questionnaire's acceptable reliability (table 1).

2.4. Statistical analysis

In the quantitative section of the research, a researcher-designed questionnaire was utilized as the data collection tool. Initially, the adequacy of the sample and their interrelationships were examined using the Kaiser-Meyer-Olkin (KMO) and Bartlett's tests. Subsequently, exploratory factor analysis was employed to identify components, and confirmatory factor analysis was used to validate the meaningfulness of the relationships between variables.

In this study, various models of hospital smartification were examined, and an attempt was made to propose a comprehensive model for hospital smartification based on the research findings. The components and stages of the proposed model were designed based on the results of the literature review and the findings from semi-structured interviews with experts in this field, followed by statistical analyses. This proposed model integrates the key dimensions of smart hospitalization, paving the way for a holistic approach to enhance the healthcare system in Iran.

After estimating the model parameters, the question arises: To what extent is the proposed model compatible with the relevant data? The answer to this question can only be obtained through examining the model fit. The fit of the model refers to how well a model corresponds and agrees with the relevant data. In the LISREL program, during the estimation process, a matrix called the implied covariance matrix (statistical estimated covariance matrix) is obtained. The closer this matrix is to the population covariance matrix, the better the model fit will be. This fit essentially indicates how close the S matrix is to the implied covariance matrix and can be measured through various measurement methods (12).

LISREL calculates a Goodness-of-Fit Index (the ratio of the sum of squared explained variances by the model to the sum of squared variances estimated in the population). This index is similar to the coefficient of determination and is between zero and one, although theoretically, it might be negative (although this should not happen as it signifies a lack of exact fit of the model with the data). The closer the Goodness-of-Fit Index and the Adjusted Goodness-of-Fit Index are to one, the better the fit of the model with the observed data.

The fit indices used in this study, including GFI (Goodness of Fit Index) and AGFI (Adjusted Goodness of Fit Index) proposed by yoreskog and Sorbom (1989), are not influenced by sample size. A GFI value equal to or greater than 0.90 is considered acceptable. The Adjusted Goodness of Fit Index (AGFI) is another fit index derived by averaging the squared differences instead of summing them in the numerator and denominator of GFI. The acceptable range for both GFI and AGFI is also 0.90 or higher.

Another general fit index utilized is the Relative Chi-Square (X^2/df) which is calculated by dividing the Chi-Square value by the degrees of freedom of the model. A value less than 2 is desirable, and if it is less than 5, it is acceptable.

The Root Mean Square Error of Approximation (RMSEA) is used in most confirmatory factor analyses and structural equation modeling. According to Maccallum, Browne, and Sugawara (1996), an RMSEA value smaller than 0.05 indicates a good fit, while values between 0.05 and 0.08 suggest a mediocre fit. Models with RMSEA values greater than 1.0 represent a poor fit.

Additionally, Comparative Fit Index (CFI), Incremental Fit Index (IFI), and Normed Fit Index (NFI) are other fit indices applied. CFI is a comparative fit index that should ideally exceed 0.90. IFI, similar to CFI, indicates the incremental fit of the model, and a value greater than 0.90 is desirable. NFI represents the fit of the model compared to a baseline model and values above 0.90 are considered good fits.

The Kolmogorov-Smirnov test was used to assess data distribution normality. Research questions were investigated using one-sample and independent samples T-tests, exploratory factor analysis, and structural equation modeling (exploratory and confirmatory factor analysis) in SPSS and Lisrel software. Finally, a model illustrating the ideal state was proposed based on variables such as dimensions, components, methods, and processes of hospital smartening.

Table 1: Cronbach's Alpha calculation for the questionnaire regarding smart hospital infrastructure in Iran

Reliability Statistics	Number of Items	Cronbach's Alpha
Component One	25	0.842
Component Two	17	0.841
Component Three	12	0.790
Component Four	14	0.841
Total	68	0.946

3. Results

3.1. Baseline characteristics of participants

The participants in the research comprised 412 individuals, including experts in hospital smartification, healthcare information technology specialists, hospital managers, quality improvement experts, specialist physicians, nurses, and hospital medical equipment managers. Among the studied population, 286 individuals (59.3%) were female, and 126 individuals (40.7%) were male. Regarding their educational qualifications, 26 individuals (12.1%) held bachelor's degrees, 178 individuals (36.4%) held master's degrees, 31 individuals (14.5%) held Ph.D. degrees, and 177 individuals (36.51%) had professional doctorates. Additionally, 43 individuals (8.02%) were medical specialists.

