Towards more integrated Medical Information Systems: How HIS and MIS hand in hand will be able to be beneficial increasingly?

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Research Article

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Abstract

Nowadays according to the intention of many hospitals and medical centers to computerize their processes and medical treatments including data forms and medical images which are generating a huge amount of data, IT specialists and data scientists who are oriented to eHealth and related issues know the importance of data integrity and its benefits. This study attempts to indicate the significance of data integrity, especially in medical information systems. It means that the medical sub-systems in HIS (Hospital Information System) must be integrated and it is also necessary to unify with MIS (Management Information System). In this paper accuracy level of the extracted reports from the Information System (to evaluate the staff’s performance) in two ways has been measured: 1- At first, the performance of the clinic reception staff will be evaluated. In this way, the personnel attendance system is an independent and separated software, and the mentioned evaluation has been done by its report. 2- Next year in the same location precisely the same evaluation has been done based on the data extracted from the personnel attendance sub-system which has been added to the medical information system as an integrated information system. After comparing the accuracy level of both ways, this paper concludes that when the personnel attendance sub-system as a part of MIS has been unified with HIS and its sub-systems, how much the reports and consequently management decisions will be more accurate and more reliable and therefore the managers and decision-makers will perceive the importance of data integrity more than the past.

Introduction

Undoubtedly in recent years almost everybody himself/herself or one of his/her family has dealt with medical information systems and their facilities even in the format of Internet lab answer and the whole of them know the advantages of these systems compared to medical data in the paper. Several eHealth systems are used during the full healthcare process. Starting from systems for managing patient documentation (e.g., an Electronic Health Record (EHR)), managing organizational issues in a healthcare site (such as patient admission), and ending with financial systems. The basic concept of the EHR is that it is a virtual container for health-related documentation for a subject of care [1]. eHealth technologies, including electronic medical records (EMR), computerized provider order entry (CPOE), e-Prescribing, and computerized decision support systems (CDSS), are promoted for their financial and clinical benefits. This has led eHealth to become central to many government agendas worldwide [2]. MIS is the use of information technology, people, and business processes to record, store, and process data to produce information that decision-makers can use to make day-to-day decisions. The full form of MIS is Management Information Systems. The purpose of MIS is to extract data from varied sources and derive insights that drive business growth [3], including:

Financials, Inventory, Personnel, Project timelines, Manufacturing, Real estate, Marketing, Raw materials, and R&D. The MIS collects the data, stores it, and makes it accessible to managers who want to analyze the data by running reports. On the other side, The Hospital Information System (HIS) is an integrated information system that provides hospital information requirements for daily operations such as
planning and patient care [4]. Regarding the medical processes, many HIS have their sub-systems including reception, sonography, radiology, patient queuing system, inpatients, etc., while it is prevalent among some hospitals to utilize MIS as a separate software to manage their personnel and administrative processes whose subsystems are consist of inventory, calculating salary, accounting, personnel attendance system, etc.

Data integrity remains one of the most critical concerns for healthcare industries also. Data integrity breach in healthcare institutions may result in any number of potentially serious consequences. Preserving data integrity in healthcare industries has become a challenging problem because of the organizational structure of the healthcare institutions that entail high-end point complexity and regulatory pressures. [5]

In recent years, many companies, industries, and also hospitals tend to computerize their processes and interactions, but many senior managers don’t aware of the importance of data integrity and having unified information systems. Indeed, they mistakenly believe that even having separate and independent subsystems is enough whereas we will indicate that although it is prevalent among hospitals to do so when we integrate them as integrated medical information (HIS + MIS) the extracted reports and subsequent decision making will be more accurate and reliable. In this regard, through bolding the avails of data integrity, especially in the medical information system, top managers and other decision-makers in this field will be encouraged to pay attention and also dedicate an adequate budget to implement integrated medical information systems.

