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REVIEW ARTICLE

Holistic View on Information Systems as Logistic in Health Sector

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A B S T R A C T

Background: In the data-rich and data-sensitive environment, health information systems (HIS) have been used for decision-making by providing reliable data. The current study aims to have a holistic view on the logistic role of IS in health sector.

Methods: PubMed, Scopus, and Science Direct were searched by keywords including "information system AND health AND data", "health information system AND challenges AND network", health information system OR clinical information system AND quality of services". 547 scientific studies from 2010 onwards were selected. At first, based on papers' relevance to the aim of this study, titles and abstracts of publications were studied. 259 studies were filtered out. Then, through analyzing the full texts based on inclusion criteria, authors selected 106 papers. Finally, contents were extracted and categorized.

Results: Due to the impact of IS on quality, effectiveness, and efficiency of services, as well as patients' safety, various types of ISs are used at different levels of the health system. They are classified based on different criteria including generality, level of the health system, managerial level, complexity, and integrity. According to IS components, non-standardized data, weak human resources capacity, incompatibility with work procedures, fragmentation of subsystems, cyber security threats, and insufficient informatics infrastructure were the main challenges.

Conclusion: IS in health play a logistic role in systematic data management and circulation of reliable information. A systematic and integrated view is needed to conquer the organizational and systemic challenges.

Key words: Information system, Logistic, Health system, Application, Challenges

Introduction

According to WHO, the aim of health system is to improve the health of individuals, families and society. Regarding prevention, treatment and rehabilitation services, this system maintains, promotes and restores health according to people's needs in their life time (1). A well-functioning health system is now understood as a product of complex and dynamic processes (2).

In addition to inherent complexity, health system is undergoing enormous transformations due to the emergence of new technologies and the necessity to provide integrated care services. Penetration of Information Technology (IT) into health system has certainly reformed healthcare landscape, provided new opportunities to redesign work processes, enabled organizational change, and contributed to the growth of health data (3, 4). WHO introduced data and information as one of the six key health system building blocks and proposed paradigm shifts towards maximizing the use of IT to accelerate health system improvement (5).

The exponential growth of health data necessitates application of IS in health care to deliver up-to-date

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information about health needs of the covered community (3). Also, it should get essential information about the environment in which the health system operates and its performance (6). Moreover, adoption of IS in health system leads to transformation of data management, how health data are being documented, processed, and disseminated, work processes, interactions, and decision making (3).

Studies suggest that organizations using IS have better performance than those who do not (3, 4). IS provides easily accessible, timely, accurate, and comprehensive information to health systems in order to identify their situations, provide value-added services, and generate the new improvement opportunities (4). Because of the importance of IS, various national governments especially in developing countries, with support of global partners such as the Global Fund, WHO, United Nations Children's Fund (UNICEF), etc. have started to make serious investments in strengthening their IS in health sector (7).

In the past two decades, considerable studies were performed with focus on IS in the health system (4, 8). However, a comprehensive study is required to review these systems in all aspects. This study aims to explore the definition, importance, and applications of IS; classify it based on different criteria, and expand the effects of IS in the health system. This study also intends to identify the components of an IS, and reveal their challenges in health environment.

Materials and Methods

The current review presents a comprehensive view on IS in health sector. Through searching electronic databases of PubMed, Scopus, and Science Direct, the authors retrieved published studies based on specific keywords with Boolean connector (AND, OR). They have selected 547 scientific papers regarding IS in health sector. The sample search strategies included "information system AND health AND data", "health information system AND challenges AND network", health information system OR clinical information system AND quality of services".

Publication year was from 2010 onward. Then, based on relevance to the aim of this study, titles and abstracts of papers were studied and 259 papers were filtered out. Through analyzing the full texts, 153 papers did not meet inclusion criteria. It included complete papers, and published after 2010. Thus, full texts of 106 remaining papers were studied carefully; the contents were extracted and categorized based on the objectives of the study.

Results

The definition, importance and application of health information systems

In different parts of the health system, ISs are basically introduced to transform the traditional way of managing information in a more modern method. They are used for systematic collection, analyzing, maintaining and dissemination data (9-11). These systems have the potential to support an array of advanced services for healthcare (8). They act as brain and nervous system for organizations which work coordinately. In this way, through afferents, they receive inputs and send them to the brain to process and perform analyses. Then, through efferent, they provide outputs to authorized users. Because of undergoing analysis, such information is sound and reliable, and can be the cornerstone of decision-making throughout the health system. They can also make evidence-based managerial and clinical decisions (10, 12).