3.2. Quantitative and quantitative analysis

The KMO statistic indicating the sample adequacy of variables (value = 0.845), signifying suitability for factor analysis. Also, Bartlett's test confirmed the interrelatedness of the variables (value = 82.58), supporting the factor analysis (Degrees of freedom= 2278; $p < 0.0001$).

For the data obtained from the hospital informatization questionnaires in Iran, exploratory factor analysis was performed on 68 identified indices based on the qualitative results. Table 2 displays the subscription numbers of the indicators for hospital smartification.

Table 2: Smart hospital index subscriptions in Iran

Indicators	Subscriptions	
	Initial	Extracted
1. IT-based Medical Services (Paperless)	1.000	0.408
2. Management of Information Resources (Integration of Information and Applications for IT Utilization)	1.000	0.560
3. IT-based Development	1.000	0.483
4. Information Exchange and Sharing Regardless of Time and Place	1.000	0.460
5. Continuous Innovation Efforts in IT	1.000	0.520
6. Electronic Medical Records	1.000	0.623
7. Ensuring Connectivity to External Systems and Exchanging Information with Centers Beyond Borders	1.000	0.542
8. Very Strong Network and Server Security (Multiple Security Measures Such as Firewall, Virus Scan, Access Authentication, and Virtual Isolation)	1.000	0.525
9. Secure Wireless Network Coverage (WLAN) Throughout the Hospital	1.000	0.417
10. Quick Error Detection and Service Switching Technology	1.000	0.427
11. Personnel Tracking and Online Consultation	1.000	0.528
12. High Internet Bandwidth and Services	1.000	0.612
13. Hospital Information System (HIS)	1.000	0.369
14. Laboratory Information System (LIS)	1.000	0.388
15. Clinical Information System (CIS)	1.000	0.446
16. Archiving and Imaging Communication Systems (PACS)	1.000	0.504
17. Radiology Information System (RIS)	1.000	0.532
18. Workflow and Patient Data Management	1.000	0.482
19. Collection, Storage, and Transfer of Clinical Information	1.000	0.632
20. Viewing and Processing Diagnostic Information	1.000	0.493
21. Telemedicine Services	1.000	0.457
22. Reducing Waiting Lines by Changing Patient Activities Using Algorithms and Smart Systems	1.000	0.621
23. Identifying Patient Needs Using Equipment and Technology	1.000	0.663
24. Creating Big Data and Converting It into Health Knowledge	1.000	0.445
25. Minimizing Environmental Impacts	1.000	0.592
26. Developing Physical and Virtual Communications in Hospitals to Reduce Patient Visits (Visits and Services, etc.)	1.000	0.538
27. Smart Wireless Sensor Devices (IEWSD) to Facilitate Employee Work	1.000	0.473
28. Remote Health Care (Telemedicine, Mobile Health, and Remote Health Care)	1.000	0.473
29. Technology to Reduce Clinical Errors	1.000	0.528
30. Identifying Infections and Improving Hand Hygiene	1.000	0.509
31. Use of Advanced Surgical Navigation Systems to Guide Surgeons and Surgical Instruments During Surgery	1.000	0.467
32. Use of Cloud Computing Systems to Establish Communication Between Patients and Physicians and Nursing Stations	1.000	0.459
33. Use of Novel Medical Techniques (Genomics, etc.) for More Accurate Disease Diagnosis	1.000	0.408
34. Performing All Admission to Discharge Tasks Robotically Without the Need for Repeated Follow-ups	1.000	0.619
35. Analyzing Information Sent from Microchips to a Specialist Doctor's Dedicated Tablet to Reduce Patient Waiting Times	1.000	0.665
36. Use of Up-to-Date and Advanced Medical Equipment for Disease Diagnosis and Treatment	1.000	0.528
37. Hospitals Equipped with High-Resolution Monitors	1.000	0.569
38. Equipping Operating Rooms with an Intelligent Infection Identification System (ORMS)	1.000	0.563
39. Use of Smart Patient Guide Smartphones for Faster Access	1.000	0.563
40. Utilizing Sensor Systems to Facilitate Staff Work	1.000	0.582
41. Identification and Monitoring Equipment for Patients Such as Bed Falls and Remote Patient Monitoring	1.000	0.449
42. Utilization of Data Mining Methods for Patient Decision Making	1.000	0.557
43. Identifying Staff and Hospital Personnel Capabilities for Hospital Smartification	1.000	0.456
44. Preparedness for Embracing Cutting-Edge World Technologies Among Medical Staff and Patients	1.000	0.654
45. Conducting Training Courses and Seminars for Healthcare Staff and Patients According to World-Class Service Standards	1.000	0.521
46. Using Smart Systems to Schedule Staff Shifts and Human Resource Allocation	1.000	0.627
47. Using Smart Systems to Determine Optimal Staff Numbers and Prevent Costs	1.000	0.441
48. Minimizing Human Errors Through Hospital Smartification	1.000	0.399
49. Patient Participation and Increasing Interactions Between Service Providers and Receivers	1.000	0.503
50. Identifying Disease-Prone Individuals and Provision of Preventive Care	1.000	0.562
51. Talent Management and Employee Competencies	1.000	0.408

