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An Evaluation of Success of Electronic Health Records in Reducing Preventable Medical Error Rates in the United States: A Detailed Report

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Abstract

Medical errors in the United States are estimated to claim anywhere between 210,000 and 400,000 human lives every year and the numbers have skyrocketed almost five times higher than the 1999 estimates published by the Institute of Medicine (IOM). With these latest revelations, it is no surprise that medical errors are the third leading cause of deaths in the United States, overshadowing auto accidents, strokes, Alzheimer's, diabetes, and everything else besides cancer and heart diseases. With hundreds of thousands of people dying from preventable medical errors every year, the issue has long been a reality and has not really received the attention it merits. The digital revolution to move paper records on digital space is in uptick and the track records have backed Electronic Health Records in curtailing medication and communication related errors but haven't shown certainty and promise in curtailing diagnostic and technology related errors. That said, the rising death toll of preventable medical errors have however, not been put to a stop. At the outset, this paper centres on evaluating the success rate of health-IT in curtailing medical error rates in the United States and asserts on the need to implement effective strategies and improve diligence on revamping systems to reduce the incidence of medical errors and make it a national priority! Outcome of the paper would help consumers perceive an understanding of health-IT's potential in reducing preventable medical errors. Is health-IT knight, knave or a pawn?

Keywords: Medical errors; Health-IT; Success rate

Introduction

A medical error is defined as a preventable adverse effect of care which might result from erroneous or careless diagnosis or treatment of a disease, syndrome, injury, infection, behaviour, or other ailment [1]. Preventable medical errors are the third leading cause of death in U.S and are estimated to cost between $17 and $29 billion in expenses, lost income and household productivity, and disability [2-4]. If the healthcare system of U.S. was a country, its monetary value would be the 6th largest economy on the entire planet. With the country making huge investments on healthcare, the promise on improvement in patient safety and productivity has not been realised. The United States of America ranks last in health and mortality when compared with 17 other developed nations [5]. Astronomical number of lives lost between 1999 and 2013 is shown in **Figure 1** [6].

Medical errors are classified into four categories: diagnostic, treatment, preventive, and other [7]. Common medical errors occur due to one of these factors medication error, failure to take the needed precaution, diagnosis, cross contamination, delayed or incorrect treatment, and miscommunication. A percentage split up of causes of medical human errors is depicted in **Table 1** [8].

EMR and health-IT technologies were primarily implemented to reduce the error rate and uphold patients' trust in the healthcare system. Not limiting to that, adoption of electronic health record system was also believed to provide an array of benefits to both physicians and the patients.

With 3 out of 4 hospitals in the United States having at least a basic EHR system in place [9], it is important to analyse and evaluate if the transitional shift has really benefitted the healthcare community. What looks good on paper may not necessarily be the same when put into practice!

This article evaluates the success of health-IT adoption in reducing medical errors and provides insights on 'where we go from here?'

'Has health-IT been a magic bullet so far?' is a question that would linger in every American citizen's mind, with a lot of their tax money being invested for the adoption of computerized health records. Results of this paper will provide a substantiated and justified response based on the research findings.

Materials and Method

The review was conducted using the resources of the online databases (PubMed, MEDLINE, Google Scholar, Web of Knowledge [WOK]), websites, search engines, magazines and manual search. All the resources including scientific databases, electronic journal citations, websites, and magazines were searched to identify articles or reports that discussed the role of health-IT in reducing preventable medical errors and improving patient safety in the United States. Criteria for inclusion of articles and reports were restricted only to those researches carried out in the U.S. healthcare setting and limited to the years 2008-2015 in order to focus on the recent studies.

