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An assessment of emergency department information systems based on the HL7 functional profile

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Abstract:

CONTEXT: Emergency Department Information System (EDIS) plays a significant role in supporting the emergency department (ED) workflow. Hence, it is vital to assess the services provided by this system in order to identify its strengths and weaknesses.

AIMS: The study aimed to assess the information systems in use in the ED of 11 teaching hospitals associated with Isfahan University of Medical Sciences (IUMS) so as to identify their strengths and weaknesses and improving the quality of these systems.

SETTINGS AND DESIGN: This study was conducted using descriptive-applied research method.

SUBJECTS AND METHODS: Data collection tool was a checklist developed based on EDIS functional profile. It covered two sections of the profile, namely direct care and supportive functions and their respective subsections.

STATISTICAL ANALYSIS USED: Data were analyzed using descriptive statistics through the estimation of the frequency and frequency percentage for each respective section and subsections using SPSS software v. 20.

RESULTS: The content conformance rate of the information systems in use in the EDs of IUMS' teaching hospitals was found to be 49.72% and 75.25% for the direct care section and supportive functions section, respectively. In addition, the overall conformance rate in the hospitals surveyed was up to 53.15%.

CONCLUSION: As per the findings of this study, it is suggested that some important clinical and administrative functions should be incorporated into the redesigned information systems in use in the EDs under study.

Keywords:

Assessment, emergency department information system functional profile, emergency department information system, HL7

Introduction

Information system is one of the best methods that enables gathering, refining, sorting, and inferring the information correctly and timely for use by all the decision makers.^[1] One of the most important information systems in the health-care domain is the Emergency Department Information System (EDIS)^[2] which can

be implemented either as a subsystem of the hospital information system or a standalone system in the emergency department (ED).^[3] EDIS can be technically defined as an electronic health record system specially developed for the management of information and workflow, supporting the patient care in the ED and emergency operations.^[4]

This system is often used for different purposes such as tracking the ED patients,

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managing the patient information, and providing access to the required data for the clinical experts and managers in the ED. Hence, it enjoys different administrative and clinical functions including the registry, storage, and retrieval of the information about the patient registration, clinical documentation, diagnostic test orderings, tracking the status of the diagnostic test, ED resources' management, diagnoses, and medical operations as well as reporting,^[5] supporting the clinical decisions,^[4,6-9] clinical coding, and accounting.^[4]

EDIS has numerous advantages for the ED, namely improving the ED's performance,^[10] reducing the costs by decreased paper use, enhancing the work productivity of the clinical professionals,^[4] providing easier and more rapid access to the patient's information through its integration with other information systems in use in the hospital,^[4,11] allowing better and more accurate record of the clinical and administrative information, assisting the decision-making and reducing the medical errors,^[4] and removing the limitations resulting from the paper records such as lack of simultaneous access to the record information by multiple users or record illegibility.^[12]

Despite the numerous advantages of EDIS^[3] and its increasingly common usage during the recent years in different nations,^[13] the adoption and application rate of such system is not still pervasive.^[3,14,15] Even some cases of system implementation failures have been reported for different reasons such as lack of support for the workflow,^[16] decreased ED efficiency, and increased patient waiting times and crowding.^[4] Accordingly, to prevent the possible failure of the information system, modifying and improving the system in proportion to the user's requirements and incorporating the required functions into the system seem to be an inevitable necessity. This in turn is only possible by the assessment of the information system.^[17] Ensuring the long-term success of this system, the assessment of the EDIS's functions is necessary so as to identify its strengths and weaknesses, take the necessary measures for removing its weaknesses and, finally, improve the system's functions.^[18] Accordingly, taking the significance of this issue into account, the present study tried to assess the functions of EDISs in use in the Isfahan University of Medical Sciences' (IUMS's) teaching hospitals in terms of the functional profile (FP) HL7 to identify the strengths and weaknesses of this system.