Because among available articles, less has been addressed about integration in medical information systems and its effect on the accuracy level of the reports and it is a serious concern for data scientists, especially in the domain of medical information systems, we have investigated the information system of Avicenna Infertility Center including Hospital Information System (HIS) and Management Information System (MIS) To measure the impact of this integration on the quality level and accuracy of reports and also its impact on staff performance evaluation. In this regard, we have evaluated the performance of the personnel in the reception unit, in two different years: before the integration of MIS and HIS, and after integration (HIS + MIS). So, we are investigating in this paper that when HIS and MIS, themselves and their sub-systems merge moving to a more integrated information system, what will happen to the accuracy level of Information? To what extent the reports and decisions will be more accurate?

We will illustrate that although the existence of medical information system (HIS) and management information system (MIS) may be a positive point for any hospital and medical center, it is not enough to achieve accurate reports and consequently perfect human evaluation, and if we decide to reach the reliable reports and accurate human evaluation, we must move forward the integrated information systems.

To express the stated goals in this article, first, we have reviewed the related works which have investigated data integrity and its significance in medical information systems. In the next step, we will point that how is HIS and MIS deployments in medical centers and then how can be integrated. After the
integration, which benefits can be achieved especially about accuracy level of information (through data analysis and reception rate concept), and then we will summarize the contents and conclude.

Related Works

Managing data integrity is a challenging task for any expert or researcher. In this study, Abhishek et al. [5] discuss data integrity techniques and postulates that the most prioritized data integrity technique is the blockchain. In another paper, Georgios et al. [6] propose a data integrity mechanism for an eHealth telemonitoring system that operates in a smart home and supports the transmission of medical data from the patient’s home to the health care center. Agent technology is applied to achieve data integrity with the use of cryptographic smart cards.

A blockchain-based eHealth integrity model for ensuring information integrity in eHealth systems that use a permissioned blockchain with off-chain information storage was created by Tomasz et al. [7]. In another paper data, integrity in medical information systems has been investigated: Poor EHR system design and improper use can cause EHR-related errors that jeopardize the integrity of the information in the EHR, leading to errors that endanger patient safety or decrease the quality of care. These unintended consequences also may increase fraud and abuse and can have serious legal implications, written by Sue et al. [8]. Another research intends to describe the threat plot of data integrity in healthcare through numerous attack statistics from around the world and Saudi Arabia and identify the criticality in Saudi Arabia in particular. The results of this SLR conducted by Mohammad et al. [9] strongly indicate that the healthcare sector needs a new and more robust data integrity approach.

Unfortunately, the integrity and anonymity of this vast amount of information are not always ensured. There exist many threats that can change or even delete part of these logs. In this paper conducted by Azahara et al. [10] has been presented a proposal to consider some of these threats and prevent their consequences in some eHealth systems.

In one of the best articles in this field prepared by Vimalachandran et al. [11], strongly and the importance of data integrity especially in Health Care Systems has been explained: one of the serious problems in depending on networked data is ‘dirty data’. Dirty data may include incomplete, missing, or inaccurate information. The concern is particularly significant in health care where dirty data represents the dark side of the great potential offered by the adoption of health-related IT systems. First and foremost, dirty data can lead to medical errors, which can kill or cause long-term damage to the health of patients. Data should be an accurate representation of its source. It should be reliable. In EHR, data integrity entails the accuracy of the complete health record’s documentation. It encompasses information governance, patient identification, and validation of authorship and record amendments. Another study which has done by Michael et al. [12] to assess operational data quality in an emergency department (ED) immediately before and after an EHR implementation and concluded that, in the immediate period following a typical EHR implementation, systematic errors and inaccuracies are pervasive in EHR operational data. Administrators and policymakers should be aware of such possibilities during EHR
implementation and should attempt to minimize the deleterious effects of EHR implementation on data integrity.

In addition, the other paper prepared by Alka et al. [13] has claimed that undoubtedly, data has turned into one of the most valuable assets of any company. The more appropriate data an organization has, the more successful it is likely to become. This is where data integrity becomes key. Data integrity has become a serious issue over the past recent years and therefore is a core focus of many industries. Integrity ensures that the data is original, correct, and safeguarded from unauthorized modification. There is also some academic review like this one prepared by Tsipi et al. [14] which has investigated the integration of some fundamental concepts together such as PHR, EMR, and HER and related challenges but it has not pointed directly to the integration of MIS and HIS: Integrated data from EMR, EHR and PHR can create gigantic databases that are suitable for big data analysis methods and tools. This type of data analysis has great promise for driving personalized care, as well as improving public health decision-making and health policy crafting.

