Abstract

It is widely believed that electronic health records (EHR) improve medical decision making by enabling medical staff to access medical information stored in the system. It remains unclear, however, whether EHR indeed fulfills this claim under the severe time constraints of Emergency Departments (EDs). We assessed whether accessing EHR in an ED actually improves decision-making by clinicians. An authentic simulated ED environment was created at the Israel Center for Medical Simulation (MSR). Four different actors were trained to simulate four specific complaints and behavior. Each physician treated half of the cases (randomly) with access to EHR, and their medical decisions were compared to those where the physicians had no access to EHR. Accessing the EHR led to an increase in the quality of the clinical decisions. The percentage of correct diagnoses was higher and physicians were more confident in their diagnoses.

Keywords: Decision making/makers, Electronic medical records, Decision analysis, Technology assimilation.
Introduction

In recent years, the healthcare sector has been widely investing in state-of-the-art medical technologies to improve medical decision-making. These technologies have prompted much research over the years (Borycki et al. 2013; Goldschmidt 2005; Lovis et al. 2011) with the aim of improving the quality and efficiency of health services through health information technology (HIT). HIT has been the subject of increasing numbers of studies, most of which have focused on the commercial aspects of the system (Jones et al. 2014). The assumption is that HIT will improve medical processes and reduce costs through the integration of patient data and their immediate accessibility to physicians and medical staff. Studies have shown that Electronic Health Records (EHR) a widely used version of HIT, can improve physicians' performance and quality of care (Cebul et al. 2011; Goldberg et al. 2012; Jarvis et al. 2013; Takian et al. 2012). Medical history retrieved by EHR allows physicians to have a more comprehensive view of the patient and improve the quality of decision-making, thus reducing some of the risks and uncertainties that stem from lack of information. Meaningful HIT use is thought to lead to: 1) improved quality, safety, efficiency of care 2) better engagement with patients and families; 3) improved care coordination; 4) better population and public health; and 5) greater privacy and security (Borycki et al. 2013). These advantages should lead to clear critical informative decisions. However, the impact of EHR on high-stress environments such as emergency departments (EDs), which often have to deal with overcrowding and heavy time constraints, raises other questions. In particular, the overcrowding in EDs often results in inferior clinical outcomes (Bair et al. 2010; Ben-Assuli et al. 2012; McCabe 2001; Schneider et al. 2001; Spaite et al. 2002) and medical errors in almost every area of emergency care, including diagnostic errors, wrong documentation, and wrong pharmacotherapy (Fordyce et al. 2003; Lecky et al. 2013) as well as poor exploitation of the EHR (Lawson and Daniel 2011). Although availability of medical information is crucial to the success of medical care (Hripcsak et al. 2007) in the ED, physicians’ access to the system is often limited (Hersh and Hickam 1998). Unsurprisingly, studies have reported high correlations between accessing medical history and improving patient care (Goldman et al. 2006; Walker et al. 2005). To help understand and counter the effects of the chaotic environment of the ED on the clinical process and its many decisions, specific research is needed.

Issues in Implementation of Integrated Medical Information Systems

The impact of using an integrated medical information system on medical decision-making has been investigated widely in numerous studies (Blumenthal and Tavenner 2010; Hersh et al. 2002; Laerum et al. 2003; Redelmeier and Shafir 1995; Westbrook et al. 2005a; Westbrook et al. 2005b). The general implications and outcomes of HIT have been explored to determine diagnostic and therapeutic strategies and planning resources (Johnston et al. 1994; Sinha and Kohne 2009; Smith-Daniels et al. 1988) and to measure the effectiveness of triaging patients in the ED through medical information systems (Michalowski et al. 2007). Black et al. (2011) pointed out that the inexorable increase in national health expenditures and the desire to improve the quality of healthcare are spearheading the widespread adoption of HIT but their outcomes should be reviewed and researched. Only a few studies have been conducted to better define a theoretical framework to assess the potential value and cost effectiveness of HIT (Basu and Meltzer 2007; Ben-Assuli and Leshno 2013; Rippen et al. 2013)

Claxton et al. (2002), Walker et al. (2005) and Kapoor & Kleinbart (2012) found that electronic healthcare information exchange (HIE) and interoperability between healthcare providers can save on costs to health maintenance organizations (HMOs). They showed that information exchange via medical information acquired by other providers helps avoid double testing and thus reduced delays and costs. Access to integrated systems and information enables the health care sector (including various medical suppliers and HMOs) to function as a single unit.