Subjects and Methods

This study was conducted using applied-descriptive research method in 2017. Research population included all the EDISs in use in 11 teaching hospitals of IUMS [Table 1]. Due to the limited size of the statistical population, the entire population was used as the sample

Table 1: Teaching hospitals under study in terms of the type of emergency department information systems

No.	Hospitals	Name of system
1	Al-Zahra	Kowsar
2	Ayatollah Kashani	Kowsar
3	Feiz	Kowsar
4	Imam Hossein	Pouya Samaneh Diba
5	Seyyed Al-Shohada	Pouya Samaneh Diba
6	Amin	Pouya Samaneh Diba
7	Farabi	Pouya Samaneh Diba
8	Imam Mousa Kazem	Hamedan Sayan Rayan Ekbatan
9	Nour and Ali Asqar	Hamedan Sayan Rayan Ekbatan
10	Shahid Beheshti	Hamedan Sayan Rayan Ekbatan
11	Shahid Chamran	Rayavarvan Toseeh

which was further assessed by the census method. EDISs under study were of four types, namely Kowsar, Pouya Samaneh Diba, Hamedan Sayan Rayan Ekbatan, and Rayavarvan Toseeh systems. It is noteworthy that except the Kowsar system, the other systems are also used in other hospitals all across Iran.

Data were collected through observation as well as a checklist prepared based on the EDIS-FP issued by the HL7 organization in 2007. EDIS-FP is a project developed by HL7 Emergency Care Special Interest Group. Creating a set of functions for the EDIS, this project incorporates a number of certain conformance criteria to be used for system assessment purpose. In general, EDIS-FP covers three major sections including direct care, supportive functions, and information infrastructures. The focus of this study was on the direct care and supportive functions sections ignoring the information infrastructures' section due to its emphasis on the technical features of the system such as security, standard terminologies, and interoperability based on the guidelines. In the functional profile, the direct care refers to those system functions which are used for the provision of the patient care and clinical decision support. By definition, supportive functions are a set of functions that back the health-care provision and optimization, generally without placing any effect on the direct care of the patients. Along with the financial and administrative requirements, these functions provide support for the medical research, general health, and health-care quality improvement.^[19] As it was mentioned earlier, the checklist used in this study was composed of two sections: direct care (including three subsections of care management, clinical decision support, and operations' management and communication) and supportive functions (including three subsections of clinical support; measurement, analysis, research, and reports; and administrative and financial). In whole, it consisted of 268 items which have been assigned the level of priority of E (i.e. essential) and have the

keyword of “shall” in their statement formulation. The major sections, subsections, and the number of items per each section have been summarized in Table 2. The content validity of the research instrument was validated by pooling the ideas of the professors of the Health Information Technology faculty as well as the experts of the IUMS’s Information Technology Office.

Data analysis was done using descriptive statistics through the estimation of the frequency and frequency percentage for each respective section and subsections using SPSS software (IBM SPSS Statistics for Windows, Version 20.0, IBM company, Armonk, New York, United States) [Table 3].

Results

The rate of the content conformance estimated for the EDISs in use in the teaching hospitals of IUMS was found to be 49.72% and 75.25% for the direct care and supportive functions’ section, respectively. Furthermore, the estimated rates of content conformance for each subsections of the direct care were as follows: 52.74% for care management, 43.93% for the clinical decision support, and 29.43% for the management of the operations and communications. As for the subsections

Table 2: The main sections, subsections, and the number of items for every section in the checklist

Sections and subsections	Item number
Direct care	232
Care management	187
Clinical decision support	24
Operations’ management and communications	21
Supportive functions	36
Clinical support	14
Measurement, analysis, research, and reports	14
administrative and financial	8
Sum total	268

Table 3: Content conformance rates obtained for the studied emergency department information systems in terms of the sections and subsections incorporated in the checklist

Sections and subsections	Total number of items	Frequency (%)
Direct care	2552	1269 (49.72)
Care management	2057	1085 (52.74)
Clinical decision support	264	116 (43.93)
Operations’ management and communications	231	68 (29.43)
Supportive functions	396	298 (75.25)
Clinical support	154	129 (83.76)
Measurement, analysis, research, and reports	154	113 (73.37)
administrative and financial	88	56 (63.63)
Sum total	2948	1567 (53.15)

of the supportive functions, the content conformance rate was found to be 83.76% for the clinical support; 73.37% for the measurement, analysis, research, and reports; and 63.63% for the administrative and financial subsections. The total content conformance rate was also found to be up to 53.15%. As for the direct care section, care management (52.74%) and operations and communications’ management subsections (29.43%) enjoyed the highest and lowest rates of conformity, respectively. For the supportive functions’ category, the highest conformance rate was observed for the subsection of clinical support (83.76%), while the lowest conformance rate was obtained for the management, administrative, and financial subsection (63.63%). More details about the content conformance rate of the EDISs in terms of the main sections and their respective subsections have been summarized in Table 3. The main strengths and weaknesses identified for the EDISs in question have also been presented in Tables 4 and 5 separately for two sections of direct care and supportive functions.