Table 2: Smart hospital index subscriptions in Iran

Indicators	Subscriptions	
	Initial	Extracted
52. Human Resource Engineering and Empowerment	1.000	0.429
53. Human Resource Training on Advanced Equipment and Facilities Usage	1.000	0.452
54. Training Skilled Personnel for Equipment Repair and Maintenance	1.000	0.528
55. Use of Technologies for Asset Management and Control	1.000	0.378
56. Integration of All Hospital Systems for Monitoring	1.000	0.591
57. Providing Managerial and Information Infrastructures to Increase Confidence, Efficiency, and Awareness	1.000	0.543
58. Real-Time Analysis of Data Using Business Intelligence for Hospital Efficiency	1.000	0.461
59. Considering Hospital Size for Change Management	1.000	0.500
60. Examining and Developing Exchanges for the Introduction of New Technologies and Equipment for Hospital Smartification	1.000	0.428
61. Proper Accreditation According to International Standards	1.000	0.486
62. Efficiency and Performance Management Using Intelligent Decision Support System	1.000	0.645
63. Designing Information Systems for Active Risk Management and Coordinating Multiple Services for Health Professionals, Policymakers, and Managers	1.000	0.487
64. Use of Simulation and Process Visualization Systems to Assist in Improving Management	1.000	0.549
65. Speed in Decision Making for Treatment Through CDSS (Clinical Decision Support System)	1.000	0.495
66. Separation of Drug Distribution and Prescription Systems in Service Providing Institutions	1.000	0.597
67. Integration of Hospital Laboratories with Regional Networks and Formation of Associations	1.000	0.654
68. Paradigm Shift from Volume to Value in Health Service Delivery	1.000	0.621