ISs are essential infrastructure for a safe and efficient health system. Increasing capabilities of ISs has led to their widespread use throughout health system. These systems are considered useful. Usefulness means that these systems can manage a large amount of public health, clinical, and administrative data produced daily in health centers. They save these organizations from drowning in the vast data channel (13). The produced information are used by different levels of health system (Table 1).

Classifying information systems based on different criteria

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HISs can be categorized according to different criteria and various types (Table 2). The most important criterion is the formation of an HIS for a function. In this regard, HIS can be classified into clinical and administrative categories (14, 15). Clinical Information Systems (CIS) are systems which manage clinical data and allow health care providers (HCPs) to use information for facilitating the management of clinical care (6, 16-18). The most important used terminologies for CIS are patient care IS (18, 19), patient care management system, medical IS, computer-based patient records, and electronic medical record (17). There are two major categories of CISs including general and specific or departmental systems (6, 20). General systems used in most clinical settings include computerized provider order entry (CPOE), clinical decision support system (CDSS), electronic medical record system (EMRS), telemedicine, telehealth, and electronic medication administration system (6, 21). In contrast, departmental systems are used in specific departments or by specific working groups, such as Radiology (RIS), laboratory (LIS), Nursing (NIS), Pharmacy (PIS), Pathology (PTIS), Intensive Care Unit (ICUIS), Anesthesia (AIS), Operating Room (ORI), Diet (DIS), Emergency Department (EDIS), Oncology (OIS), and Emergency Medical Service (EMSIS) (22-25).

Administrative ISs, which are managerial and financial activities, support general operations of health organizations (26). They actively support the decision-making process and planning. All ISs have administrative subsystems. In a hospital, a variety of administrative ISs exist including insurance IS, admission, discharge, and transfer (ADT), accounting, and staff (27, 28).

According to the level of health service, ISs can be divided into three categories of prevention, treatment and rehabilitation (29-30). Prevention or primary health care information systems (PHCIS) manage the data of primary care settings to allow regular monitoring of the health status in the community (31-32). This system has health and administrative modules. The health module has two categories of data including basic health like socio-family data, personal and family history, and allergies; as well as encounter data, such as the health status of patients and the actions taken (33-34).

Therapeutic ISs are used in inpatient and outpatient departments of health care organizations. Hospital Information System (HIS) is a famous example of inpatient ISs (35). In outpatient systems, there is a wide variety of outpatient departments such as the emergency departments, paraclinics, clinics, etc. Because of their differences, they have their own special ISs; but in general, an outpatient IS is created for managing outpatient data (36).

Rehabilitation ISs have been created to support rehabilitation services, given the current challenge of increasing the number of elderly people with multiple chronic diseases. With the logistic support of these systems, authorities can make interventions to ensure the best compatibility between the capacity of the disabled and the environment (37).

Another categorization of ISs is operational, tactical, and strategic. Specific ISs have been created in each of these levels (38). Transaction processing systems are at the operational level, decision support systems and management information systems are at the tactical level, and expert systems and neural networks are at the strategic level (39). Another type of IS classification suggests classification into information-based and knowledge-based systems regarding their complexity (40, 41). ISs can range from stand-alone to fully integrated networks (11, 42).

Effects of information systems on health system

Quality and effectiveness of health care services

If the health system seeks quality, it must be transformed. ISs have the potential to create this change (6, 43). They provide valuable opportunities to receive more effective and high quality services in the relationship between the patient and professionals. They make the required data available, speed up interdepartmental communication, eliminate repetitive procedures,

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and reduce patients' waiting time (6, 9). The quality of services has been a concern of health managers for a long time. One solution has been developing scientific protocols and guidelines for providing any type of service based on which best practice is provided. The use of these protocols is one of the challenges of service quality. By including guidelines in software programs of ISs, performance of employees increases and by reducing medical errors, the quality of services improves (14, 44). On the other hand, service providers with access to comprehensive information about the condition of the recipient can provide services tailored to his/her condition with a comprehensive view (45, 46).

Moreover, the method of transforming services and empowering patients are other effects of IS; in this way, patients can actively participate in the process of their own treatment as well as managing of data (46). Chaudhry et al. (14) stated that many studies have shown an increase in quality regarding primary (influenza and pneumococcal vaccinations) and secondary (controlling the pressure ulcers, and postoperative infections) preventive care.