Results and Discussion

Evaluation of EHR in reducing diagnostic errors

Exordium: Diagnostic errors are defined as medical mistakes which involve inaccurate diagnoses, missed, wrong, or delayed, as uncovered by subsequent definitive test or finding [10]. These medical errors accounted for the largest fraction of medical malpractice claims pay-out ($38.8 billion between 1986 and 2010) eclipsing surgical errors

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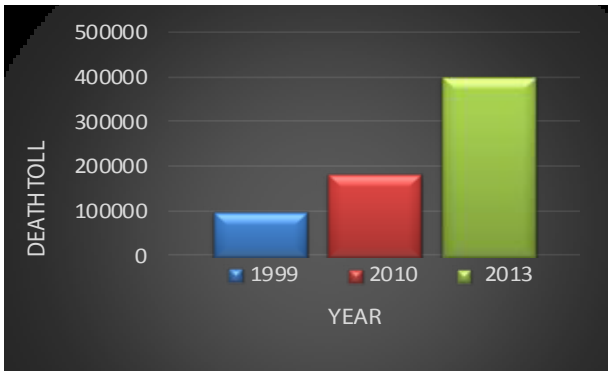

Figure 1: Human lives claimed due to medical errors in the United States (1999-2013) [6].

Table 1: Medical human error [8].

Why Error Occurred	Percentage
Diagnostic (Failure to act on results)	22
Treatment (Error in drug use, delays, technical)	61
Preventive (Failure to prevent, inadequate monitoring)	16
Other	1

and mistakes involved due to medical overdoses. Though critically important, diagnostic errors are often overlooked and haven't really received the attention they deserve [11].

Studies show, 5% of adults who seek outpatient care annually experienced a delayed or wrong diagnosis. To add to that, post-mortem results suggest that 1 of every 10 patient deaths resulted from errors in diagnostics [12].

Overall, diagnostic errors have been downplayed and underappreciated by the experts owing to the difficulty in gap between tracking the point of occurrence and its detection point. Health-IT tools like symptoms checker, and self-diagnosis were introduced to start with before the evolution of electronic health records [11]. Have computerized health records aided improved diagnosis is a big question and the next section of context implies the solution.

Studied outcomes: Health-IT and computerized health records are regarded as being clumsy and represents a 'barrier to good health care and diagnosis', because of the difficulty in interpreting the matter and is attributed to the way it's presented [12].

Health-ITs were adopted with the aim to enhance communication; however they have failed to do so and has in turn increased the rift between the communities. Compatibility in sharing between different EHRs have limited the information sharing between physicians and such intricacies have made EHR's potential to reduce diagnostic errors extremely gruelling. Existing health technologies and the HITECH federal act have eventually increased the distractions that encumber physicians' face-to-face interactions with patients making the patient centred focus out of context. Electronic Health Records have, however, managed to record good results in identifying patients who're at a very high risk of being misdiagnosed. These triggers have helped the medicos identify needles in a haystack by making the haystack smaller [13].

Physicians exclaimed their constraints in time and connected that to making mental shortcuts and heuristics, which in most cases lead to poorer quality decisions [14].

No studies have been published on comparative evaluation of reducing diagnostics related medical errors with and without health-IT in a U.S. hospital setting. Overall, not much has changed in curtailing diagnostic related errors using heath-IT.

Advantages :

Preventing patients who are at a very high risk of being misdiagnosed

Alert messages that lets the physicians contemplate and enhance cognitive bias

Drawbacks :

Limited interoperability to share data between physicians that cuts down the potential of improved diagnosis

Alert fatigue- Too many alerts overwhelm both patients and physicians leading to a saturation level

Where are we?: The adoption of health-IT to prevent or reduce diagnostic related errors have not really served its purpose. Limitations in the computerized set up, like 'auto-fill', feature make the physician not give any notice to the entire history and hence results in a poor diagnosis or life threatening adverse effects. Transparency in reporting errors have not been on a positive stand as physicians is extremely reluctant to open up on their medical error(s). Such information will help fellow physicians learn from mistakes and will pave the way towards experiential learning [13,14].

Where we go from here?: Ensuring health-IT to support health professionals in diagnostic process will facilitate efficacious team work in diagnostic process among physician and physician, and physician and patient that would potentially help achieve the goals of implementation. It's important to develop a reporting environment that make improving diagnosis and learning from diagnostic errors and near misses possible.

Diagnostic errors are finally getting the attention they deserve and it's evident from the recent report on 'Improving diagnosis in healthcare.' A recent work flow design to integrate and improve diagnostic process has received much attention and is depicted in **Figure 2** [10].