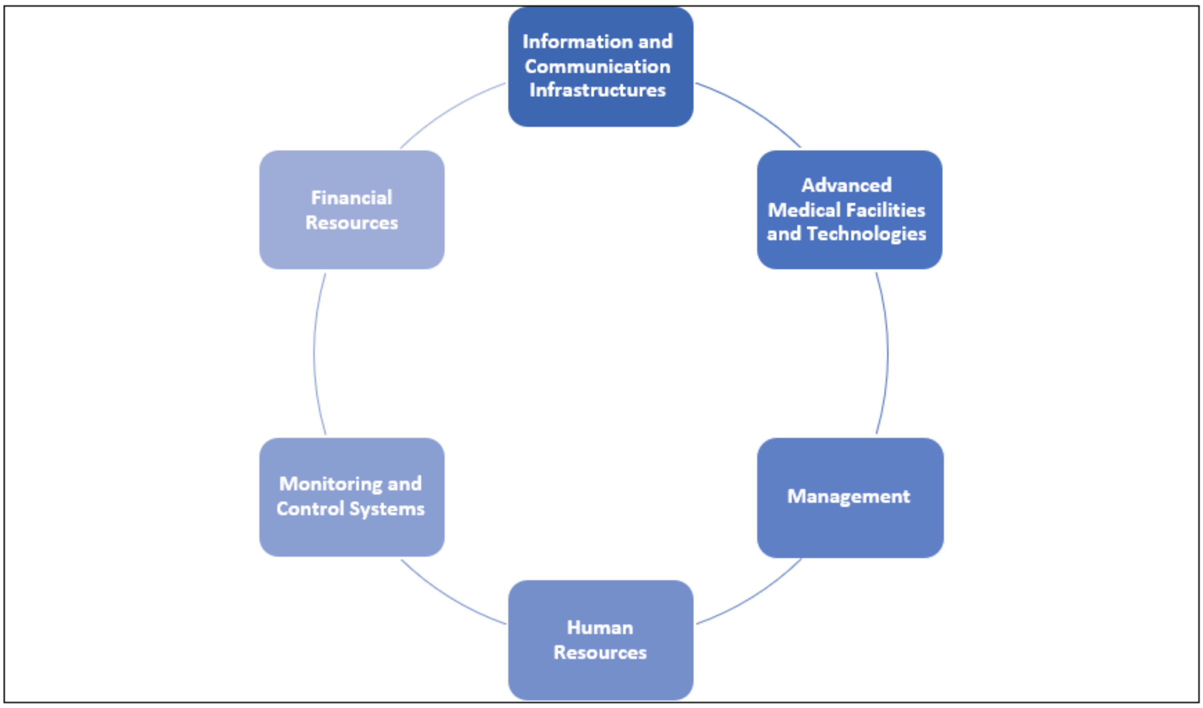

Figure 1: The final model of smart hospital infrastructures in Iran

The results obtained from exploratory analysis indicate that out of 68 existing indicators, 6 main factors (dimensions) are identifiable for smartification, which include: information and communication infrastructures; advanced medical facilities and technologies; human resources; management; monitoring and control systems; and financial resources. Table 3 shows the percentage of variance explanation for each dimension after varimax rotation.

Table 3: Percentage of variance explanation (VE) for each dimension after varimax rotation

	Dimension	VE (%)
1	Information and Communication Infrastructures	17.673
2	Advanced Medical Facilities and Technologies	14.452
3	Human Resources	10.364
4	Management	8.940
5	Monitoring and Control Systems	7.892
6	Financial Resources	5.878

3.3. Infrastructural model for smart hospital in Iran

As observed in the figure 1, the presented infrastructural model is primarily comprised of 6 main factors in order of priority: Information and Communication Infrastructures, Advanced Medical Technology Facilities, Management, Human Resources, Control and Monitoring Systems, and Financial Resources.

The structural equation test demonstrated that there is a significant direct relationship between the dimension of information infrastructures (factor loading of 0.943); advanced medical technologies (factor loading of 0.763); management (factor loading of 0.711); human resources (loading of 0.631); monitoring and control (factor loading of 0.650); and financial resources (factor loading of 0.960) with the smartification of hospitals in Iran.

3.4. Fitness of infrastructure model

Based on the findings, all fit indices used in this study indicate a good fit for the model. Therefore, it can be concluded that the research model has a high capability in measuring the main variables of the study. The standardization of the model ensures the reliability of the LISREL findings. The fit indices have confirmed the modified pattern of the research. These fit indices demonstrate that the ratio of X^2/df to the degrees of freedom is 1.902, which is significant at the 0.001 level ($X^2/df = 1.902$, $p < 0.001$). The Goodness of Fit Index (GFI) is 0.990, the Adjusted Goodness of Fit Index (AGFI) is 0.980, the Comparative Fit Index (CFI) is 0.980, and the Root Mean Square Error of Approximation (RMSEA) is 0.038, all of which fall well within the acceptable range, indicating an excellent fit of the model with the observed data.

4. Discussion

In light of the research findings, the first aspect highlighted after the designed model refers to the existence of informational and communication infrastructures for smart hospital integration. Currently, the rapid development of digital technologies significantly impacts unified information management processes across all sectors, instigating transformative changes. The presentation of a smart hospital service model based on the Internet of Things (IoT) emphasizes that each stage of the model will be the groundwork for the subsequent level of performance. The overarching framework and foundation of all services consist of two major components: communication infrastructure and informational infrastructure.

Communication infrastructure encompasses elements such as wired, wireless communications, and internet services, while informational infrastructure pertains to the storage, processing, and management of information. This aligns with the study by Jeon Hung and colleagues conducted in Japan in 2021, emphasizing the importance of intelligent communication platforms. Efficiency and patient safety remain top priorities in every surgical procedure. One effective approach to achieving these goals involves the automation of many logistical and routine tasks within the operating room. Shayegan and colleagues, presenting a reference model for healthcare information technology, demonstrated that suitable software applications (apps) for staff and patients, along with computer systems for hospital operations, can enhance the quality of services provided. Hence, the Internet of Things, cloud computing, big data, microelectronics, and artificial intelligence can be extensively utilized in all aspects of smart healthcare. Additionally, physicians can utilize support systems for intelligent clinical decisions, aiding in improving diagnostics, and leveraging surgical robots and mixed reality technology to achieve greater precision in surgeries. An important consideration in smart hospital design is the attention to establishing communication capabilities between electronic systems installed within a hospital.

