

# Health information exchange and patient safety

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## Abstract

One of the most promising advantages for health information exchange (HIE) is improved patient safety. Up to 18% of the patient safety errors generally and as many as 70% of adverse drug events could be eliminated if the right information about the right patient is available at the right time. Health information exchange makes this possible.

Here we present an overview of six different ways in which HIE can improve patient safety—improved medication information processing, improved laboratory information processing, improved radiology information processing, improved communication among providers, improved communication between patients and providers, and improved public health information processing. Within the area of improved medication information processing we discuss drug-allergy information processing, drug-dose information processing, drug-drug information processing, drug-diagnosis information processing, and drug-gene information processing. We also briefly discuss HIE and decreased patient safety as well as standards and completeness of information for HIE and patient safety.

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## 1. Introduction

Among the many potential advantages of health information exchange (HIE), patient safety stands out as one of the most promising. Healthcare is an information rich environment which requires many pieces of information for even the simplest healthcare decisions. As the Institute of Medicine's 2000 *To Err is Human* report underscored, iatrogenic causes of injuries are frequent, and they represent an important cause of death among patients, with an estimated 44,000–98,000 deaths per year [1]. Patient safety can be eroded by both errors of commission and errors of omission if the right information is not available to the right person at the right time. As care is delivered in the US today, information gaps represent the rule rather than the exception.

Better patient safety through enhanced, technology enabled, HIE will directly improve patient safety because it will provide a more complete clinical picture of a patient. A significant evidence base already exists showing that HIE can improve patient safety in a number of areas, although in practice robust HIE today is only occurring in a small number of institutions a small proportion of the time. However, patient safety can be improved using health information technology (HIT) even without interoperability, though HIE can be expected to substantially potentiate the effect of HIT.

HIE can be thought of both in terms of who the exchange is between and what the type health information exchanged is (Fig. 1) [2]. Usually, the more people and more information involved in the HIE, the more valuable the exchange will be for patient safety. Up to 18% of patient safety errors have been estimated to have occurred because the appropriate information was not available at the time the medication decision was made [3]. For example, of the estimated 770,000 adverse drug events (ADEs) that occur each year

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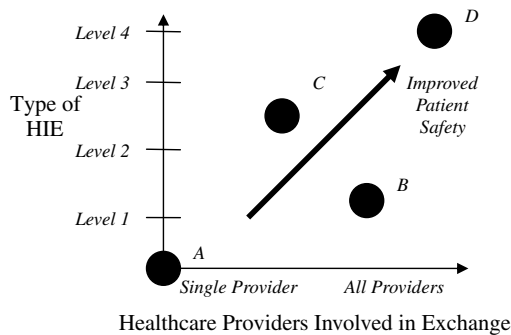


Fig. 1. Two-dimensional view of healthcare information exchange and patient safety. Level 1—phone and mail health information exchange. Level 2—machine transportable data (standard fax). Level 3—machine organizable data (e-mail and electronic messaging). Level 4—machine interpretable data (interoperable data exchange with standardized formats and content) [2]. (A) Historical health information exchange paradigm with individual isolated providers not exchanging any information. (B) Relatively common current paradigm with many providers exchanging generally paper records among themselves. (C) Increasing common paradigm with some providers exchanging electronic health information among themselves. (D) Ideal future state in which all providers are exchanging robust electronic health information leading to improvements in patient safety.

in the United States [4–6], from 30% to as much as 70% may be preventable [7–9]. Below we will discuss a variety of areas in which HIE can impact patient safety (Fig. 2).

## 2. Health information exchange and increased patient safety

### 2.1. Improved medication information processing

With regard to patient safety, medication information processing probably represents the most studied area of HIE today. While the exact figure is uncertain, one study has estimated that over 100,000 deaths occur annually in the United States because of adverse drug events (ADEs), including both non-preventable and preventable ADEs [4]. In most large safety studies, ADEs have been the most common cause of iatrogenic illness; they appear to occur in about 5–15% of therapeutic drug courses [10]. Although

most of these ADEs will not be amenable to elimination with improved HIE, an important proportion will, and many opportunities and strategies that improve patient safety through HIE have been studied. We will divide HIE's impact on medication information processing into five subsections below.