Patients' safety

In the field of patient safety and services, ISs have been introduced as one of the main blocks of a safe healthcare system (45). In this context, ISs prevent the occurrence of adverse effects and reduce errors. Ultimately, they help the safety of patient by removing complexities and simplifying the process of services; identifying errors; illogical and illegible orders with alerts and corrections; as well as the possibility of tracing, helping in knowledge-based decision-making, providing feedback in the field of clinical performance, improving communication through data exchange especially among different levels of the health system, and reminding the service provider for what he should do. As a result, a safe electronic environment is created, which ultimately leads to the provision of high quality services. In other words, the path of quality goes through safety (18, 45).

Efficiency and cost control

Regarding efficiency, ISs have two types of effects in the health system: utilization of services and saving the time of service providers. Information systems increase efficiency through the following activities: calculating the probability of a specific test to diagnose a disease, displaying the cost of each laboratory test and announcing suitable alternatives for expensive tests and services. Moreover, a reduction in total service costs (12.70 %) and hospitalization days (0.90 days) are reported (14) in the studies.

By facilitating the flow of data between different parts of health system, ISs can facilitate communication between different providers and avoiding phone calls or waiting to receive a paper-based answer. It can be a very effective factor in reducing the time spent by providers. Most of their time is spent on providing specialized services. Saving time by reducing the time spent on documentation is another effect of ISs to increase efficiency (19).

Components and challenges of information systems

An IS is a set of input (data), output (information), procedures, human resources, and hardware and software equipment that work in harmony with each other. This is to collect data, process and distribute information in a specific environment (47, 48). The review of literature showed that the coordination of these components is necessary for the proper functioning of an IS. Presence of a problem in any component can challenge the implementation and even make it useless (47). In Table 3, challenges related to each of the components of ISs are mentioned.

In a limited resource environment, the cost of providing hardware and software equipment and network as well as their maintenance and update is one of the important challenges (48). Moreover, in most cases, technological challenges such as incomplete data sets, incorrect design, system malfunction, low speed of systems, and lack of access to broadband Internet prevent the full utilization of IS capabilities (9).

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Table 1. Application of information systems based on different levels of health system

Level	Application
Individual level	Providing information on the status of patients or visits to health centers Influence on decision-making and planning for necessary services
Health organization level	Providing ongoing and timely information about health organization services Assessing the quantity and quality of services Planning based on needs
Population level	Providing information on the health status of covered population Identifying particular epidemics and acute problems for immediate decision-making (12, 13)

Table 2. Classification of health information systems based on various criteria

Criterion	Classification	Name or Example
Function	Clinical Administrative	Clinical Information System (CIS) (17, 18) Administrative Information System (26-28)
Generality	General Departmental	Computerized Provider Order Entry (CPOE), Clinical Decision Support System (CDSS), … Radiology (RIS), Laboratory (LIS), Nursing (NIS), … (20-25)
Levels of health system	Prevention Treatment Rehabilitation	Primary Health Care Information System (PHCIS) Therapeutic Information Systems (Hospital IS) Rehabilitation Information Systems (33-37)
Managerial levels	Operational Tactical Strategic	Transaction processing systems (TPS) Decision Support Systems (DSS), Management Information System (MIS) Expert System, Neural Networks (38-39)
Complexity	Information-based Knowledge-based	Hospital IS CDSS (40, 41)
Integrity	Stand-alone Integrated	Stand-alone IS (office or small department) Network (11, 42)

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Table 3. Information system components and challenges

Component	Challenges
Data/ Information (8, 11, 49-51)	Incomplete data sets and failure to comply with data standards Documentation of non-standard data Inaccuracy in data recording and poor quality data entry Providing low-quality information that is not based on the needs of the users at different levels Inappropriate use of standard nomenclature and classification systems
Procedures (processes) (8, 47, 49, 51, 52)	Lack of planning for implementation of ISs Incompatibility of IS with work procedures Failure to modify work processes before digitalization electronic
Human resources (People) (11, 47, 49, 53-55)	Users' resistance Lack of understanding of the importance of ISs Not having knowledge, awareness and computer skills Changing work processes and communication between people and fear of changing and replacing systems instead of people Increase of workload Lack of trust in systems
Hardware and software (11, 47, 49, 51, 56)	The high cost of hardware and software equipment Absence of required hardware or aging equipment The cost of maintaining and updating hardware and software equipment Poor interface and less user-friendly software Lack of usable software and malfunctions Incompatibility of different software Improper and incomplete design, malfunctioning of the system, and making numerous errors Low processing speed of systems Hardware and software security
Environment (network) (11, 49, 51, 56, 57)	Lack of access to broadband network Lack of necessary infrastructure for data interoperability Absence of central databases Network security and unauthorized access to patients' data