In recent years, more systematic and empirical studies and reviews on technology acceptance in the healthcare domain have begun to emerge (Holden and Karsh 2010; Lapointe and Rivard 2005). They show that the integration of HIT in health care facilities is not without pitfalls. The issue of rejection factors has been investigated, and many factors identified including IT resistance (Bartos et al. 2010), incorrect measurement methodologies (Liu and Wyatt 2011) and misguided expectations from the IT (Bloomrosen et al. 2011). Two of the most important design principles that have emerged are identifying users’ needs, and incorporating workflow integration (Peleg et al. 2009). An additional element in HIT is
the specific needs of health care professionals from different fields (Vest and Jasperson 2010). For example, psychiatrists need further information such as prescription compliance and/or abuse and additional functions within the system such as wireless patient monitoring (Varshney 2009). Pediatricians, on the other hand, check for growth parameters and might need the system to calculate a development curve.

The Current Study

Healthcare organizations use different kinds of local and external computerized HIT systems to manage medical care and support decision making. In Israel, full patient medical records are in various phases of assimilation. However, the electronic medical record (EMR) system is currently limited in the country to one hospital or in rare cases to one HMO and is not equipped to provide access to medical information stored in other medical institutes.

The current study examined "OFEK", a specific interoperable EHR system which enables direct access to patients’ medical information as recorded by healthcare providers in both hospital and community settings. This system has been fully operational since 2005 in a specific HMO (Clalit Health services), and incorporates medical information from both hospitals and community centers. Currently OFEK is implemented in all hospitals in Israel and all health institutes owned by Clalit HMO, the largest Israeli HMO with more than three and a half millions customers.

Our main goal was to examine the impact of EHR on clinical decision making and its contribution to clinical decision making for ED physicians and especially the accuracy of diagnoses. The study was conducted at the Israel Center for Medical Simulation (MSR) (http://www.msr.org.il/e). MSR is a national resource for simulation-based training and assessment where multiple studies have been conducted on the effectiveness of simulations in improving health professionals’ clinical proficiencies, including studies in the challenging area of doctor-patient computer skills, where health professionals encounter simulated patients (SPs) in an authentic simulated environment which includes their customized EHR and receive feedback on their communication skills in this setting (Farfel et al. 2010; Reis et al. 2011; Reis et al. 2013).

The use of simulation as a research method in empirical studies on EHR nevertheless remains the exception to the rule. A previous study investigating genetic testing using an EHR simulation reported a positive impact (Deshmukh et al. 2009). Another EHR simulation revealed security faults in an EHR system (March et al. 2013). However few studies have used simulation to evaluate the effect of EHR on clinical decision making. Moreover, this research addresses some of the gap of previous research, which dealt with similar issues but were bounded to many other goals and among them: the implementation of technology for the triage of patients at EDs (Michalowski et al. 2007) and the implementation of EHR for assisting to admission decisions (Ben-Assuli et al. 2013; Ben-Assuli et al. 2014).

Research Questions and Hypotheses

The main objective of the current study was to assess EHR use and examine whether it improves medical decision-making during ED triage. Physicians’ performance in the ED depends to a great extent on access to medical information (such as medical history, previous tests, allergies etc.) including the EHR systems (Ben-Assuli et al. 2014). Physicians must have access to this information under the time constraints of emergency cases (Pickering et al. 2013). Traditionally medical histories were almost always obtained through medical interviews. Clearly, the more information there is about a certain patient, the better the decision and diagnosis the physician can make (Henriksen and Brady 2013). Previous studies have reported a significant association between EHR use and better medical care (such as cancer screening, diabetes testing, etc.) (Kern et al. 2013). This led to the following hypothesis:

**H1:** There is a positive relationship between the use of EHR and making an accurate admission decision. Hence, access to an EHR should lead physicians to:

