

February 2015

Recent Evidence that Health IT Improves Patient Safety

Issue Brief

Prepared for

DHHS Office of the National Coordinator
Office of Policy and Planning
330 C Street SW, Rm 1200
Washington, DC 20201

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CONTENTS

Section	Page
Issue Brief	1
Recent Systematic Reviews	1
Additional Recently Published Evidence	6
Looking to the Future	8

FIGURES

Number	Page
1. Number of Peer-Reviewed Publications on Health IT Safety per Month, as Identified in Four Systematic Reviews	3
2. Meaningful Use Functionality Has Positive Effects on Health Care Quality, Safety, and Efficiency	7

TABLES

Number	Page
1. Systematic Reviews of Health IT's Impact on Quality and Safety	2

ISSUE BRIEF

Takeaway Points

Health information technology (health IT) has been adopted widely in U.S. health care systems, and a great deal of attention has focused on whether these systems can help improve the quality and safety of health care.

Four separate but linked systematic reviews examining this concern have been published over the last decade. These analyses have revealed the following:

- Health IT is working. With each review, the evidence base is expanding, with articles that describe net benefit in a wide range of settings and applications.
- The number of health care organizations perceived as leaders in advancing health IT is growing.
- The initial question, “Can health IT improve the quality and safety of health care?” has been answered affirmatively.

Research should now turn to understanding the relatively small but important number of unintended consequences that detract from the overall impact of this new technology and the variability in the success of health IT implementations, especially in areas that impact patient safety.

Advances in health information technology (health IT) have had dramatic effects on health care quality and safety. Possibly the best example is the safety of laboratory testing, which has improved by four orders of magnitude over the past half century, associated with the implementation of automated systems and test management programs.(1, 2) The overall impact of health IT in other areas of health care, however, is still debated. A report from the Institute of Medicine in 2011 concluded that the available evidence was mixed (3) and, similarly, a recent article concluded that “...the overall impact of health IT on patient safety remains an unsettled empirical question.”(4) The equivocation reflects the need for robust studies that address issues of implementation context and its contribution to success or failure, and the very real problem of unintended negative consequences of health IT.

Advocates point out that health IT is evolving rapidly, which implies that older studies may have focused on now-outdated systems, and that judgments on the impact of health IT should favor more recent studies. Thus, this brief reviews recent summaries and research on the impact of health IT, and finds that this evidence strongly supports the impressions from earlier studies: Health IT improves patient safety.

Recent Systematic Reviews

Between 2006 and 2014, a linked series of four systematic reviews of health IT impact were published, each using a consistent methodology to identify and review articles of interest (see **Table 1**). Although many other systematic reviews of health IT exist (Buntin and colleagues state that at least 34 were published between July 2007 and February 2010), these four offer a unique view of changes in the health IT literature over time. Two of the

Table 1. Systematic Reviews of Health IT's Impact on Quality and Safety

Year	Authors/ Journal	Title/Journal	Years Covered	Articles Reviewed	Health IT Leaders
2006	Chaudhry et al.(5) <i>Annals of Internal Medicine</i>	Systematic Review: Impact of Health Information Technology on Quality, Efficiency, and Costs of Medical Care	January 1995– January 2004†	257	Four organizations: <ul style="list-style-type: none"> • Regenstrief • Brigham and Women's/Partners • VHA • Intermountain
2009	Goldzweig et al.(6) <i>Health Affairs</i>	Costs and Benefits of Health Information Technology: New Trends from the Literature	June 2004– June 2007	179*	Six organizations: <ul style="list-style-type: none"> • Regenstrief • Brigham and Women's/Partners • VHA • Intermountain • Kaiser Permanente • Vanderbilt
2011	Buntin et al.(7) <i>Health Affairs</i>	The Benefits of Health Information Technology: A Review of the Recent Literature Shows Predominantly Positive Results	July 2007– February 2010	154	Seven organizations: <ul style="list-style-type: none"> • Regenstrief • Brigham and Women's/Partners • VHA • Intermountain • Kaiser Permanente • Vanderbilt • DOD
2014	Jones et al.(8) <i>Ann Int Med</i>	Health Information Technology: An Updated Systematic Review with a Focus on Meaningful Use	January 2010– August 2013	236	Not mentioned

†Includes manual review of literature through April 2005.