Success rate: *Nil or very less success*.

Evaluation of EHR in reducing medication errors

Exordium: Medication errors have long been ascertained to be a chief cause of medical errors and have become an inevitable part of the healthcare system. These errors have been deemed to occur frequently and are related to adverse drug events, unseemly medication use, increased length of hospital stays, and astronomical costs of medical treatment [15-17].

Prescription errors and errors associated with paper charting, which comprises illegible handwriting and incomplete orders, are a subcategory of medication errors that are recurrently encountered in the hospital setting [18-21]. The impetus of Electronic prescribing (e-prescribing) and Computer Physician Order Entry (CPOE) have been adopted to overcome the medical error rates. Let us further discuss how each of these has fared in curtailing the error rates.

Electronic prescribing (e-prescribing): E-prescribing is a technology which enables physicians to generate and transmit computer-based electronic prescriptions to community pharmacies, thereby reducing the use of paper and faxed prescriptions which are

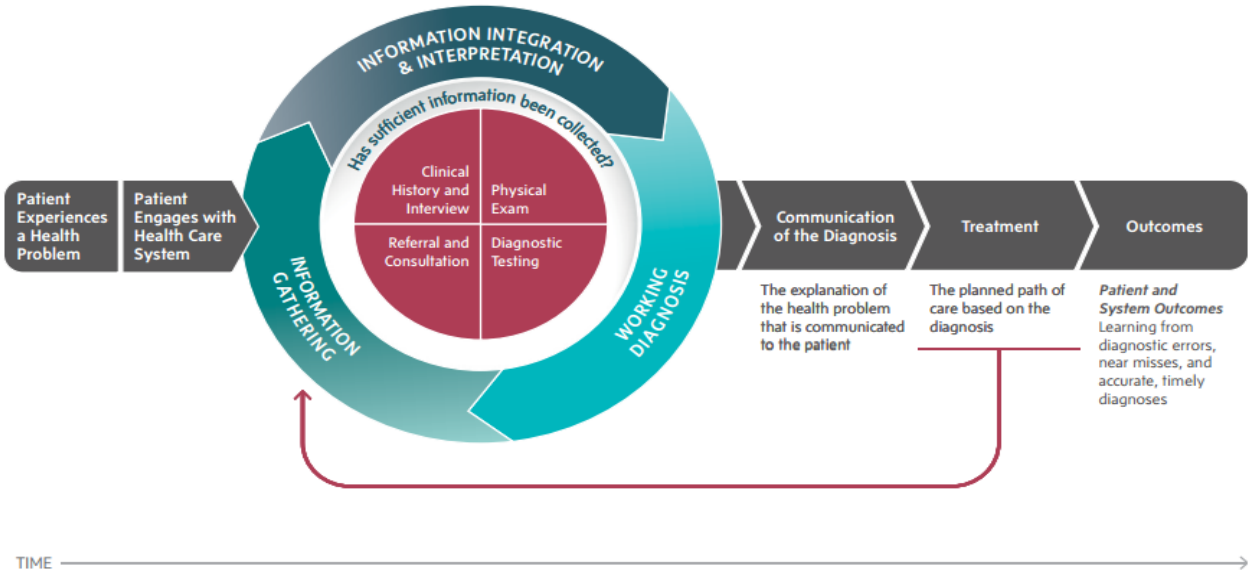

Figure 2: New diagnostic model [10].

prone to a greater number of manual errors [22].

Given that errors in medication pertinent to prescribing and filing are some of the most common causes of medical errors, e-prescribing was implemented to primarily serve the purpose of cutting down adverse drug effects related to prescription and filing, hence upholding the patient safety.

Studied outcomes: Weingart et al. [23] analysed the impact of e-prescribing in ambulatory care and found that electronic prescribing systems prevented the medical error rates in 83% of the cases, and enhanced patient satisfaction and clinical efficiency by 71% and 75% respectively. Not limiting to that, quality of care delivered also improved by 78%. One significant finding expatiated that 35% of e-prescribers in the last 30 days have modified a potentially dangerous prescription with the help of electronic alerts generated from e-prescribing system.