Discussion

Today, the high-performance of health system is one of the signs of development in any country. Health system is a data-sensitive field. Through timely and complete access to patients' data, it can provide appropriate services to save lives or improve their life quality (14, 51). Sahay et al. (7) stated that HIS have been accepted by countries as powerful tools to strengthen health system and make evidence-based decisions. There is a consensus that strong HIS helps the identification of problems. It reduces morbidity, mortality, and medical errors and improves coordination and quality of care. Moreover, a strong system determines the extent of health services coverage. Developed countries typically focused on strengthening CIS, and their integration. In contrast, in less-developed countries, ISs are fragmented or standalone. Due to the lack of electronic data circulation in health system, authorities have not completely used the capacity of ISs.

In his study, Mohamadali (9) mentioned healthcare organizations now experience increased efficiency, improved patient care, quality of services, and safety as a result of HISs. HISs support clinical and administrative processes in a secure atmosphere to efficiently and effectively improve performance in the health system. As mentioned by Nilashi (58),

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other effects of HIS are saving time for medical professionals and administrative workers, as well as reducing patients' waiting time especially during registration. Fu et al. (59) reinforced the positive effect of HIS on hospital performance. They stated that although HIS increases cost, the increasing effect in revenue is much more. Stamatian et al. (60) indicated that the application of HIS in hospital plays a vital role in coordinating the operations of subsystems and providing a synergistic organization. It also improves the quality of patient care by immediate access to information and suitable alerts and recommendations. Morover, it enables a hospital to move from a retrospective review to a concurrent one.

Different types of ISs are utilized in health system. Chaudhry et al. (14) pointed out that preventive aspect of health system has the capacity to benefit the most from IS. Considering that PHC is the foundation of health system, an efficient IS will lead to the provision of quality services from the beginning. Dayama et al. (61) stated that nursing homes admit approximately 1.4 million vulnerable Americans. They declared that the most relevant application of ISs in nursing homes included clinical data repository (CDR) (86.80 %), CDSS (57.16 %), CPOE (88.11 %), Order entry (32.43 %), and Physician documentation (28.30 %). They found that nursing homes with more use of health information technology (HIT) improved their financial performance to 7 % lower than the operating cost per resident day. Radley et al. (62), also showed that adoption of CPOE system resulted in reduction of medication errors and incorrect prescription due to medical personnel's illegible handwriting in hospitals. This is because users insert patients' information directly to the system. Chaudhry et al. (14) reinforced that through the use of CPOE, 11 % of physicians' time was saved by the alerts to their pagers. Hence, if organizations design and utilize ISs correctly, healthcare centers can benefit from their capacity.

"Garbage in, garbage out" in HIS explains the poor quality of data entry which leads to unreliable information output (50). Data entry errors lead to insufficient data, which can affect the quality of health services (11, 51). Lack of reliable information in Africa's health system has also been reported as a challenge in Sheikh's study (53). Due to the weakness of ISs, the required data about mortality and morbidity as well as causes of diseases are not recorded completely. Thus, authorities are unable to evaluate and plan. In addition, lack of health infrastructure, and up-to-date hardware and software has face African countries with unreliable and speculative health reports. Sheikh reinforced that the gap in sharing of health information in Africa is a main obstacle in development of a functional and high quality health system.

Afrizal et al. (47) have defined four themes in categorizing the challenges of PHCIS. They include human resources, infrastructure, organizational support, and processing. Lack of IT skills and increasing the workload have been mentioned as challenges of medical staff. Maia's study (55) demonstrated that there are limited human resources with IT skills. Moreover, the personnel do not receive training on how to operate an IS; so, they have to spend more time for using computers. Kuek et al. (54) stated poor engagement of human resources with ISs adversely affects safety and quality of patient care. Hence, training of medical and non-medical staff on ISs and justifying their importance in patient care are facilitators of IS acceptance as logistic in health system.

According to Rahimi et al.'s (52) research, when IS is matched well with users' needs and supports organizational processes and procedures, organizations consider it an important part of the job. Limited network capacity, aging hardware, failure to update software, and exchange and interoperability problems of systems also interrupt the work and influence employees willingness to use the system (63, 64). Therefore, to handle issues regarding HISs, authorities should consider all aspects of the system in harmony with each other.