Discussion

The main purpose of the present study was to identify the strengths and weaknesses of the EDISs in use in IUMS’s teaching hospitals so as to promote the functions of such systems. As per the obtained results, the rate of content conformance of the EDISs with the EDIS-FP was medium (49.72%) for the direct care section and desirable (75.25%) for the supportive functions. The total conformance rate was medium (53.15%).

The lowest conformance rate in the direct care and supportive functions’ sections was observed for the operations’ management and communications’ subsection and financial and administrative subsections, respectively. As it is evident, the content conformance rate of the direct care section was lower than that of the supportive functions’ section. It can be attributed to the weakness of the clinical functions of the system compared to the administrative functions. Shortly, operations’ management and communications’ subsection under the direct care category obtained the lowest conformity rate due to the lack of the functions related to the management of the clinical job descriptions and communication with the external providers. In contrast, the financial and administrative subsection subsumed under the operations’ management and communications’ section showed the lowest conformance rate because the system failed to support some functions including the accessibility to all the patient-related information so as to support the diagnostic encoding and operations and care results and preparing a comprehensive record of the patients’ admission to the ED.

Table 4: The most important strengths and weaknesses identified for the emergency department information systems in use in Isfahan University of Medical Sciences' teaching hospitals for the subsections of direct care

Direct care subsections	Major strengths	Major weaknesses
	The systems supported the following functions:	The systems did not support the following functions:
Care management	<p>Quick registration ED patients</p> <p>Creating an individual record for all the patients even for those whose identity is unknown</p> <p>Receiving, storing, retrieving, and editing the demographic information</p> <p>Viewing the previous records of the patients in the system</p> <p>Exchanging the information with other subsystems of HIS such as information systems used for admission, laboratory, radiology, billing, etc.</p> <p>Writing the prescriptions and recording the drug orders and diagnostic tests orders</p> <p>Capturing the details of drug orders including the prescription date, drug dose, method of drug dispensing, explanations about the drugs prescribed</p> <p>Tracking the status of the medication orderings, diagnostic tests orders, and obtaining the results of the tests</p> <p>Capturing the vital signs of the patients, namely blood pressure, temperature, heart rate, respiratory rate, and severity of pain</p> <p>Registering the measures taken for the patients</p> <p>Recording the status of ED patients (admission, discharge, or transfer)</p> <p>Obtaining the comprehensive data related to the triage assessment</p> <p>Managing the discharge instructions</p>	<p>Capturing and displaying the patient histories relating to the diagnoses, surgeries, and other measures taken for the patients</p> <p>Obtaining the family and social history of the patients</p> <p>Documenting the clinical information at different times in the structured and nonstructured format</p> <p>Documenting the medical decisions</p> <p>Documenting the patient training, consulting, and communicating with the patient's family by the ED physician and other persons in a descriptive format</p> <p>Recording the details relating to the future care including follow-up, returns, and appropriate time for future care</p> <p>Creating legal documentations for patient transfer</p> <p>Obtaining one or more emergency diagnoses</p> <p>Capturing the allergies, contraindications, and patient's drug reactions' type</p>
Clinical decision support	<p>Displaying the essential information for identifying the correct patient</p> <p>Displaying the patients on the waiting list to be examined by the physician</p> <p>Providing the access to the nursing care plans, guidelines, and assessment protocols</p>	<p>Obtaining the clinical decision support prompts and decisions made by the users regarding the acceptance or rejection of these prompts</p> <p>Checking and reporting the allergies and drug reactions when a new drug is prescribed</p> <p>Giving automatic warning to the care providers when a case of contraindication is recognized for the prescribed drug doses and the possibility of canceling the warning</p> <p>Warning the care providers about the wrong patient, wrong medication, or wrong dispensing method or wrong drug dispensing time</p> <p>Creating and displaying some useful templates developed on the basis of patient data, nursing care plans, guidelines, and protocols</p>
Operations' management and communications	<p>Recording the counseling services delivered to the patients</p> <p>Recording the telephone/verbal communications occurred between the care providers</p> <p>Providing access to a library of educational resources</p>	<p>Managing the clinical task descriptions such as creating clinical task descriptions manually or electronically, providing the possibility of manual modification of the task descriptions, keeping them up to date, and tracing the status of the task descriptions</p> <p>Displaying the up-to-date list of tasks that must be done for each patient</p> <p>Marking the tasks that have not been done at the time of patient admission, transfer, or discharge</p> <p>Providing the possibility of integration of the scanned documentations delivered by the external care providers into the patient records</p>