#### 2.1.1. Drug-allergy information processing

One of the most obvious forms of medication information processing for patient safety is drug-allergy processing. This involves checking drugs against known patient-specific drug allergies before the drugs are given to the patient. Up to 30% of people mention a drug allergy when asked and up to 10% of ADEs are thought to involve significant allergic reactions [11–13].

Some particular characteristics of effective drug-allergy checking make it very amenable to improved HIE. First of all, a complete list of all patient allergic reactions and medications must be available. Second, details of the circumstances of the possible allergic reaction and possible medication(s) should be accessible. Determining the exact circumstances can be particularly complicated as many reported allergic reactions occurred years or even decades before the current medication decision. Typically the patient is relied upon as the source of allergic reaction and causal agent(s), however up to 50% of patient reported medication related allergic reactions are thought not to be true allergic reactions [11]. More robust HIE could greatly reduce the frequency of ADEs from known allergic reactions, by finding prior allergies that the patient may not have remembered, and by improving the accuracy of the allergy list.

#### 2.1.2. Drug-dose information processing

Dosing errors represent the most common type of medication error leading to preventable ADEs and account for up to 60% of prescribing errors [3,7,14–21]. Drug-dose information processing helps improve patient safety by helping to ensure that the individual dose, daily dose, and total dose will minimize toxicity while providing therapeutic efficacy. At the most basic level, drug-dose information processing involves being sure that the individual dose, dosing frequency, and total duration of medication fall within accepted general standards. At a more advanced level, drug-dose information processing can take into account patient-specific information such as patient age (geriatric dosing), weight (pediatric dosing), and creatinine clearance (renal dosing).

Drug-dose information processing has been shown to improve patient safety in a number of settings. For example, renal dosing of medications is perhaps the single most important piece of decision support, and when dosing is based on the patient's renal function it is more often appropriate; in one study, hospitalized patients' length of stay decreased [22]. Also, more appropriate geriatric dosing of psychotropic medications decreased falls among the elderly in the inpatient setting [23]. Antibiotic-related decision

Improved Patient Safety Opportunities Through Health Information Exchange (HIE)	
<ul style="list-style-type: none"> <li>• Improved Medications Information Processing               <ul style="list-style-type: none"> <li>○ Drug-Allergy Information Processing</li> <li>○ Drug-Dose Information Processing</li> <li>○ Drug-Drug Information Processing</li> <li>○ Drug-Diagnosis Information Processing</li> <li>○ Drug-Gene Information Processing</li> </ul> </li> <li>• Improved Laboratory Information Processing</li> <li>• Improved Radiology Information Processing</li> <li>• Improved Provider to Provider Communication</li> <li>• Improved Patient to Provider Communication</li> <li>• Improved Public Health Information Processing</li> </ul>	

Fig. 2. List of areas of improved patient safety from enhanced health information exchange (HIE).

support, which attempts to optimize antibiotic dose based on a number of parameters, has significantly decreased adverse drug event rates, as well as cost and days of unnecessary therapy [24]. With respect to interoperability, renal dosing will probably be especially important, as the patient's level of kidney function should be available for dosing decisions in all settings.

### 2.1.3. Drug–drug information processing

The most robust medication information processing currently occurs at the drug–drug level. This support can significantly improve patient safety, but it will be most effective only if the entire list of all of a patient's medications, including over the counter medications, herbal medications, and supplements, are available at the time of medication prescription and administration.

Drug–drug information processing generally takes three forms. The most commonly thought of involves adding an additional medication(s) to a patient's other medications, which might then cause a known side effect, in which case the new or existing medications might be changed in order to prevent the adverse drug event.

A second type of drug–drug information processing involves duplicate pharmacological class checking. Although therapeutic duplication accounts for less than 6% of adverse drug events, improvements in this area will also benefit patient safety and are enhanced by improved HIE [3,7,16].

A third type of drug–drug information processing for patient safety occurs when one medication is being added that could indicate the addition of another medication for improved patient safety. For example, patient safety is improved when chronic non-steroidal anti-inflammatory drugs (NSAIDs) are using in conjunction with proton pump inhibitors (PPIs) [25–27] or probiotics are used in association with antibiotics [28]. This erosion of patient safety due to lack of appropriate use of synergistic medications has also been well documented in AIDS patients on HAART [29–31].