The other academic paper has discussed integrated medical information systems and their exigency in medicine. It has been written by Tsung et al. [15] and it has quoted that As the development of the structure and format of electronic patient records and prescriptions matures, the implementation of a comprehensive medical information system is imperative, one which is constructed by integrating the various electronic information systems that are being developed. It is important to allow the implementation of such a system applicable to the present medical environment, which facilitates the integration of electronic patient records from all levels of medical centers and clinics, secures the transmission of these integrated patient records between them, enables the combined use of electronic prescriptions with patients’ medications, and permits anonymous or confidential transmission of patients’ private data. In another study which has been done by Shiyun et al. [16], the integration issues in eHealth have been scientifically addressed and have been concluded that different disciplines have different knowledge functions in the eHealth field. For example, medical and health-related disciplines, supplied more knowledge of Research subjects, entities, and Research Methodology, while information technology-related disciplines played a more prominent role in providing Technology and Data related knowledge. the integration pattern of different knowledge types became stable along with the maturity of the eHealth field, which could be revealed that the proportion of knowledge amount, references, and source disciplines, as well as citation interval of different knowledge types, were becoming stable in recent years.

The impact of information system integration on the healthcare management and medical services has been reviewed by Zijian et al. [17] has emphasized that medical care combined with information technology is a new trend and the completeness and consistency of information directly affect the efficiency and quality of healthcare services as well as the safety of diagnosis and treatment. The level of internet information technology is reflected in its realization degree of integration between information systems and processes. This concept is defined as Information Systems (IS) integration, the degree to which data and applications are shared and accessed over different communication networks.
In this regard, there is a dissertation about Regional Integration of Electronic Medical Records which has been done prepared by Sadiq et al. [18] and has revealed that there are clear and present challenges to regional integration of EMR. Although regional integration initiatives such as the implementation of Clinical Connect, a regional EMR clinical viewer, continue to expand, physicians face challenges related to implementation, support, and advanced use of electronic records. He has concluded that physicians used the EMR in a variety of ways and often took advantage of basic useful features rather than more advanced, integrated features. Patients interact with caregivers with the expectation of full integration of patient information despite the apparent lack of full integration of patient portals or linkages to their physician's practice.

Another research performed by Petral et al. [19] has expressed that the Integrated care approach and the broader view on a patient's care is something that today's healthcare systems thrive for. Medical information collected from many disparate sources, accessed by authorized users through electronic healthcare records (EHR) is enabling technology behind. This article gives an overview of different interoperability aspects related to data exchange and maps it to usual healthcare business processes. Furthermore, another investigation about the integration of EHR, EMR, and PHR has moved forward by Tsipi et al. [20] and claims that this integration of medical information combines demographic, lifestyle, and behavioral data with health records thus providing a comprehensive view that coincides with the definition of patient-centered medical care. It can lead to a dramatic amelioration in personalized care as well as public health decision-making, resulting in improved health and wellness, but also poses serious challenges and threats to security and privacy.

The study which is conducted by Manish et al. [21] has been highlighted that the Integration of electronic health records (EHRs) in the national health care systems of low- and middle-income countries (LMICs) is vital for achieving the United Nations Sustainable Development Goal of ensuring healthy lives and promoting well-being for all people of all ages. National EHR systems are increasing, but mostly in developed countries.

