



REVIEW ARTICLE

## Holistic View on Information Systems as Logistic in Health Sector

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### ABSTRACT

**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

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,

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

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. Moreover, 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,

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.

### Acknowledgments

This paper is the result of independent research without any financial and organizational support.

### 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.

### Funding

Non applicable.

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