Technologies, alongside intelligent healthcare, can effectively reduce costs and the risks associated with medical and nursing procedures. Haji Pour Talebi and colleagues also addressed the elucidation of challenges and implementation solutions for smart systems in the healthcare system, which resonates with our research findings.

The second aspect, as indicated by the presented model, pertains to advanced medical equipment. Biomedical engineering plays a pivotal role in the design and production of medical tools and equipment used in the country. Flourishing studies with titles such as "Conceptual Framework for Smart Hospital" have shown that artificial intelligence and robotics can assist physicians in diagnosing and treating diseases. Moreover, intelligent devices designed for disease diagnosis, derived from artificial intelligence, are gaining momentum. Ballouhey and colleagues also mentioned the application of robots in surgical procedures. The use of assistant robots in surgeries can significantly aid in reducing medical errors and post-surgical infections. The presence of intelligent electronic hospital systems, alongside intelligent medical care, can effectively reduce costs and mitigate the risks associated with medical and nursing interventions.

The third aspect highlights management in smart hospitals. Hospital management systems are among the most advanced solutions globally, encompassing the management of assets, staff, patients, and equipment within a unified system. Identifying the hospital size to facilitate changes involves employing experts in the hospital's planning stage, considering aspects such as space optimization, efficient use of equipment, and ensuring safety and security measures. Noteworthy management tasks in smart hospitals include optimizing energy consumption through the design of various intelligent systems. Lian and colleagues examined crucial factors influencing decision-making to employ cloud computing technology in developing countries' hospital industry. Abu Fazeli and Rabiee, along with a research conducted by Rezaei and colleagues, delved into the role of intelligent management systems in optimizing energy consumption in buildings. Kim and colleagues proposed a model for intelligent healthcare services to efficiently manage outpatient care and provide smart infrastructures to enhance patients' medical diagnostics and deliver effective treatments aligned with physiological needs. The results demonstrated that managers aiming to transform a hospital into a smart hospital must provide the necessary infrastructure and facilities for the integration of information and communication technologies within their hospitals to offer better services to patients and visitors. Furthermore, the implementation of certain technologies, such as the Internet of Things or big data analytics, requires support from policymakers in the national healthcare and information technology management hierarchies.

The fourth aspect addresses human resources in the context of hospital smartification. Human resources are the backbone of any organization, and this holds true for hospitals. Therefore, training employees to create motivation, improve quality, and establish a sense of job security is crucial. This training is essential to prevent resistance from employees regarding the changes intended for smartifying hospitals. Dervish and colleagues conducted research on modeling hospitals and using intelligent systems to schedule work shifts and determine the optimal number of staff. The results showed that using these systems not only enhances efficiency but also reduces the number of service providers to patients by optimizing work shift schedules, addressing challenges in hospital management in this regard.

Fischer and colleagues examined approaches to reorganizing human resources in smart hospitals based on the Internet of Things. Attention to employees' capabilities and the evaluation and planning of physical and human resources are of particular importance. Control, evaluation, and planning in this matter give hospitals a competitive advantage. Therefore, focusing on human resources is essential for implementing smart hospitals. Furthermore, resistance from some users towards adopting technology and replacing traditional methods with innovative and technology-based approaches is due to the lack of training resulting from not using or lacking skills for working with new methods and systems. The fifth aspect pertains to monitoring and control systems, including control of lighting equipment, traffic and access control systems, surveillance and security systems, monitoring various environmental conditions, patient safety, fire safety, gas leakage, and other related aspects. Esmaeili Fard and colleagues, in their research titled "Analysis and Modeling Based on the Objectives of Security Requirements for Smart Hospitals," concluded that a smart hospital is an intelligent and highly interactive environment saturated with heterogeneous computational tools. Given the necessity of fully integrating technology with daily hospital functions, a significant number of vital and considerable assets are at risk. Consequently, information security becomes a key concern for smart hospitals. Rashidi's study and colleagues also highlighted various intelligent control methods to optimize energy consumption, and Nazari and colleagues emphasized the responsibility of monitoring and control systems in smart hospitals.