In another article performed by Renwen et al. [22] the integration issue in the EHR domain has been investigated from a new perspective whilst has been pointed out that integrating patient-reported outcomes (PROs) into electronic health records (EHRs) can improve patient-provider communication and delivery of care. However, new system implementation in healthcare institutions is often accompanied by a change in clinical workflow and organizational culture. This study sheds light on the ecosystem around EHR-integrated PRO systems (such as user needs and organizational factors). In the other work done by Anuj et al. [23] determines whether an electronic health record (EHR)-integrated patient portal was associated with increased understanding of the care plan, including the key recovery goal, among patients and clinicians in an acute care setting. Patient–clinician communication during acute care is suboptimal. Patient portals tethered to the EHR have the potential for improving patient-clinician communication over acute episodes of care by enhancing mutual understanding about the care plan and facilitating goal-concordant care, which is increasingly important for seriously ill hospitalized
patients. There is also a study that has processed the other aspect of integrated EHR and behavioral health by Katelyn et al. [24] in which has been quoted that integrating behavioral health into primary care can improve care quality; however, most electronic health records are not designed to meet the needs of integrated teams. And it has been concluded that health information technology tools designed for behavioral health integration must fit the needs of clinics for the successful uptake and improvement in patient experiences.

**Deployment Of His And Mis**

As mentioned above, these concepts (HIS and MIS) are utilized among IT professionals and other groups with different definitions. It means that many medical centers and hospitals employ HIS for the medical and treatment processes. In this more prevalent way, medical information systems including several sub-systems are known as eHealth and consist of all the medical images and data related to the patients and maybe some information of the doctors and nurses with data structure shown in Figure 1.

Hospital Information System:

MIS (Management Information System) is an information system that employs generally both medical and industrial centers and enterprises to manage and perform the administrative and official processes including human resources, accounting, storage management, and personnel attendance system. It is typically considered as an independent and separate software which is consist of several sub-systems as shown in Figure 2.

Management Information System

It means that frequently be utilized two distinct information systems and it is often accepted that they are fundamentally different in nature and type of information and should be separated. In this way they calculate the salary of the personnel and also evaluate them in MIS meanwhile medical process of the patients will be under control in HIS.

*Transferring one subsystem from MIS to HMIS*

As we have pointed out in Figure 2 one of the subsystems of MIS is the personnel attendance system. As usual, in Avicenna Clinic Infertility, this sub-system had been placed in MIS. At the end of 2019, IT specialists decided to transmit the mentioned sub-system from MIS to HMIS(HIS+MIS) to move forward to implement a more integrated information system. In this regard, the necessary technical confirmations took place as followings:

- Performing fundamental definitions and professional expressions in the destination subsystem.
- Connecting the attendance devices to the new sub-system.
- Customize the destination sub-system to prepare some features available in MIS.
Carrying out the essential data entry such as identities, work shifts, leave, and mission authorizing also permitted delay and haste.

Building the necessary reports in the second personnel attendance sub-system.

In early 2020, the personnel attendance system which had been prepared in HMIS was exploited. It means that staff presence, work time shift, and all related processes were handled in the sub-system available in HMIS. By this, calculating the active time, salaries, and even staff performance evaluation will be done more integrated.

Now that the mentioned transmission from MIS to HMIS as shown in Figure 3 has taken place, it is possible to compare the accuracy level of the reports related to the evaluation of staff performance. For this purpose, we need to evaluate the personnel quantitatively with a measurable factor that is calculable in both statuses (before integration of the sub-system and after that). So, we have utilized a professional expression in a medical environment which is called “Reception Rate”.

**Reception Rate**

When Personnel Attendance System had been placed in the separated software (MIS) and also after its transmission to HMIS, permanently was being used a measurable criterion which is known as Reception Rate. This expression uses to evaluate reception personnel and calculates as follows:

\[
\text{Reception Rate} = \frac{\text{number of admitted patients}}{\text{number of useful working hours}}
\]

The Reception Rate has been calculated for the reception personnel for 2019 and separately for 2020. In this study, the obtained Reception Rate related to 2019 is called abbreviated RR_19, and about 2020 it will be called RR_20.

For calculating RR_19, the number of admitted patients has been extracted from HIS whereas the number of working hours has been obtained from MIS (independent software).

Undoubtedly, RR_20 has been obtained from both variables (the number of admitted patients and working hours) available in HMIS.

Now, in this step, we start to rummage that which RR_19 or RR_20 is more accurate and reliable. Although we know that RR_20 has originated from an integrated information system and conversely RR_19 from two separate ones.