**H1.1 – Make more justified admissions to the hospital.**

**H1.2 – Make fewer unjustified admissions to the hospital (more justified discharges).**

Justified admissions refer to a medical situation in which the patient’s condition requires admission to one of the units in the hospital. Justified discharges refer to a situation where the physician determines that the patient’s condition does not require hospitalization and can be treated at community clinics.
Recently, many studies have discussed using a checklist when diagnosing patients (McHugh and Slavney 2012; Sibbald et al. 2013), and some have even suggested incorporating one into the EHR system (Schiff and Bates 2010). The checklist provides a structure for medical staff to rely on when making diagnoses. Given that the diagnostic process and informed medical decisions are best served by access to information, using the EHR system is likely to provide (most) of the information needed for physicians to diagnose. Consequently, we formulated the following hypothesis:

H2: There is a positive relationship between the use of EHR and increased diagnostic accuracy.

An informed medical decision that relies on both current symptoms and past medical history (which can be obtained from the EHR) should be more founded and substantial. Additional information such as the community physician’s opinions, lab tests and other physiological parameters can assist physicians in making accurate decisions and can also increase their confidence. Under such conditions, physicians are more likely to work more effectively, provide better care, and show a higher degree of confidence in less time (Duan et al. 2011). Consequently, we formulated the following hypothesis:

H3: There is a positive relationship between the use of EHR and the confidence of the decision-maker regarding the choice of future management and diagnostic actions for the patient.

Methodology

The experiment and medical scenarios

We observed the performance of physicians in four simulated cases. The physicians were ED senior physicians and internal medicine residents who also work at the ED. The cases were all frequent ED clinical scenarios, chosen from among the most common clinical scenarios at the National Center for Health Statistics (NCHS), the principal health statistics agency in the US. These scenarios also appear in the textbooks of the Educational Commission for Foreign Medical Graduates (ECFMG), which assesses the readiness of international medical graduates to enter residency or fellowship programs in the USA. The scenarios were presented by SPs at a mock ED at MSR. Prior to the simulation, the participating physicians received a brief description of the experiment. They were aware that the situation was a simulation and that the patients were in fact actors. These actors were trained to fully simulate an emergency case including high stress levels during their examinations. They were trained to present the same symptoms and to answer uniformly in the medical interview to keep the clinical picture constant for all participants. The participating physicians were able to examine the actor-patients (by asking any question they wanted about their physical condition and receiving full answers). Two cases dealt with chest pain complaints and two with abdominal pain.

The scenarios were developed by senior physicians from Sheba Medical Center’s ED and MSR. In two scenarios, the information from the EHR supported the decision to discharge the patient despite conflicting clues from the medical interview and medical tests. In one scenario, this information supported an admission decision despite the information provided without OFEK, whereas in the control scenario, admission was the expected decision in both cases. In the experiment, the physicians interviewed the SPs, took their history, and examined them with no time limitations, and then were asked to state their preliminary differential diagnosis (DD) and their level of confidence in their DD. Following this phase, they could order medical tests. Pre-prepared results were given to them on request. After this phase, they were asked to state their final DD and to decide whether to admit or discharge the patient (they could also add further management strategy and a diagnostic workup plan). This study was designed to fully simulate an ED (as well as a chaotic environment and distressed patients). The participating physicians were all volunteers who took part in the study during their working hours in the real ED (they were excited in the middle of their shift for the simulation study), and therefore treated the SP as part of their daily routine (somehow like seeing regular ED patients). As in real life, the physicians had no inherent time limit for the medical encounter, but needed to return to their daily work. They could return to examine the patient at any time during the simulation (two physicians did so). All physicians interacted with the same actors. Moreover, each one of the four simulated cases was presented by the same actor in all observations (to prevent bias). Each SP had a list of physiological indices to match their illness in addition to the symptoms they were asked to portray. These were given to the physicians if asked. The entire sequence of the study were (including different test results) was carefully planned by a group of experienced medical professionals.
The study was designed to enable a comparison between the decision making of physicians who had access to complete clinical information (via the OFEK EHR system) and those without access. To test our assumptions, we equipped the simulated environment with the OFEK system, including the information and medical history of the SPs. Each physician had access to OFEK in two out of four cases. The access was available just after the medical interview and prior to their preliminary DD.