The sixth aspect underscores financial resources, the reduction of operational costs as a benefit of smart systems, reducing control and maintenance costs, minimizing maintenance and repair costs, shortening service delivery times, and generating better income by providing services considering the competitive environment among organizations. The need for fresh ideas, process and equipment improvement, and staying up-to-date is keenly felt, especially in the context of hospital smartification. Mirsaeidi's research on presenting a model for the deployment of intelligent services in Iran's healthcare sector shows that one of the impactful dimensions in implementing smart healthcare is estimating the required resources and attracting private sector participation. Najafipour and colleagues pointed out the role of smart hospitals in medical tourism and improving the financial situation of hospitals for the implementation of smart services.

Current global trends underscore the increasing significance of intelligent healthcare services, driven by factors such as population growth, the aging demographic, surging chronic illnesses, economic pressures on healthcare, and a scarcity of specialized professionals.

This study has endeavored to propose a comprehensive model outlining the essential infrastructures required for the implementation of smart hospitals within the country's healthcare sector.

4.1. Limitations

It's crucial to note that this study had limitations, having been conducted in three provinces; hence, generalizing the results nationwide might require cautious consideration.

5. Conclusion

Based on the findings, information and communication infrastructures; advanced medical facilities and technologies; human resources; management; monitoring and control systems; and financial resources were identified and validated as 6 main infrastructures of smart hospital in Iran.

6. Appendix

6.1. Acknowledgment

This article stems from the doctoral thesis of Tayebeh Layeghi-Ghalehsoukhteh, specializing in Healthcare Management, conducted under the supervision of Dr. Somayeh Hassam and Dr. Soad Mahfoozpour. We extend our heartfelt appreciation to all contributors who played a role in the execution of this research.

6.2. Conflict of Interest

The authors declare no conflicts of interest regarding the content of this article.

6.3. Funding and supports

The authors received no specific funding for this work.

6.4. Authors contributions

Study design: TL, SH, SM.SHV; Data gathering: TL; Data analysis: TL, SH, SM; Interpretation of the findings: All authors; Drafting: TL, SH, SM; Critically revised: All authors read and approved final version of manuscript.

References

1. Behbahani S, Moridani M. electronic and smart hospital are an urgent need of todays life. Journal Biomedical Engineering. 2014 Jun;(164):34-45 http;//iranbmemag.com.
2. Jung KY, Kim T, Jung J, Lee J, Choi JS, Mira K, et al. The effectiveness of near field communication integrated with a mobile electronic medical record system: emergency department simulation study. JMIR Mhealth Uhealth 2018Dec;6(9):e11187.
3. Darshan KR, Anandakumar KR. A comprehensive re-view on usage of Internet of Things (IoT) in healthcare system. Proceedings of 2015 International Conference on Emerging Research in Electronics, Computer Scienceand Technology (ICERECT); 2015 Dec 17-19; Mandya,India.
4.Yoo S, Hwang H, Jheon S. Hospital information systems: experience at the fully digitized Seoul National University Bundang Hospital. Journal of Thoracic Disease. 2016;8(Suppl 8):S63 http://doi.org/10.21037/jtd.2016.
5. Shaabany Y, Vafaeenajar A, Meraji M, Hooshmand E. Designing a green hospital model in Iran. Journal of Health Administration. 2018; 21(72):64-76 http://jha.iums.ac.ir/articel-1-2407-en.html.
6.Hesam S,Vahdat SH, Masoudi Asl A,Kazemipoor M.parkinsons disease detection using biogeography-based optimiziation:computers,materials and countinu.Journal of computer, materials&Continua.2019Oct;61(1):11-26.
7. Mahmoodi S, Afshar K. Modeling a smart Hospital information archeitecture based on internet of things and recommender agent. Journal of Health and Biomedical Informatics Medical Informatics Research Center. 2020Sep;7(2):133-149 available in http://jhpm.ir/article-1-443-en.pdf.
8.GHadami L,Masoudi ASL I,Hessam S,Modiri M. Developing hospital accreditation standard:Applying Fuzzy DEMATEL,I nternational Journal of Healthcare Management.2021Jul;14(3):847-81055.
9. Austin JA, Smith IR, Tariq A. The impact of closed-loop electronic medication management on time to first dose: A comparative study between paper and digital hospital environments. International Journal of Pharmacy Practice. 2018Dec;26(6):526-33.
10.Soopramanien A, Jamwal S, Thomas PW. Digital health rehabilitation can improve access to care in spinal cord injury in the UK: A proposed solution. International Journal of Telerehabilitation. 2020;1.3(1):124-139.
11.Layeghi T.Hessam S,Mahfoozpour S,Identifying Effective Factors in making smart Hospital.2023,12(2),63-77 doi:10.22034/jhpm.12.2.61.
12. Lian J, Yen D,Wang Y. An exploratory study to understand the critical factors affecting the decision to adopt cloud computing in Taiwan hospital. International Journal of Information Management. 2016Nov; 34(1): 28-36.
10.Darokar V,Ghatge T,Wakchaur M, Pande V.The role of robots in smart heallth care system. International Research Journal of Engineering and Technology.2021Mar;8(8):3973-3979.
13. Rashidi Aghdam H, Yarmohamadi L, Malakooti S. [Study variety of intelligent control system techniqes in hospital for optimization of energy consumption]. Building Engineering and Housing Seienc Journal.2018 Nov.11(4):57-63.
13. Soudagar H, Soudagar SH. Using solar energy and intelligent manangment system to optimize energy consumption. The fifth International Conference on Applied Research in Science and Engineering.2020Nov2;123-142.
14. Nilashi M, Ahmadi H, Ahani A, Ravangard R, Ibrahim O B. Determining the importance of hospital information system adoption factors using Fuzzy Analytic Network Process (ANP). Technological Forecasting and Social Change. 2016Jun; 111(C): 244-264.
15. Guba E, Lincoln Y. Paradingmatic Controversies,