Based on security threats classification, experts identified 84 different categories of threats based on source (internal or external), agents (human,

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environmental or technological), motivation (malicious or non-malicious), intent (intentional or unintentional), and impact (destruction, disclosure of information, denial of service, etc.). These threats pose a huge security risk which must be managed (65). Providing information security disciplines is a good solution for controlling threats and managing security challenges.

This study has given a comprehensive description of information systems in the field of health, as well as a detailed explanation of their role, application, types, components, and challenges. However, the studies used for categorizing the different kinds of information systems in this study were scarce. Furthermore, the existence of different categories in the resources made the summarization difficult and needed to spend a lot of time.

Conclusion

Globally, HISs have been accepted as logistic for administrative and clinical processes of healthcare organizations. They strengthen health system through systematic management of data and delivering reliable information for evidence-based decision-making. This is to improve the quality of health services. Today, there are many types of HIS in three levels of PHC, treatment, and rehabilitation. In many studies, improving the quality, efficiency and effectiveness of health care services, and patients' safety have been reported as the most important effects of applying ISs in the health system. Nevertheless, most organizations face a series of challenges classified into organizational and systemic problems. Systematic and integrated perspectives are needed for overcoming the non-interoperability and fragmentation problems of HISs.

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Conflict of interests

Authors declared no conflict of interests.

Authors' contributions

Mastaneh Z and Mouseli A designed research; Mastaneh Z conducted research; Mastaneh Z analyzed data; and Mastaneh Z and Mouseli A wrote the paper. Mastaneh Z. had primary responsibility for final content. All authors read and approved the final manuscript.

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References

1. World Health Organization. Health systems strengthening. The Global Health Observatory. Available from URL: https://www.who. int/data/gho/ data/themes/topics/health-systems-strengthening. Last access: 20 May, 2022.
2. Lomazzi M. A global charter for the public's health-the public health system: Role, functions, competencies and education requirements. Eur J Public Health. 2016; 26(2): 210-12. doi: 10.1093/eurpub/ckw011.
3. Vidal de Carvalho J, Rocha A, Vasconcelos J, Abreu A. A health data analytics maturity model for hospitals information systems. Int J Inf Manage. 2019; 46: 278-85. doi: 10.1016/j.ijinfomgt. 2018.07.001.
4. Aydiner AS, Tatoglu E, Bayraktar E, Zaim S. Information system capabilities and firm performance: Opening the black box through decision-making performance and business-process performance. Int J Inf Manage. 2019; 47: 168-82. doi: 10.1016/j.ijinfomgt. 2018.12.015.
5. Nomura Sh, Siesjo V, Tomson G, Mohr W, Fukuchi E, Shibuya K, et al. Contributions of information and communications technology to future health systems and Universal Health Coverage: Application of Japan's experiences. Health Res Policy Syst. 2020; 18(73): 1-9. doi: 10.1186/s12961-020-00585-x.
6. Wager KA, Lee FW, Glaser GP. Health care information systems: A practical approach for health care management. 5th edi. US: Wiley; 2022.
7. Sahay S, Rashidian A, Doctor HV. Challenges and opportunities of using DHIS2 to strengthen health information systems in the Eastern Mediterranean region: A regional approach. E J Info Sys Dev Countries. 2020; 86(1): e12108. doi: 10.1002/isd2.12108.
8. Aceto G, Persico V, Pescap A. The role of information and communication technologies in healthcare: Taxonomies, perspectives, and challenges. J Netw Comput Appl. 2018; 1-48. doi: 10.1016/j.jnca.2018.02.

[DOI: 10.18502/jebhpme.v7i1.12356]