For each scenario, the EHR contained test results (such as CTs, blood tests, etc.) reflecting the specific illness presented by the SP (for example, in chest pain scenario B the EHR system contained a chest X-ray, an ECG and a recent discharge letter from another hospital). Note that access to data does not necessarily imply access to useful information. Since our framework focused on the clinical implications and accuracy of diagnosis when accessing the system, the key pieces of information were provided.

**Independent variables**

**EHR use:** Each physician had access to EHR in half of the cases (randomly), and no access in the other half. This variable was coded as dichotomous (1= Full access to EHR/ 0= No access). The system was the commercial version of OFEK. All participants had used the system previously. Background medical information was "planted" in the EHR. Physicians had access to this information by entering the SP's simulated ID number. In general, OFEK EHR collects medical information from distributed health care providers, external labs, pharmacies and hospitals. Then, this interoperable information is integrated into a representation of the patient and his/her information in the system. Consequently, via the OFEK any physician or authorized clinician can analyze the information and search for more information. The information sources include prior hospitalizations, prior diagnoses, medication lists, allergies, previous lab results, primary physician medical records, etc. However, in this experiment, we did not include all of the SPs' history in OFEK. Primarily we included general health information and history applicable to the medical cases.

**Seniority status:** Based on previous studies that have reported differences in the decision-making processes of professionals depending on status (Ahituv et al. 1998; Dew et al. 2009; Salas et al. 2010) the physician's seniority was taken into account (1= senior physicians / 0= residents).

**Specialty:** Based on studies that reported differences among the information components used by physicians with different specialties, decision-makers in the study were classified according to their specialty (internal medicine vs. emergency). Internists were coded as 1 and the emergency physicians as 0.

**Familiarity with the certain EHR:** To control for different levels of familiarity with the EHR used in this study, this variable represented level of familiarity with the system (on a scale of 1 to 9).

**Years of Experience with EHR:** To control for different levels of experience in the use of any EHR, this variable represented the actual years of experience with any EHR.

**Time:** This is known to be a factor that impacts decision-making (Ahituv et al. 1998; Hwang 1994; Hwang 1995; Ramanujan et al. 2000; Topi et al. 2005), especially in EDs. This variable was measured in minutes, representing the amount of time handling each case by each physician.

**Dependent variables**

The participants filled in their initial and final DD, admission decision, and confidence level on a questionnaire provided to them. We used open-ended questions for DDs with check boxes, yes/no check boxes for admission decisions and a Likert scale for measuring the confidence level. The gold standard for admission decisions and correct DDs were defined by senior ED physicians at the Sheba Medical Center.

**Differential Diagnosis (DD):** This variable represents the diagnosis made by the physician for each case (according to diagnostic standards of the ICD10).

**Admission decision:** This variable represents the physician's decision to admit (coded 1) or discharge (coded 0) the patient.

**Confidence level:** This variable evaluated the effect of the use of EHR on confidence level (the strength of belief in the accuracy of diagnosis and decisions) of the decision-maker. It was formulated as an odd Likert scale ranging from 1 to 7 (7=highest confidence level). We tested this variable twice: before physicians ordered tests and after.
Results

Twenty six physicians (15 internal medicine physicians and 11 emergency physicians, all working in the ED) volunteered to participate in this study. They were exposed to 103 simulated cases in total (four cases for each physician; one physician could only participate in only three cases).