ED=Emergency department

According to the National Hospital Ambulatory Medical Care survey in 2011, from among 14 functions as

determined based on the federal standards' stipulations, only these functions have been incorporated in the

Table 5: The most important strengths and weaknesses identified for the emergency department information systems in use in Isfahan University of Medical Sciences' teaching hospitals for the subsection of the supportive functions

Supportive functions' subsections	Major strengths	Major weaknesses
	The systems supported the following functions:	The systems did not support the following functions:
Clinical support	<p>Managing all the personnel who use the system or have access to the system</p> <p>Defining new users for the system and providing appropriate access for the users</p> <p>Recording the accurate time when the patient is admitted to the ED</p> <p>Identifying and displaying and updating the current location of the patient and triage time, admission time, in-room time, and discharge time</p> <p>Managing the ED and emergency rooms</p> <p>Displaying the empty beds ready for the admitted patients</p>	<p>Managing the clinical personnel who are not among the system users</p> <p>Providing essential information for identifying the primary and secondary job locations or physician offices in the system</p> <p>Identifying the current and real-time location of the patient in the hospital immediately and clearly</p>
Measurement, analysis, research, and reports	<p>Generating reports from all or a part of the patient's records</p> <p>Generating reports from a part of the clinical and administrative data</p> <p>Sending or retrieving the data required for access to the health-care level of quality, performance, and accountability of the ED</p> <p>Providing access to the key reports of the ED (including the number of admissions, the percentage of bed occupancy rate, patient length of stay, and the number of patients that have left the ED without any examination by the physician or before completing the treatment process)</p>	<p>Exchanging information with other clinical health-care centers</p> <p>Generating some reports which shall be used as a formal health record for disclosure purposes</p> <p>Generating comprehensive reports based on the electronic records of the patients</p>
administrative and financial	<p>Sending the data to the financial and administrative systems</p> <p>Organizing the patient data in terms of each single visit</p> <p>Collecting patient information as a resource for supporting and assisting the care providers with further diagnoses and treatments</p>	<p>Providing access to all the patient-related information to support the coding of the diagnosis, procedure, and treatment results</p> <p>Creating a comprehensive record of the patient admission to the ED, namely all the documentation prepared by all the care providers during the encounter</p>

ED=Emergency department

electronic health record in use in 14% of the EDs: 1.order writing and entry of prescriptions, 2.warnings about the drug interactions or contraindication, 3.the entry of demographic and patient history information, 4.the list of patient problems, 5.clinical transcripts including the list of the drugs currently dispensed by the patient and allergies, 6.reminders for interventions proposed based on the guidelines, screening tests as well as drug interactions and contraindications, 7.preparing clinical summaries for the patients for each visit, and 8.electronic exchange of the clinical summaries with other care providers. This study revealed that none of the systems supported four functions including the entry of vital signs, smoking condition, preparing and sending the service quality reports, and preparing the electronic copies of health information.^[20] The majority of the EDISs surveyed in this study were found to support the functions of the electronic entry of the diagnostic and drug orders, the entry of the demographic information,

the record of the vital signs and reporting, considered as the most important functions, and strengths of the information systems in question. In this regard, the results obtained from our study were in line with those of the National Hospital Ambulatory Medical Care survey. However, none of the systems had the functions of the drug contraindication and drug dosage warnings, reminders of guideline-based interventions, reminders of screening tests, reminders of drug, the entry of the information on the medical histories, the listing of patient problems as well as the electronic exchange of the history summaries with other care providers. It is noteworthy that such functions are deemed as vital for achieving a comprehensive EDIS. However, the results of this study did not conform to the results obtained in the National Hospital Ambulatory Medical Care survey. Lack of participation of the emergency team in the development process of the system and the users' resistance toward using such functions due to the

work overload are among the possible causes for the lack of such functions. According to numerous studies, the clinical decision support can enhance the patient safety through lowering the errors and providing the information, guideline-based recommendations, and warnings on the drug allergies and contraindication. This, in turn, allows better decision-making and better service delivery for the ED patients.^[21,22] Furthermore, besides being a very good educational resource, the clinical guidelines incorporated in the EDIS might facilitate the evidence-based decision-making by the practitioners^[6] improving emergency patient care provision.^[23]

In one study, Landman *et al.* have argued that a comprehensive EDIS must support the function of preparing and sending the general health reporting as well as the function of information exchange with other systems.^[8] In this study, all the hospitals in question were found to support the function of preparing and sending the reports using their EDISs. Although this reporting function does not cover all the reports required by the ED due to the incomplete collection of the information, it somewhat satisfies the requirements of the ED. This result was in full conformity with the results of the study by Landman *et al.* It is noteworthy that all the EDISs in use in the hospitals in question failed to support the function of the information exchange with other health-care centers due to the lack of appropriate infrastructures.