Duffy et al. [24] found that overall rate of after-hours calls was reduced by as much as 22% from the baseline, whereas there was a significant increase in medication related calls. Providers and patients were evaluated for satisfaction with EP and were observed to be very high.

Another study based on usability of EP with PCPs revealed that 83% of e-prescribers showed high satisfaction over traditional prescribing. Also, 22% of respondents exclaimed stop and start use of EP, but showed inclination to resume using EP in the near future [25].

At the outset, use of EPs in U.S. healthcare has shown good track records in reducing medical errors.

Advantages:

Increase in patient's medication adherence

Improved cost saving for consumers

Enhanced patient safety

Streamlined process that facilitates less clarification calls

Drawbacks:

Human factors that contribute to accidentally checking, unchecking, or dropping down in the prescription list

Mismatch of EP information between prescriber and pharmacy system

Alert fatigue- Too many alerts overwhelm both patients and physicians leading to a saturation level

Where are we now?: An estimate of 5% error rates have been recorded with the use of e-prescribing. Taxonomy of WHO prescribing errors suggests that error rates with EP are almost similar to the traditional paper prescription. A few errors related to traditional model have been eliminated with EP and they include: wrong pharmacy, wrong prescriber notes, and duplicate therapy. Prescription errors caused due to wrong drug, dose, and formulation has, however, not been cut down with e-prescribing [26].

Where we go from here?: To put the EP system to best utility, it's important to research and analyse two important subjects [26].

1. Unintended consequences of e-prescribing compared to paper prescription in order to better evaluate the risks and benefits of EP
2. Errors peculiar to EP and the ways to eliminate them

Success rate: *Success.*

Computerised physician order entry (CPOE): CPOE is an electronic order service and prescription form that increases physician's speed, removes abbreviations and physician's hand written order legibility [27]. Erroneous results in order entry increase the risk of Adverse Drug Events (ADEs) and results in extended length of hospital stay, rocketing medical expenditures, disability, and possibly death. CPOEs co-exists with CDSSs and were primarily implemented to reduce the number of medical errors and ADE's arising from hospital setting. Is CPOE a success? [28].

Studied outcomes: Contradictory results have been obtained on studies based on CPOE in the United States. A study performed by

the American College of Surgeons evaluates: 15 out of 6,815 (0.22%) medication errors discovered in surgical procedures before CPOE use vs. 10 out of 5,963 (0.16%) medication errors after CPOE use. A duplicate study was performed to test the reliability of CPOE and it yielded 0.21% error rate for 6,106 surgical procedures. Mean time for placing an order was estimated to be 41.2 minutes before CPOE adoption and 27 seconds per order after CPOE use [29].

A recent study carried out at Children's Hospital of New Jersey suggests a slightly different outcome as compared to the study discussed above. The study typically examined medication order errors (OEs) over a period of 26 weeks before and after implementation of CPOE **(Figure 3)**.

Post CPOE OEs slightly exceeded in this study (2226 vs. 1741), but the errors reported were analysed to cause less or no harm to the patient and was well within the control of physician's intervention [30].

Note:

Severity scale description:

A: Circumstances or events that solely has the capacity to cause error without harm to the patient

B: Error that occurred but did not reach the patient

C: Error that reached the patient but did not cause the patient harm

D: Error that reached the patient and required monitoring to confirm that it did not result in harm and/or required intervention to preclude harm

E: Error that reached the patient and may have contributed to or resulted in temporary harm while also requiring intervention

F: Error that reached the patient and may have contributed in temporary harm to the patient and required initial or prolonged hospitalization

Advantages:

Legible medication orders

Legible medication dosing

Time consuming

On-screen alerts on drug-drug interaction

Greater accessibility to change orders anywhere in hospital or remotely

Drawbacks:

Look-alike medication confusions

Cumbersome screen views

Longer duration for placing an order

Increased order entries secondary to unfamiliarity with software

Where are we now?: CPOE has so far been quite productive in eliminating or curtailing medical error rates and ADEs. This might eventually be the sure-fire solution we are looking for in cutting down the error rate [29,30].