Descriptive statistics

The sample consisted of a relatively equal proportion of men and women, with a higher proportion of internists (compared to ED physicians). Most of the sample consisted of residents, with substantial variability in terms of years of experience. The percentage of residents represented the proportion of residents in the real EDs in the hospital; namely, most physicians in the ED are residents and not senior physicians. Most of them rated their level of EHR use around the middle range of the scale. Table 1 lists the demographic measures of the participating physicians.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean(SD)/Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>36.42 (3.95) / 30 – 45</td>
</tr>
<tr>
<td>Gender (%)</td>
<td>M-12 (46.15%) / F-14 (53.85%)</td>
</tr>
<tr>
<td>Specialty (%)</td>
<td>Internal Medicine-15 (57.69%) / Emergency-11 (42.31%)</td>
</tr>
<tr>
<td>Seniority (%)</td>
<td>Seniors-7 (26.92%) / Residents - 19 (73.08%)</td>
</tr>
<tr>
<td>Years of experience as a physician</td>
<td>3.75 (3.26) / 1-13</td>
</tr>
<tr>
<td>Level of EHR use</td>
<td>4.89 (2.37) / 1-9</td>
</tr>
<tr>
<td>Years of experience with any EHR*</td>
<td>4.35 (2.39) / 0-10</td>
</tr>
</tbody>
</table>

Note: * On a scale of 1 to 9.

Impact of using EHR on admission decision

The impact of EHR use on admission decision varied as a function of the case. This variability was expected, given the nature of the cases and differences in medical information which suggested different clinical strategies. For instance, in ‘Chest pain scenario A’, EHR use increased admission rates, whereas in ‘Chest pain scenario B’, EHR use dramatically reduced admissions (see Table 2 for all scenarios).

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Access to EHR Percentage (number of physicians)</th>
<th>No Access to EHR Percentage (number of physicians)</th>
<th>Change rate in Admission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest Pain – Scenario A*</td>
<td>92.3% (12)</td>
<td>58.3% (7)</td>
<td>+58.32%</td>
</tr>
<tr>
<td>Chest Pain – Scenario B*</td>
<td>71.4% (10)</td>
<td>100% (12)</td>
<td>-28.6%</td>
</tr>
<tr>
<td>Abdominal Pain – Scenario A***</td>
<td>0% (0)</td>
<td>41.7% (5)</td>
<td>-</td>
</tr>
<tr>
<td>Abdominal Pain – Scenario B***</td>
<td>100% (13)</td>
<td>23.1% (3)</td>
<td>+332.9%</td>
</tr>
</tbody>
</table>

Note: *p<0.1  p<0.05  **p<0.01  ***p<0.001  n/a not applicable (similar conventions appear in the tables below). Because the Admission rate for Abdominal Pain – Scenario A was zero we ran a Fisher test.
In order to assess the contribution of EHR use to admission decisions, and compare it to that of the other variables, we ran two logistic regression analyses (see Table 3 for admission decisions and Table 4 for discharge decisions). As shown in Table 3, EHR was the only variable that significantly predicted (p<0.01) a high increase in admission rates.

### Table 3. EHR contribution to admission decisions (cases 1, 4)

<table>
<thead>
<tr>
<th>Variables</th>
<th>B</th>
<th>S.E.</th>
<th>OR</th>
<th>95% C.I. for OR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EHR Used, **</td>
<td>4.531</td>
<td>1.341</td>
<td>92.814</td>
<td>6.7</td>
</tr>
<tr>
<td>Time (minutes)</td>
<td>.082</td>
<td>.119</td>
<td>1.086</td>
<td>.859</td>
</tr>
<tr>
<td>Specialty, b</td>
<td>-1.232</td>
<td>.955</td>
<td>.292</td>
<td>.045</td>
</tr>
<tr>
<td>EHR familiarity, c</td>
<td>-.136</td>
<td>.203</td>
<td>.873</td>
<td>.587</td>
</tr>
<tr>
<td>Years of EHR experience</td>
<td>.294</td>
<td>.201</td>
<td>1.341</td>
<td>.904</td>
</tr>
</tbody>
</table>

Note: * Coded as: 1= access to EHR, 0= No access to EHR. ** Coded as: 1= Internal, 0= Emergency. * Coded on a scale of 1-9 (9 representing higher levels of familiarity). **p<0.01. Similar conventions appear in the tables below.

Here also (Table 4), EHR use significantly contributed (p<0.01) to predicting discharge decisions. Using EHR was associated with an 84.9% reduction in admission decisions.