### 2.1.4. Drug–diagnosis information processing

Drug–diagnosis (drug–disease) information processing is an expanding area in which enhanced HIE has the potential to improve patient safety. In some ways an outgrowth of patient-specific drug–dose information processing, drug–diagnosis information processing takes into account medical conditions and contraindications that would affect drug dosing or administration at all. These reasons for problems in patient safety are known to occur and cause morbidity and morbidity [32–34].

Examples of diagnoses that would affect drug choice or dosing range from pregnancy and breast feeding to hepatic impairment in people with cirrhosis. Additional specific examples include not prescribing non-selective  $\beta$ -blockers to someone with asthma, giving streptokinase to someone with a recent bleed, and various medication contraindications in people with myasthenia gravis, glaucoma, and pro-

longed QT intervals. The British National Formulary shows approximately 1500 contraindications between drugs/drug groups and various morbidities and clinical states [35].

A next-generation drug–diagnosis information processing system might also check to see if the drug being prescribed is indicated for any of a patient's diagnoses. This would help eliminate inappropriate sound-alike/look-alike medications from being prescribed such as clonidine and klonopine. Drug–diagnosis information processing will optimize patient safety only in an environment in which HIE allows all of a patients' diagnoses to be available at the time of drug prescribing and administration.

### 2.1.5. Drug–gene information processing

Although not currently a reality, as gene analysis becomes more prolific and pharmacogenomics becomes more developed, the ability to interchange drug information and patient-specific genomic information will become increasingly important for patient safety. HIE in this area has the potential to optimize pharmaceutical choices to avoid/reduce ADEs and other side effects, as well as optimize effectiveness [36].

## 2.2. Improved laboratory information processing

Patient safety can also be improved by enhanced laboratory information processing enabled by HIE. The two primary areas for this include (1) helping to ensure that indicated lab testing is ordered and (2) helping to guarantee that lab test results (especially abnormal results) are appropriately followed up on. HIE is particularly critical in this process in this era of few in-office tests, many “send-out” tests, and numerous independent laboratories.

A prime example of the interplay between laboratory information processing and patient safety is in the area of medications. Dozens of commonly used medication require labs prior to initiation and/or after initial administration to monitor for patient safety [35,37]. Unfortunately, many studies document inappropriate laboratory information processing [38–44]. Other examples in this area include appropriate ordering and follow-up of Pap smears, prostate-specific antigen (PSA) levels, cholesterol levels, and stool guaiac testing, to name a few. Improved HIA could improve patient safety in this area.

## 2.3. Improved radiology information processing

Typically the provider ordering an imaging study is different from the provider interpreting the imaging study. Therefore, health information has to be exchanged between these two health professionals for the radiology study to be effectively ordered and interpreted. Patient safety can be enhanced in both of these areas of radiology information processing through improved HIE.

For example, improved HIE could decrease adverse intravenous contrast reactions and decrease exposure to

inappropriate radiology testing [45] and unneeded radiation exposure [46]. Probably more important for patient safety is improvement in HIE to ensure appropriate follow-up of abnormal radiology findings. For instance, up to 2% of abnormal mammograms were found to be lost to follow-up without enhanced information exchange [47].

#### 2.4. Improved communication among providers

Every year each patient has, on average, four outpatient visits with just over half of these visits being to primary care providers, approximately 40% to specialists, and approximately 10% to emergency departments [48]. In addition, there are 114 hospital discharges per 1000 people per year [49]. The result of these healthcare interactions is that many providers (physicians and others) are involved with each patient every year. Although many of these interactions are for acute/subacute issues, each of these encounters can provide valuable information for the patient's future care. Also, when different primary care providers and/or subspecialists are managing different medical issues, effective information sharing is critical, but does not always occur.

Many healthcare scenarios exist in which patient safety is jeopardized because of lack of HIE among providers. Patients routinely present to emergency departments outside of their normal healthcare system, sometimes unable to communicate, where their providers may have little or no prior information about them [50]. Providers who do not know the patient, either in an inpatient or outpatient setting, make safer decisions with improved HIE [51,52]. Surgeries present times when many significant decisions and changes in patient care occur, involving many providers, in a relatively short period and can result in significant erosion of patient safety. Changes in location of care—for instance hospitals to home or nursing home settings—also present opportunities for HIE to improve patient safety [53]. The Joint Commission on Accreditation of Healthcare Organizations in their medications across the continuum standard and others, have identified patient hand-offs as a key point of breakdown in patient safety.