**Data analyzing**

In this study, we endeavor to find out what effect data integrity will have on the accuracy level of calculating employee performance appraisal? For this purpose, we have compared the accuracy level of admission rate calculation in two different circumstances:

- Calculation of the reception rate (RR_19) through two separate information systems: HIS and MIS.
As we had told before, to calculate the reception rate we need both “the number of admitted patients” and also “number of working hours”. The necessary data has been extracted from the available reports but along with this difference in 2019, a part of data (number of admitted patients) has existed in HIS and another part (number of working hours) has been extracted from MIS. Meanwhile, in 2020, both parts of the reception rate have been originated from an integrated information system (HMIS). To clarify this issue, the extracted information, as well as the sources used, are given in Table 1.

Table 1. Data extraction in 2019 and 2020

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Number of personnel</th>
<th>Sum</th>
<th>Average</th>
<th>Source of data extracting</th>
<th>Year of data extraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total working hours in a year</td>
<td>21</td>
<td>352878.75</td>
<td>16803.75</td>
<td>MIS</td>
<td>2019</td>
</tr>
<tr>
<td>Total admitted patients in year</td>
<td>21</td>
<td>119153</td>
<td>5673.95</td>
<td>HIS</td>
<td>2019</td>
</tr>
<tr>
<td>Total working hours in a year</td>
<td>21</td>
<td>367937.22</td>
<td>17520.82</td>
<td>HIS+MIS= HMIS</td>
<td>2020</td>
</tr>
<tr>
<td>Total admitted patients in year</td>
<td>21</td>
<td>156392</td>
<td>7447.25</td>
<td>HIS+MIS= HMIS</td>
<td>2020</td>
</tr>
</tbody>
</table>

As we have indicated in table 1, the sample has been consisting of 21 reception personnel including 15 females and 6 males. Their age is between 25 to 37 years. During 2019 and also 2020, there has been not any change in the reception staff and consequently, some effective factors such as age, marital status, and education level have been controlled in this study.

For the required data such as “the working hour” and “the admitted patients” has been utilized the available reports in MIS, HIS, and HMIS as a source of data extraction (according to table 1).

In 2019, the sum of working hours which belong to these staff has been divided by 21 to calculate the average (this calculation has occurred in the personnel attendance sub-system belongs to separate software of MIS) while the number of admitted patients and also the average has been extracted from the available reports in HIS. In 2020, the mentioned variables are extracted from related reports in the Reception sub-system in addition to the personnel attendance sub-system in HMIS. According to the value of **Sig. in the Shapiro-Wilk test in SPSS software which is Sig.<0.05 and indicates that the variables are not normally distributed**, so **Mann-Whitney U** Test has been applied to compare differences between the two groups.

The statistical data related to research variables are shown in the following table:

Table 2. Statistical data in 2019 and 2020

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Work hours</td>
<td>16803.75</td>
<td>2488</td>
<td>17520.82</td>
<td>1308.82</td>
</tr>
<tr>
<td>Number of Admitted Patients</td>
<td>5673.95</td>
<td>1658.39</td>
<td>7447.25</td>
<td>1759.84</td>
</tr>
<tr>
<td>Admission Rate</td>
<td>0.3468</td>
<td>0.1153</td>
<td>0.4298</td>
<td>0.10909</td>
</tr>
</tbody>
</table>
The statistical data in Table 2 indicates the status of data distribution in this study. It also shows that the average admission rate in 2019 has been 0.3468 and its standard deviation has been 0.1153 meanwhile the number of these criteria for 2020 in the same order has been 0.4298 and 0.10909.

We are looking for answering this question: Whether adding the Personnel Attendance System to HMIS effects calculating Admission Rate or not? Does it have been effective?

To find out an answer to the above question, in SPSS software we have utilized the Mann-Whitney Statistical Test whose results have been inserted in Table 3.

Table 3. The output of the Mann-Whitney Test

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean Rank</th>
<th>Sum of Ranks</th>
<th>Mann-Whitney</th>
<th>Z</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reception Rate</td>
<td>2019</td>
<td>18.71</td>
<td>449.00</td>
<td>14900</td>
<td>-2.866</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>30.29</td>
<td>727.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Regarding Table 3, Mean Rank (about Reception Rate) has been calculated at 18.71 in 2019, and the Sum of Ranks in the same year has been 449.00 whilst the Mean Rank and Sum of Rank have been 30.29 and 727.00 in 2020. As it shows Mann-Whitney value is 14900 and also the number -2.866 has been assigned to Z Since the Significance Level has been equal to 0.004 and the p-value<0.05, we can conclude that the difference between the population medians is statistically significant and the assumption that adding personnel attendance system to HMIS has caused the difference between RR_19 and RR_20 will be accepted.