### Impact of using EHR on differential diagnosis

In 'Chest-pain scenario A', it could be claimed that neither of the two main DDs given constitute a medical error. The more appropriate DD is acute coronary syndrome and in fact, EHR use increased the rate of this DD. However, musculoskeletal chest pain was a fairly reasonable diagnosis as well, though not as accurate as acute coronary syndrome. Given the patient's medical information stored in the EHR physicians were probably unable to rule out this DD. However using EHR was associated with a significant improvement in DD accuracy (See Table 5).

### Table 5. Chest pain - scenario A - differential diagnosis

<table>
<thead>
<tr>
<th>DD</th>
<th>Preliminary DD Percentage (number of physicians)</th>
<th>Final DD Percentage (number of physicians)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No EHR Used</td>
<td>EHR Used</td>
</tr>
<tr>
<td></td>
<td>No EHR Used</td>
<td>EHR Used</td>
</tr>
<tr>
<td>Acute coronary syndrome</td>
<td>33.3% (4)</td>
<td>76.9% (9)</td>
</tr>
<tr>
<td>Musculoskeletal chest pain</td>
<td>50.0 (6)</td>
<td>15.4% (2)</td>
</tr>
</tbody>
</table>

Note: Data do not sum up to 100% due to cases in which neither of the above DDs was made. Preliminary DD was made prior to testing, in the ED, and Final DD was made after receiving test results. Conventions as above.
In the ‘Chest pain scenario B’, no access to the EHR system led to dissection of aortic aneurysm as the most likely DD, whereas using EHR provided data on previous tests that made musculoskeletal chest pain a more reasonable choice. Hence, without using EHR, 66.7% of the participants diagnosed aortal dissection, and none diagnosed musculoskeletal chest pain, whereas using EHR, 57.1% of the participants diagnosed musculoskeletal chest pain, and only 14.3% diagnosed dissection of aortic aneurysm (Table 6).

Table 6. Chest pain scenario B - differential diagnosis

<table>
<thead>
<tr>
<th>DD</th>
<th>Preliminary DD</th>
<th>Final DD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No EHR Used</td>
<td>EHR Used</td>
</tr>
<tr>
<td>Aortic Aneurysm</td>
<td>33.3% (4)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>Pericarditis</td>
<td>0.0% (0)</td>
<td>7.1% (1)</td>
</tr>
<tr>
<td>Acute Coronary Syndrome</td>
<td>33.3% (4)</td>
<td>35.7% (5)</td>
</tr>
<tr>
<td>Esophageal Spasm</td>
<td>0.0% (0)</td>
<td>7.1% (1)</td>
</tr>
<tr>
<td>Pulmonary Embolism</td>
<td>8.3% (1)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>Musculoskeletal chest pain</td>
<td>25% (3)</td>
<td>50% (7)</td>
</tr>
</tbody>
</table>

Note: The table entries are the percentages of cases diagnosed with and without EHR use.

In addition to the chest pain scenarios, two scenarios in which abdominal pain was the main complaint were presented to the participants. In ‘Abdominal pain scenario A’, the correct diagnoses were either irritable bowel syndrome (IBS) or Gastroenteritis. Table 7 shows that using EHR improved DD accuracy by increasing the rate of diagnosing IBS to 92.9% (compared to 58.3% without using EHR), together with 7.1% diagnoses of gastroenteritis.

Table 7. Abdominal pain scenario A - differential diagnosis

<table>
<thead>
<tr>
<th>DD</th>
<th>Preliminary DD</th>
<th>Final DD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No EHR Used</td>
<td>EHR Used</td>
</tr>
<tr>
<td>Peptic disease</td>
<td>8.3% (1)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>IBS</td>
<td>41.7% (5)</td>
<td>78.6% (11)</td>
</tr>
<tr>
<td>Diverticulitis</td>
<td>8.3% (1)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>Epiploic Appendicitis</td>
<td>8.3% (1)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>IBD (Inflammatory bowel disease)</td>
<td>8.3% (1)</td>
<td>0% (0)</td>
</tr>
<tr>
<td>Incarcerated Hernia</td>
<td>0% (0)</td>
<td>7.1% (1)</td>
</tr>
<tr>
<td>Gastroenteritis</td>
<td>8.3% (1)</td>
<td>7.1% (1)</td>
</tr>
<tr>
<td>Pancreatitis</td>
<td>8.3% (1)</td>
<td>0% (0)</td>
</tr>
</tbody>
</table>

Note: Data do not sum up to 100% due to cases in which none of the above DDs was made.