008.
9. Mohamadali NA, Ab Aziz NF. The technology factors as barriers for sustainable Health Information Systems (HIS): A review. 4th Information Systems International Conference. Bali, Indonesia; 6-8 Nov 2017.
10. Haux R. Health information systems: Past, present, future. Int J Med Inform. 2006; 75(3-4): 268-81. doi: 10.1016/j.ijmedinf.2005.08.002.
11. Asadi F, Moghaddasi H, Mastaneh Z. Situation analysis of biochemistry information systems in hospital laboratories of Shahid Beheshti University of Medical Sciences and Health Services (2008). Journal of Health Administration. 2011; 13(42): 25-34. [In Persian]
12. World Health Organization. Health information systems and rehabilitation. WHO/NMH/NVI/ 17.2, WHO: 2017. Available from URL: https:// cdn.who.int/ media/docs/default-source/ documents/ health-opics/ rehabilitation/ call- for-action/ healthinformationsystemsandrehaboctober17. pdf? sfvrsn=a0461dd9_5. Last access: Jun 7, 2022.
13. Dehnavieh R, Haghdoost AA, Khosravi A, Hoseinabadi F, Rahimi H, Poursheikhali A, et al. The District Health Information System (DHIS2): A literature review and meta-synthesis of its strengths and operational challenges based on the experiences of 11 countries. Health Inf. Manag. J. 2019; 48(2): 62-75. doi: 10.1177/ 1833358318777713.
14. Chaudhry B, Wang J, Wu Sh, Maglione M, Mojica W, Roth E, et al. Systematic review: Impact of health information technology on quality, efficiency, and costs of medical care. Ann Intern Med. 2006; 144(10): 742-52. doi: 10.7326/0003-4819-144-10-200605160-00125.
15. Littlejohns P, Wyatt JC, Garvican L. Evaluating computerised health information systems: Hard lessons still to be learnt. BMJ 2003; 326(7394): 860–3. doi: 10.1136/bmj. 326.7394.860.
16. Hovenga EJS, Kidd MR, Garde S, Cossio CHL. Health informatics: An overview. 2nd ed. Amsterdam: IOS Press; 2010.
17. Gruber D, Cummings GG, LeBlanc L, L Smith D. Factors influencing outcomes of clinical information systems implementation: A systematic review. Comput Inform Nurs. 2009; 27(3): 151-63. doi: 10.1097/NCN.0b013e31819f7c07.
18. Islam MM, Nasrin Poly T, Jack Li YCh. Recent advancement of Clinical Information Systems: opportunities and challenges. IMIA Yearbook of Medical Informatics. 2018; 83-90. doi: 10.1055/s-0038-1667075.
19. Van der Meijden MJ, Tange HJ, Troost J, Hasman A. Determinants of success of inpatient clinical information systems: A literature review. J Am Med Inform Assoc. 2003; 10(3): 235-43. doi:10.1197/jamia. M1094.
20. Ngafeeson MN. Healthcare information systems opportunities and challenges. In: Khosrow-Pour M. Encyclopedia of Information Science and Technology. USA: IGI-Global; 2014. 14.
21. Lilly CM, Fisher KA, Ries M, Pastores SM, Vender J, Pitts JA, et al. A National ICU telemedicine survey. Chest. 2012; 142(1): 40-7. doi: 10.1378/chest.12-0310.
22. de Mul M, Alons P, van der Velde P, Konings I, Bakker J, Hazelzet J. Development of a clinical data warehouse from an intensive care clinical information system. Comput Meth Prog Bio. 2012; 105(1); 22–30. doi: 10.1016/j.cmpb. 2010.07.002.
23. Bosman RJ. Impact of computerized information systems on workload in operating room and intensive care unit. Best Pract Res Clin Anaesthesiol. 2009; 23(1): 15-26. doi: 10.1016/j.bpa.2008.10.001.
24. Vezyridis P, Timmons S, Wharrad H. Going paperless at the emergency department: A socio-technical study of an information system for patient tracking. Int J Med Inform. 2011; 80(7): 455-65. doi: 10.1016/j. ijmedinf.2011.04.001.
25. Mahoney ChD, Berard-Collins ChM, Coleman R, F Amaral J, Cotter CM. Effects of an integrated clinical information system on medication safety in a multi-hospital setting. AJHP. 2007; 64(18): 1969-77. doi: 10.2146/ajhp060617.
26. Kivinen T, Lammintakanen J. The success of a management information system in health care: A case study from Finland. International Journal of Medical Informatics. 2013; 82(2): 90-7. doi: 10.1016/j.ijmedinf.2012.05.007.
27. Hubaish AMA, Addeeb BM, Al-Serouri A, Mughalles S, Ghaleb Y. The impact of com-puterized health information system on medical & administrative decisions, Sana'a hospitals, Yemen (2017-2020). Ehealth Telecommun Syst Netw 2022; 11(2): 47-66. doi: 10.4236/etsn.2022.112004.
28. Charles-Nelson A, Lazzati A, Katsahian S. Analysis of trajectories of care after bariatric surgery using data mining method and health administrative information