Where we go from here?: With an almost perfect system, it's important to perfect the nuances and make it an error free system that would potentially enhance the patient's trust and safety in healthcare. Insights describe the need for objective data analysis to achieve the error-free CPOE model [30].

Success rate: *Moderate or high.*

Evaluation of EHR in reducing miscommunication

Exordium: Miscommunications are one of the chief causes of preventable medical errors. This is one of those types of errors that could well be prevented with a better work flow in place. Anything that comes with better structure and functionality is perceived as good and strongly applies to the process of reducing errors due to communication [31].

Studied outcomes: Errors due to communication were primarily sought to be improved by implementation of a handoff program. Two different studies were conducted at Boston Children's Hospital in 2013 and 2014 to evaluate the track records of handoff program in reducing

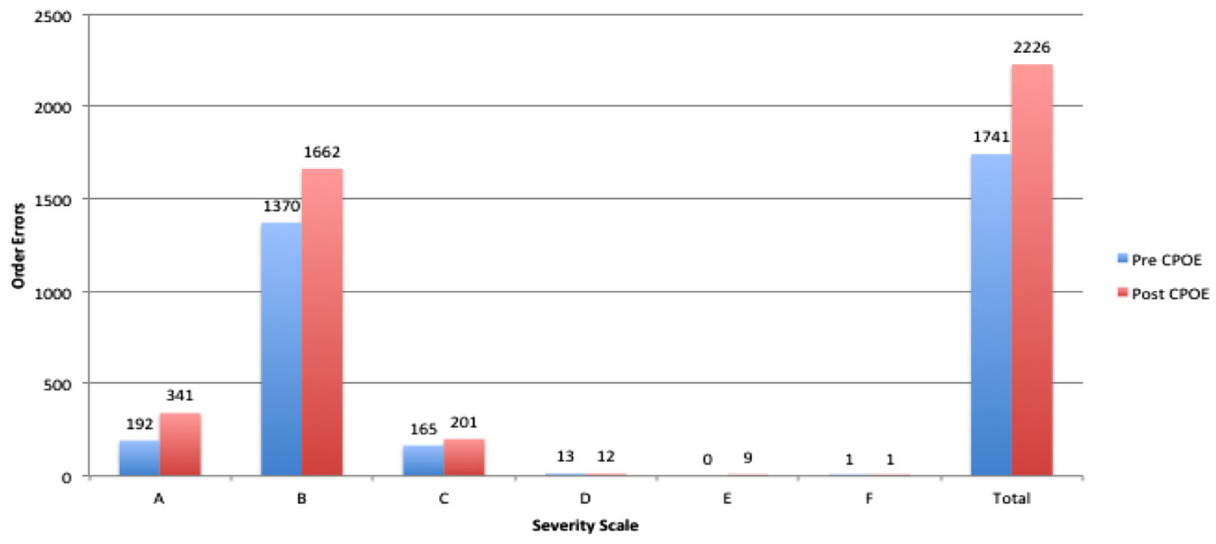

Figure 3: Cumulative Order Errors grouped by severity scale over the 26 weeks before and after CPOE [28].

the error rates due to communication.

The study carried out in 2013 [31] comprised a total of 1255 patients and evaluated medical error rate, preventable adverse events, omission of key handoff elements on printed handoff document, percentage of time spent at the patient's bedside, and average duration of verbal handoffs, before and after handoff intervention program. Results of the finding are depicted in **Table 2.**

Another study carried out in 2014 comprised 10,740 patients and the results of the finding are tabulated in **Table 3**

It is evident from the results that handoff intervention program improved the efficacy and potential in reducing the error due to communication.

Advantages:

Potential to reduce medical errors, preventable ADE's, and non-preventable ADE's

Increased time spent by the physician at the patient's bedside

Drawbacks:

Lack of comprehensive studies to assess the handoff improvement programs

Where are we now?: The system is all set to deliver prolific results in curtailing medical error rate due to communication, given there's a comprehensive setup to assess the efficiency and quality of the handoff program [31].