As per the findings of another study by Mayer *et al.* conducted in the ED of one hospital in America, the interns used emergency information system for tracking the patients.^[24] The EDISs studied here were not equipped with a monitor for accurate tracking of the emergency patients. The EDISs only supported the function of displaying room number or emergency bed number. This result contradicted the findings of Mayer *et al.*'s study. Patient tracking from the time of his/her admission in the ED to the discharge time may be advantageous for knowing the movement flow of the patients and their current position, coordinating the operations better, knowing the patient wait time and, finally, refining the ED's performance.^[25]

Rao in his study in an Indian hospital reported that compared to the paper operations, the EDIS allows more rapid access to the diagnostic codes reported in the International Classification of Diseases book, vital signs, allergies, and notes of the assessment of the patients' status.^[6] In this study, none of the EDISs in question could be characterized as a comprehensive electronic health record due to usage of paper-based profiles together with the system. Hence, they did not provide the function of accessibility to all the patient-related information

required for the diagnosis and encoding of operations and results. Hence, this result was not in line with that obtained in Rao's study.

Besides the strengths summarized in Table 4, the EDISs in question lacked some major functions such as clinical documentation, diagnostic record, the possibility of creation of precompiled guidelines for the patients with similar condition for time-saving purpose, the receipt of disease history, creation of legal records for transferring the patient, clinical decision support, and information exchange with other medical centers. Despite numerous benefits of EDIS, its broad and sophisticated functions are not fully exploited by Iran's hospitals for some factors. These factors could be classified into three subcategories, namely organizational, technical, and human factors. From among organizational factors, lack of organizational and technical support, managers' unwillingness toward investment on the advanced informational systems due to the high costs required for the information system development, purchase and technical support, crowding and high workload in the ED, insufficient training of the personnel about how to work with the system, and the application of paper records as a legal resource in the courts and invalidity of the electronic records can be enumerated. As for the technical factors, the following ones can be named: the low quality of system and collected information, problems relating to the information security and privacy, unexpected failure of the system and the loss of patient information and lack of specific laws, and regulations and requirements regarding the essential functions to be incorporated in the EDIS in Iran. For the human factors' category, the following cases can be mentioned: lengthy time required for the entry of the information into the system by the personnel, the resistance of the ED's personnel toward the entry of the information in the paper records, the low computer knowledge of the ED's personnel, workforce shortage in the ED and the request of the patients for receiving the emergency care services at the earliest, weakening of the interactions between the health-care providers and the patients, and lack of participation of the ED's personnel in designing the system's functions.

The results of this study can assist the system designers and developers to improve the available functions and integrate the new functions into the information systems in use in the EDs. This, in turn, will lead to better management of the information and the ED resources and improvement of delivery of the care services.

The current study was the first of its kind on the assessment of EDISs based on the HL7 functional profile to compare the functions of the information systems in use in the EDs of the selected hospitals with standardized

functions of these systems in the world. With the exception of Kowsar system, all the EDISs surveyed are also used in other parts of the country. As a result, the findings of this study can reflect an overall picture of the status of these systems in Iran.

One of the limitations of the study was the difficult and time-consuming process of information gathering, given the high workload of the ED staff and their high interaction with the system.

Conclusion

Taking the findings of this study into account, it is recommended that the following functions—as the most important functions—to be put at the top of the priority list when redesigning the EDISs in question: recording the clinical information and the cares provided for the patients in the system rather than using paper records; recording the diagnoses, surgeries, and other measures taken for the patients; obtaining the disease, family, and social histories of the patient; performing the medical follow-ups for the discharged patients; managing the clinical job description of the care providers; creating the legal records for transferring the patients; receiving the drug contraindication, reactions and allergies for the patient, and their respective reporting; supporting the advanced clinical decisions regarding drug–drug and drug–diet interactions, drug contraindication, allergies, and drug dosages; exchanging information with other medical centers; producing comprehensive reports from the patient records and other reports required by the ED; and providing access to all the information required for coding the diagnoses and procedures.

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Conflicts of interest

There are no conflicts of interest.

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