#### 2.5. Improved communication between patients and providers

In general, no one should be more invested in their own healthcare safety than patients themselves. In our current healthcare paradigm, however, minimal HIE occurs with patients and healthcare organizations typically do not sufficiently recognize the key role that patients can play in ensuring their own healthcare safety. With the significant interest and impending growth of improved HIE with patients through personal health records (PHRs), many hope this paradigm will change.

There are many ways in which HIE can improve patient safety through enhanced patient–provider communication. Examples include patients checking for errors in their med-

ical history, adding additional valuable information into their medical records, following up on their own test results, reviewing medications and other healthcare instructions, and being able to communicate more quickly with healthcare providers when they think their safety may be at risk. PHRs may also allow providers to more quickly and more accurately provide information to their patients, which should improve patient safety.

Because PHRs are in their infancy, improved patient safety through HIE facilitated by a PHR has not been proven, although interest is high. Sixty-nine percent (69%) of patients indicate that they would look for errors in their medical record if a PHR allowed this [54]. Sixty-three percent (63%) of patients would track their test results [54]. Sixty-five percent (65%) of patients would transfer information to a new healthcare provider through a PHR if they could [54]. All of this increased patient to provider exchange should improve patient safety. Over 60% of people feel that PHRs will help prevent medical mistakes [54].

#### 2.6. Improved public health information processing

A rapidly growing area of HIE is public health informatics. Patient safety could be greatly enhanced through this growth. Opportunities for improved patient safety in this area include post-marketing drug surveillance, infectious disease surveillance, biohazard surveillance, and environmental exposure surveillance. For instance, in 2006 the Centers for Disease Control recommended expanding the age for childhood influenza vaccination based on enhanced public health informatics HIE [55].

### 3. Health information exchange and decreased patient safety

Although the overwhelming evidence points to improvement in patient safety with health information technology (HIT), some studies appear to have shown degradation in patient safety with increased use of HIT, although these studies did not focus specifically on HIE [56,57]. These post-implementation studies tried to evaluate the effect on patient safety of electronic medical record systems and specifically computerized physician order entry. Careful review of these studies and attempts to replicate these studies highlighted unusual circumstances that appear, in the Han study, to have led to the increase in morbidity and mortality reported [58,59]. However, these studies do typify the fact that increasing use of HIT alone does not lead to superior patient safety. Rather, for improved patient safety, healthcare systems must be organized to facilitate effective use of their HIT [60,61].

Increasing the level of HIE could reduce patient safety in a variety of ways, for example, if incorrect patient-specific information were made available to providers, if one patient's information was believed to be that of another, if there were errors in translating information between one system and others or if implementation of HIE slowed

systems to a significant degree, since delays can affect safety. Those who are evaluating HIE should be alert to these and other unintended consequences of implementation of HIE.

#### 4. Standards for health information exchange and patient safety

For robust, efficient HIE, standards must be developed dictating the type and content of information to be exchanged. A prototypical example of this is the near ubiquitous proliferation of PACS (Picture Archive and Communication Systems) standards within the field of radiology. Allergy, medication, laboratory, diagnosis, and notes messaging standards must be developed and implemented with a similar degree of rigor in order for equivalent HIE in these other areas to yield similar results.

#### 5. Completeness of information for health information exchange and patient safety

Another challenge is the completeness of the HIE. As electronic HIE increases, health professionals run the risk of assuming that all information is being exchanged and everyone is having their information exchanged. Systems currently in place for dealing with paper records and/or dealing with people who opt-out of HIE networks (for instance Regional Health Information Organizations (RHIOs)) may not continue. Therefore, our ability to process health information in patients who have some health information that is not readily exchanged and/or to deal with patients who do not want their information exchanged may decrease and these patients could potentially see their patient safety eroded.

#### 6. Conclusions

As more and more health care information becomes digital, the potential for HIE to improve patient safety will grow, and it is already robust. One challenge will be to develop healthcare systems capable of processing and utilizing the dramatic increase in information. Only then will the potential of improved patient safety through enhanced HIE be realized because we will have increased the percentage of time that the right information is presented to the right person at the right time so that the right healthcare decision can be made.

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