Where we go from here?: Two things to do to get the best output of the handoff program [32],

1. Deploy a committee to closely monitor and assess the handoff improvement program
2. Error rates do not change at all sites despite significant improvements in written and oral handoff process at all sites. The reason is to be figured out

Success rate: *Moderate or High.*

Evaluation of EHR in reducing technology related errors

Exordium: With 'converging technologies' it is important to be mindful of the risks and ADEs associated with the implementation of health-IT. They have the potential to create or perpetuate obnoxious effects, which have often been overlooked due its lesser prevalence. Barcode and mislabelled medication errors are the most common causes of technological related errors [33]. Uses and potential risks of these technologies are to be thoroughly assessed before implementation. Let us see how health-IT can potentially reduce technological related errors.

Studied outcomes: Human factors have long been associated with medical errors for several decades. Machines also tend to produce errors and that's been the reason why combination of humans and machines have greater potential than either alone. Though humans are erratic and tend to err, their resourcefulness and creativeness cannot be denied and also they manage to recover from both their own errors and those of the equipment's [33].

Bar code technology, in conjunction with electronic medication administration record (eMAR) has shown successful track records to reduce barcodes and unlabelled medication errors [34].

An alert detection system that is integrated with Clinical Decision Support is believed to be very handy in alerting the physician about the technical problems asynchronously. It is ascertained that such systems may reduce error rate, improve therapy, outcomes, survival, hospital stays, and costs [35].

Technology related errors in healthcare are remarkably sparse and require much more studies in place. Some of the recommendations suggested to reduce technology related errors include:

1. Use of modern electronic systems to communicate confident pieces of asynchronous data
2. Implementation of CPOE, bar-code, CDSS
3. Alert detection system etc.

Advantages:

Asynchronous alert system

Efficient in terms of reducing labour and costs

Drawbacks:

Expensive (Implementation)

Upgrade and maintenance cost

Difficult to troubleshoot

Where are we?: Though the potential of IT to cut down technology related error looks good on paper, there hasn't really been an emergent situation to test its potential in the health sector. This could partially be attributed to the insignificant amount of research been done on the topic [33].

Where we go from here?: It is important to make sure that the recommendations are in place and the system is ready for any outbreak

Table 2: Outcomes before and after intervention of handoff program [31].

Outcomes	Before Intervention	After Intervention
Medical error rate	33.8 per 100 admissions	18.3 per 100 admissions
Preventable adverse events rate	3.3 per 100 admissions	1.5 per 100 admissions
Percentage of time spent at the patient's bedside in a 24 hour period	8.3 hours	10.6 hours
Average duration of verbal handoffs	No change	

Table 3: Outcomes before and after intervention of hand-off program [32].

Outcomes	Before Intervention	After Intervention
Medical error rate	24.5 per 100 admissions	18.8 per 100 admissions
Preventable adverse events rate	4.7 per 100 admissions	3.3 per 100 admissions
Non-preventable adverse events rate	3 per 100 admissions	2.8 per 100 admissions
Average duration of oral handoffs	No significant change	

or damage to ensure the system has the working potential to transmit alert messages asynchronously [33,35].

Success rate: *Hypothetical.*

Conclusions

The common perception of hospitals being thought of as a place of healing has been shattered with the revelation of rates of preventable medical errors in the United States. Although it is evident from the analysis that health-IT in the U.S. healthcare system has made significant contributions to reduce the medical error rates, it has ideally not created any wonders! The U.S. still continues to occupy the bottom most position in terms of healthcare and mortality compared to other developed nations, despite spending 1.75 times more on healthcare.

The transitional shift from paper to electronic based records has however not benefitted the consumers of American healthcare industry. From my view point, it's the political revolution that's needed more than the informatics revolution. This institutional change in healthcare is what would be the hope of most families that have been affected. For the victimised families of the United States, it's not the malpractice pay-out, but the change in system for a betterment that's going to please them.

The review of the paper thus leaves little doubt that the U.S. has poorer healthcare despite top notch doctors, pioneering medical industry, and a rich government. So, health-IT has been no magic bullet in reducing medical errors.

After all the analysis and read outs, I would rate health-IT as pawns, with respect to the question that was posed at the start of the paper. Strategies to reduce the incidence of adverse medical errors should become a national priority!

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