We can look at this issue from another angle: looking at the statistics in table 2 we will realize that the number of admitted patients in 2020 has increased by 31.24% compared to 2019 whereas the number of working hours in 2020 compared to 2019 has increased just by 4.2%. what is it meaning?! The increasing trend of the admission rate in 2020 compared to 2019, with a ratio higher than the ratio of increasing working hours, shows the high accuracy of calculating RR_20 and it is also indicated that due to the use of integrated information systems, personnel performance evaluation has been performed several times more accurately and conversely in the evaluation of performance among reception staff in 2019, some of the effective factors have been ignored.

Conclusions

Although immediately, the number of hours related to the reception personnel has increased in 2020 compared with 2019 this growth can’t cause to increase Reception Rate because the number of admitted patients has increased by a larger proportion. When an employee is working in the reception unit, she/ he is passing her/his active time and only the active time should be the measurement criterion, not the length of time that admission staff is in the hospital or medical center. Indeed, the active time is a more important factor and must be considered for the evaluation process, not just her presence at work. In the
previous section, the effect of ignoring active time due to the inability of separate software was visible. When a personnel attendance system is separate software, how can we (as an assessor) distinguish the active hours from inactive ones? The extracted reports from independent software just will entail the arrival time, exit time, hourly leave, and their duration (just these data fields which are available). It means that in this condition, when they calculate the reception rate it cannot be accurate and consequently the evaluation which has been done is not reliable!

When we are utilizing separate MIS to calculate Reception Rate, technically it is impossible to consider and control all of the factors (even manually) which are affecting this calculation, and conversely, while HMIS is employed to gain Reception Rate, many influencing factors such as login time, active time, history of data entry (which user has registered patient's data) and even canceled admitted patients will be carefully involved in the calculation. This is the same golden key and the great advantage of integrated systems!

Probably, many IT experts who are working in medical centers and hospitals have encountered the claim that in our expertise and field the software of company X (for example) is the best and it has many features and our group (for example genetic group) prefers to utilize it. Although they are right! But developing a subsystem that is completed every day and also belongs to an integrated information system will help each company to achieve their organizational purposes more than a complete and experienced but separate and independent software. This is precisely the same fact that we need to pay attention to about integration.

This study shows that when senior managers and decision-makers utilize the reports which is extracted from integrated information how much it can be more accurate and reliable. So despite the method that is common among many of the medical centers and hospitals in which they employ some professional software but independent and in the form of an island, never is not recommended by IT experts who perceive the importance of data integrity and even in some cases perhaps there may be several defects and information gaps which definitely will affect in decision making, now imagine this hazard takes place about medical decision system and the fate of the patients!

We hope that this issue can be good evidence to encourage all those who determine the strategies in the field of medical information systems, especially medical ones, and it can help to change (even a bit) their attitude.

Declarations

Conflict of interest statement: The authors have no conflicts of interest to disclose.

Role of funding source: The author received no funding for this work.

Ethical Approval: This study didn't take place in any private or protected areas and has been used just the number of staff and the average hours without any private and identity information. So, the identities of
the participants are not known at all.

**Informed Consent:** This assurance was given to the participants that in this study, will be used merely the summation of the working hours and admitted patients and there are none of the reports related to the staff (separately for each user or personnel) in this study.

**Authors’ Contributions:** Ali Azadi wrote the main manuscript text. He prepared figures 1-3 and also the extracted tables 1-3. Francisco J. García participated in this article to prepare and technical revise the manuscript and data analysis. All authors reviewed the manuscript.

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Figures
Figure 1

Data structure in HIS

Figure 2

Prevalent subsystems of MIS
Figure 3

HMIS (HIS+MIS)