In ‘Abdominal pain scenario B’, without using EHR the expected diagnoses would have been nephrolithiasis and radiculitis. As expected, these were the two most frequent diagnoses in this case (Table 8). However, using EHR exposed participants to a past abdominal CT scan, indicating a likely
Improving Diagnostic Accuracy Using EHR in EDs

The diagnosis of abdominal aortic aneurysm. Table 8 shows how the rates of this diagnosis increased significantly by several percent alongside a decrease in diagnosing radiculitis in the case of EHR use.

<table>
<thead>
<tr>
<th>Table 8. Abdominal pain scenario B - differential diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>DD</td>
</tr>
<tr>
<td>No EHR Used</td>
</tr>
<tr>
<td>Muscle Pain</td>
</tr>
<tr>
<td>Renal Vein Thrombosis</td>
</tr>
<tr>
<td>Nephrolithiasis</td>
</tr>
<tr>
<td>Abdominal Aortic Aneurysms</td>
</tr>
<tr>
<td>Radiculitis</td>
</tr>
</tbody>
</table>

Note: Data do not sum up to 100% due to cases in which none of the above DDs was made.

Impact of using EHR on DD confidence

Using EHR led to a significant increase in the mean confidence level by 0.9 points (approximately 16%), compared to the mean confidence level without using EHR. The level of confidence in the preliminary diagnosis was unaffected by using EHR (Table 9).

<table>
<thead>
<tr>
<th>Table 9. EHR impact on the diagnosis confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean without EHR(SD)</td>
</tr>
<tr>
<td>Confidence in preliminary DD*</td>
</tr>
<tr>
<td>Confidence in final DD**</td>
</tr>
</tbody>
</table>

Note: Differences were subjected to Mann-Whitney test for confidence levels, which were represented on a Likert-type scale and therefore treated using parametric statistics.

Discussion

Overall, our findings suggest that using EHR helps improve the quality of medical decision making. Physicians utilize the system and take advantage of the availability of the patient's medical history. EHR provides a more comprehensive picture enabling physicians to make more informed decisions. The results also supported the hypotheses, as detailed below. This may imply that physicians make more accurate decisions by using EHR which may optimize the health care given to patients. The simulated environment in MSR was found to be appropriate for testing the efficiency of the use of EHRs. It combined simulated patients and controlled scenarios in a mock hospital setting and the actual (commercial) EHR. Future experiments could add time constraints and crowdedness levels to the test setting.

The effect of EHR use on admission decisions varied with the scenario. As expected, in the case of 'Chest pain scenario A', using EHR raised admission rates and in 'Chest pain scenario B' using EHR lowered admission rates. These results suggest that physicians were in a position to make more informative admission decisions on patients because of the severity of their symptoms, in addition to previous medical history found in the EHR. In the abdominal pain scenarios, the results were comparable; in scenario A, EHR use decreased the rate of admissions and in scenario B, EHR use increased the rate of admissions. The EHR can thus enhance the physician's understanding of a patient's status and illness and enable better medical service. These results suggest that preliminary exposure to medical records puts physicians in a better position to make more informative admission decisions (Hypothesis 1 supported).
Unlike memory-based medical history from a medical interview, the documented medical history information provided by the EHR was probably the key factor that led to more correct diagnoses. Higher rates of correct diagnosis were accompanied by a decrease in erroneous diagnoses, a crucial factor in improving quality and safety of care. In 'Chest pain scenario A', use of the EHR substantially raised the percentage of physicians who diagnosed the patients correctly. In 'Chest pain scenario B', a vital piece of information from the patient's medical history differentiating two likely DDs was recorded in the EHR. The results show that without the ability to access EHR, most physicians made an inaccurate diagnosis. In both abdominal pain scenarios, EHR use increased the accuracy of diagnosis (Hypothesis 2 supported). These findings illustrate the importance of access to EHR as a source of previous medical information, which medical staff might not have in situations when no oral information is available or incomplete, when patients are unconscious or disoriented or are unable to speak coherently for any reason.