Contradictions, and Emerging Confluences,Revisited.The Sage Handbook of Qualitative Research.2005;4(2):97-128 .
16.Drashan KR,Anandakumr KR.A comperehnsive review on usage of internet of tings in healthcare system .proceeding of 2015 International Conference on Emerging Research in Electronics,Computer Science and Teechnology;2015Dec17-23
17. Haghighathoseini A, Bobarshad H, Zare H. Extracting the information tecnology architectur of hospitals with approach of impelemention in Iran . Journal of Information and Comunication Technology.2019Dec (27):34-46.
18. Tabatabaei M, Rasoulian M, SHarifzadeh N. Making hospital smart in an important step towards achiving smart health. 2nd Conference Intrnational Smart City Challenges and Strategies. SHiraz.Iran.2021Mar(2):1-8.
19.Shayegan Z, Nabiolahi A.Peresenting the Reference Model of health information tecnology with a comparative study of the Reference Models of other Countries. 2nd Conference on Machanice, Electrical, Aerospace Engineering and Enginerring Sciences.2021Jul(12):76-84.
20. Ronaghi MH. A Conceptual framework for smart hospital toward industry4.0. Journal of Hospital. 2020Feb;(19):73-79.
21. Ballouhey Q, Villemagne T, Cros J, Szwarc C, Braik K, Longis B. A comparison of robotic surgery in children weighing above and below 15.0 kg: Size does not affect surgery success. National Library of Medicine .Surg Endosc.2015Mar;29(9):26432650.
22. Darvish N, Khayyati R, Vaezi M. Investigating the increase of hospital efficiency using intelligent networks. Hospital. 2010Dec;9(34):93-110.
23.Kim Y,Jeong Y,Park G.Smart healthcare service model for efficient management of patient at hospital outpatient visits.Indan J Sci TECHNOL.2016Apr;9(44):105098.
23. Fischer GS, Righi RdR, Costa CAd, Galante G, Griebler D. Towards evaluating proactive and reactive approaches on reorganizing human resources in IoT-based smart hospitals. Sensors. 2019m;19(17):3800-3829.
24.Aboufazeli M, Rabiee M. The design and landing systems of the clever mind reader at the hospital using radio technology. Tehran, Science and Technology. 2017Mar;17(19):123-137.
25.Rezaei M, Bagheri MJ, Jafari B. Management of energy consumption using new building smart techniques. International Conference on Research in Engineering Science and Technology.2016Apr;1-14.
26.Najafipoor F,Masoudi Asl I,Hessam S,Mahmoudi M .In search a medical tourism marketing pattern in Iran:The case of cultural sensitivities. International Journal of Healthcare Management.2021Mar;14(4):1081-1086