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systems. OBES SURG. 2020; 30: 2206–16. doi: 10.1007/s11695-020-04430-6.
29. Reid PP, Compton WD, Grossman JH, Fanjiang G. Building a better delivery system: A new engineering/health care partnership. Washington D.C: The National Academies Press. 2005. doi: 10.17226/ 11378.
30. McPherson A, Durham J, Richards N, Gouda H, Rampatige R, Whittake M. Strengthening health information systems for disability-related rehabilitation in LMICs. Health Policy Plan. 2017; 32(3): 384–94. doi: 10.1093/heapol/czw140.
31. Gimbel S, Micek M, Lambdin B, Lara J, Karagianis M, Cuembelo F, et al. An assessment of routine primary care health information system data quality in Sofala Province, Mozambique. Popul Health Metr. 2011; 13(9): 12. doi: 10.1186/1478-7954-9-12.
32. Krishnan A, Nongkynrih B, Yadav K, Singh S, Gupta V. Evaluation of computerized health management information system for primary health care in rural India. BMC Health Services Research. 2010; 10(310): 1-13. doi: 10.1186/1472-6963-10-310.
33. Shrivastava SR, Shrivastava PS, Ramasamy J. Need of a sound health information system in public health: Program managers. Int J Health Sys and Disast Manag. 2014; 2(2): 127-9. doi: 10.4103/2347-9019.139073.
34. Protti D, Bowden T, Johansen I. Adoption of information technology in primary care physician offices in New Zealand and Denmark, part 5: Final comparisons. Inform Prim Care. 2009; 17(1): 17-22. doi: 10.14236/ jhi.v17i1.710.
35. Soontornpipit P, Taratep C, Teerawat W, Satitvipawee P, Piroonratana T. The study of hospital information systems in the 8th health region. Procedia Computer Science. 2016; 86: 252-6. doi: 10.1016/j.procs.2016.05.112.
36. Abdelhak M, Hanken MA. Health information: Management of a strategic resource. 5nd ed. US: Elsevier Saunders; 2016.
37. Schmider A. Improving data for rehabilitation in health information systems. WHO, Department for Information, Evidence, and Research. Available from URL: http://www.who.int/disabilities/care/ 1000-Improving -data-for-rehab-in-HIS-Anneke-Schmider. pdf? ua=1. Last access: 15 Mar 2017.
38. Beaumont R. Types of health information systems. 2011: 1-15. Available from URL: https://www. floppybunny.org/robin/web/virtualclassroom/chap12/ s2/systems1.pdf. Last access: Mar 15, 2022.
39. Euromed Marseille. Types of Information System and the Classic Pyramid Model. In: World Med MBA Program, Information Systems and Strategy Course, School of Management. Available from URL: http://www.chris-kimble.com/Courses/World_Med_MBA/Types-of-Information-System.html Last access: Apr 20, 2022.
40. Ertugrul DC, Ulusoy AH. Development of a knowledge-based medical expert system to infer supportive treatment suggestions for pediatric patients. ETRI J. 2019; 41(4): 515–27. doi: 10.4218/ etrij.2018-0428.
41. Diriba Ch, Meshesha M, Tesfaye D. Developing a Knowledge-Based System for Diagnosis and Treatment of Malaria. Journal of Information & Knowledge Management. 2016; 15(04): 108-12. doi: 10.1142/S0219649216500362.
42. Sinard JH, Castellani WJ, Wilkerson ML, Henricks WH. Stand-alone laboratory information systems versus laboratory modules incorporated in the electronic health record. Business Process Management Journal. 2015; 139(3): 311-8. doi: 10.5858/arpa.2013-0711-SO.
43. Wamba-Taguimdje SL, Wamba SF, Kamdjoug JRK, Wanko ChET. Influence of Artificial Intelligence (AI) on firm performance: The business value of AI-based transformation projects. Bus. Process Manag. J. 2020; 26(7): 1893-1924.
44. Gorla N, Somers T, Wong B. Organizational impact of system quality, information quality, and service quality. J Strateg Info Syst. 2010; 19: 207-28.
45. Ash JS, Berg M, Coiera E. Some unintended consequences of information technology in health care: The nature of patient care information system-related errors. J Am Med Inform Assoc. 2004; 11(2): 104-12. doi: 10.1197/jamia.M1471.
46. Littlejohns P, Wyatt JC, Garvican L. Evaluating computerised health information systems: Hard lessons still to be learnt. Information in practice. BMJ. 2003; 326 (7394): 860-3. doi: 10.1136/bmj.326. 7394.860.
47. Afrizal SH, Handayani PW, Hidayanto AN, Eryando T, Budiharsana M, Martha E. Barriers and challenges to Primary Health Care Information System (PHCIS) adoption from health management perspective: A