The physicians who used EHR were significantly more confident in their diagnoses; however, this was only true for the final diagnosis (after the test results were available) and not for the initial diagnosis (Hypothesis 3 supported for the final diagnosis). This may be due to the fact that decision makers need specific information to be confident about their medical decisions. Given their typical work flow, physicians will wait to make a decision until all the required information (such as lab tests and imaging) has been obtained. The additional EHR information contributed to the traditional decision making process. Thus, medical records provide important clues whose impact is stronger after test-based information, such as previous ECG, CT, blood tests, etc. have been obtained for comparative purposes.

Overall, these results show from different perspectives that EHR use results in better care by providing more information, which helps medical staff reach a more correct diagnosis. Consistent with previous findings (Hripcsak et al. 2013), an EHR system emerges as clearly beneficial to the health care sector.

**Contributions, Limitations and Future Research**

In recent years, the use of EHR has grown worldwide as well as in Israel where increasingly more hospitals and health care providers have recognized its benefits. However, it is difficult to pinpoint the specific factors contributing to improved care. Medical staff needs information to provide quality medical care but they lack the time to view the information on the EHR. One of the major issues in this field is whether the information provided by the EHR is effective and whether it helps physicians in their decision making. We aimed to shed light on these questions. Specifically, the findings show the relationships between use of the system and accuracy and confidence in diagnoses. In general, our hypotheses confirmed that the use of EHR improves medical decision making in terms of accuracy of diagnosis and correct admission decisions, as well as better quality of care as shown in the reduction in the percentage of wrong diagnoses. Specifically, we found an EHR in the ED to be a useful tool for clinicians. It enables faster, easier access to the information needed by physicians. One in every seven admissions to an ED can be attributed to missing information (Frisse and Holmes 2007). This study provides evidence that EHR use in ED affects the process of medical decision making. In particular, the DD (among other decision components) is more accurate. High-stress medical environments are an under-explored area of health IT usage. This study sheds light on the process of medical decision making. It also contributes to medical decision making policy in the sense that the results show how access to an EHR can improve patient care. The findings may help increase the cooperation and willingness of medical staff to adopt an IT system by demonstrating its contribution to correct diagnosis.

Our study also has some limitations. The finding were only obtained on two cases (chest pains and abdominal pain) in four scenarios and with a specific EHR (OFEK). This may limit the generalizability of the findings. Second, the study took place in a simulated environment where the participants encountered each patient in an isolated manner. This of course does not fully resemble the authentic conditions in a real, busy ED where multiple patients and staff crowd the physicians and create considerable distraction. Third, the participating physicians volunteered to take part in the simulation study and differed in terms of their seniority, their prior experience with these specific cases (or ones like them), their specialty, their experience with the EHR and other factors. This, might have biased the results of the study and the accuracy of the diagnoses. However, we conducted several statistical analyses including logistic regressions, which reduced the likelihood of this bias.
In addition, some of the physical findings (such as elevated heart rate, high blood pressure, etc.) were impossible to replicate as is, since the actors were healthy. However physicians were aware of the simulation situation and could ask questions and receive such information verbally or in written form. All the physicians who took part in the simulations were in the middle of their work day, and all were eager to complete their cases and get back to their wards. Future research could take more clinical cases into consideration, as well as other EHR systems (which may vary in their user-friendliness in terms of real-time accessibility to patient data) and, of course, in terms of the actual environment (i.e. – conducting the study in a real ED). In addition, the EHR (OFEK) is developing its capabilities to work on mobile devices at all points of care, including the ED. Thus, it would be worthwhile to study the impact of such incremental technology within the crowded ED environment.

HIT designers, medical staff, patients and policy makers can benefit from the data shown here. EHR assimilation can improve the care given to patients and enhance the efficiency and safety of the system. There is a growing need for training medical staff and exposing them to HIT and its benefits. The findings also suggest investing in a system that will allow the sharing of information between health care providers to increase the pool of information provided to medical staff at the point of care.

References


Improving Diagnostic Accuracy Using EHR in EDs