[DOI: 10.18502/jebhpme.v7i1.12356]

qualitative study. IMU. 2019; 17: 100198. doi: 10.1016/j.imu. 2019.100198.
48. Perez G, Popadiuk S, Coelho Cesar AM. Internal factors that favor the adoption of technological innovation defined by information systems: A study of the electronic health record. RAI Revista de Administração e Inovação. 2017; 14(1): 67–78. doi: 10.1016/j.rai.2016.12.003.
49. Gesulga JM, Berjame A, Moquiala KS, Galido A. Barriers to electronic health record system implementation and information systems resources: A structured review. Procedia Computer Science. 2017; 124: 544-51. doi:10.1016/j.procs.2017.12.188.
50. Kilkenny MF, Robinson KM. Data quality: garbage in – Health Information Management Journal. 2018; 47(3): 103–5. doi: 10.1177/1833358318774357.
51. Mastaneh Z, Mouseli A. Technology and its Solutions in the Era of COVID-19 Crisis: A Review of Literature. Evid. based health policy manag. econ. 2020; 4(2): 138-49. doi: 10.18502/jebhpme.v4i2.3438
52. Rahimi B, Vimarlund V, Timpka T. Health information system implementation: A qualitative meta-analysis. J Med Syst. 2009; 5(33): 359–68. doi:10.1007/s10916-008-9198-9.
53. Sheikh M. Digital health information system in Africa's resource poor countries: Current challenges and opportunities. JHIDC. 2014; 8(1): 78-87.
54. Kuek A, Hakkennes S. Healthcare staff digital literacy levels and their attitudes towards information systems. Health Informatic Journal. 2020; 26(1): 592–612. doi:10.1177/1460458219839613.
55. Maia JX, de Sousa LAP, Marcolino MS, Cardoso CS, de Silva JLP, Alkmim MBM, et al. The impact of a clinical decision support system in diabetes primary care patients in a developing country. Diabetes Technol Ther. 2016; 18(4): 258–63. doi:10.1089/dia. 2015.0253.
56. Flahault A, Geissbuhler A, Guessous I, Guerin PJ, Bolon I, Salathe M, et al. Precision global health in the digital age. Swiss Med Wkly. 2017; 147: w14423. doi:10.4414/smw.2017.14423.
57. Ronquillo JG, Winterholler JE, Cwikla K, Szymanski R, Levy Ch. Health IT, hacking, and cybersecurity: national trends in data breaches of protected health information. JAMIA Open. 2018; 1(1): 15-9. doi: 10.1093/jamiaopen/ooy019.
58. Nilashi M, Ahmadi H, Ahani A, Ibrahim O, Almaee A, Evaluating the factors affecting adoption of hospital information system using analytic hierarchy process. J Soft Computing. Decision Support Syst. 2016; 3(1): 8-35.
59. Fu L, Li L, Li L, Zhang W, Luo Z. Impact of hospital size on healthcare information system effectiveness: Evidence from healthcare data analytics. JMA. 2022; 9(2): 211-31. doi: 10.1080/23270012.2022.2036647.
60. Stamatian F, Baba CO, Timofe MP. Barriers in the implementation of health information systems: a scoping review," Transylvanian Review of Administrative Sciences. 2013; 9: 156-73.
61. Dayama N, Felix H, Pradhan R, Morris M, Karim S. Does nursing home health information technology adoption improve financial performance? A longitudinal study. 2022; 5: 1-25. doi: 10.21203/rs.3.rs-1781286/v1.
62. Radley DC, Wasserman MR, Olsho LE, Shoemaker SJ, Spranca MD, Bradshaw B. Reduction in medication errors in hospitals due to adoption of computerized provider order entry systems. J Am Med Informatics Assoc. 2013; 20(3): 470–6.
63. Asadi F, Mastaneh Z. Challenges of using information technology in hospitals affiliated to Shaheed Beheshti University of Medical Sciences, 2009. Iran J Surgery. 2012; 20(1): 1-9. [In Persian]
64. Or C, Dohan M, Tan J. Understanding critical barriers to implementing a clinical information system in a nursing home through the lens of a socio-technical perspective. J Med Syst. 2014; 38(9): 99. doi: 10.1007/s10916-014-0099-9.
65. Tanwar S, Tyagi S, Kumar N. Security and privacy of electronic healthcare records: Concepts, paradigms and solutions. London: The Institution of Engineering and Technology; 2020.

[DOI: 10.18502/jebhpme.v7i1.12356]