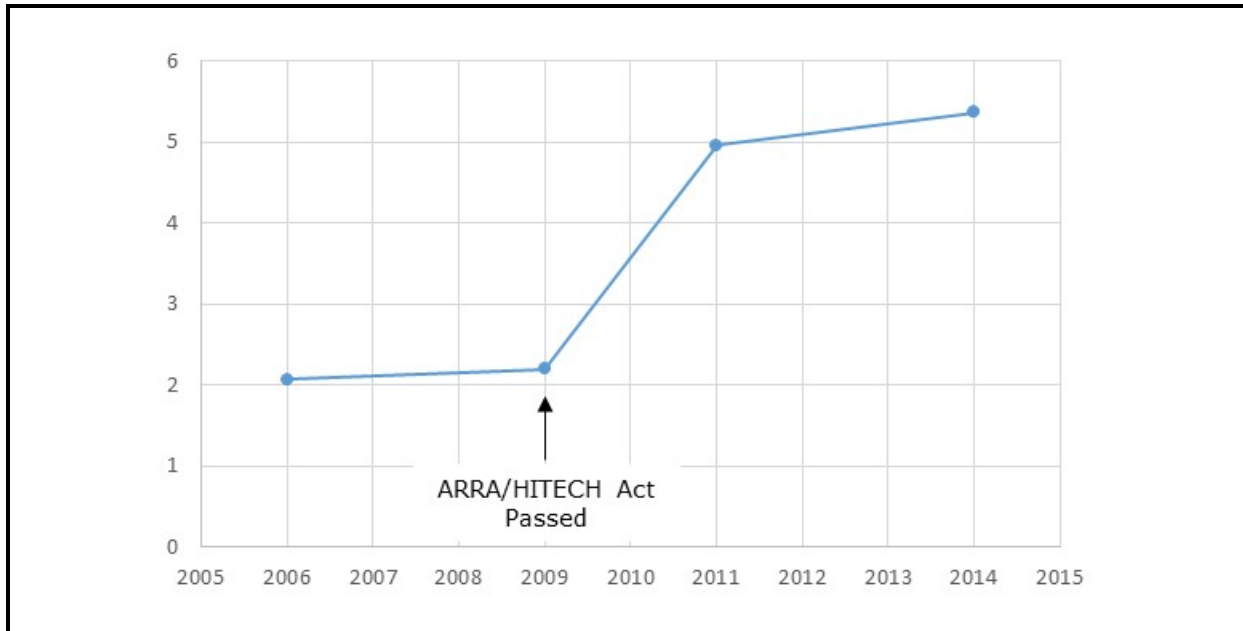
*Includes 179 articles encompassing 182 studies.

Abbreviations: Regenstrief = Regenstrief Institute; Partners = Partners HealthCare; VA = Veterans Health Administration; Intermountain = Intermountain Health Care; Kaiser = Kaiser Permanente; Vanderbilt = Vanderbilt University; DOD = U.S. Department of Defense.

reviews were published before passage and implementation of the American Recovery and Reinvestment Act (ARRA) in 2009. ARRA included the Health Information Technology for Economic and Clinical Health (HITECH) Act, which provided substantial incentives for eligible professionals and hospitals to adopt and “meaningfully use” certified electronic health records (EHRs).(9) The second two reviews were published after the passage of ARRA and the HITECH Act, and provide an instructive follow-up on the earlier findings. Overall, the findings from these four reviews are positive, each concluding that health IT has contributed to improvements in the quality of care.

Between 2006 and 2014, the review authors traced an increase in the number and quality of the studies available. **Figure 1** illustrates the growth in the number of publications on health IT safety during this time.

Figure 1. Number of Peer-Reviewed Publications on Health IT Safety per Month, as Identified in Four Systematic Reviews



Furthermore, the gaps identified in the earlier studies are, in most cases, addressed in later studies. However, all four reviews call for more research on the contextual factors that support or inhibit successful health IT implementation and use. The conclusion is that more work is needed in this area, and that the context in which health IT is implemented and used may be an important driver of quality and safety, ultimately determining the true impact of health IT.

Chaudhry et al., 2006. The first review in this series, published in 2006, covers literature from 1995 through April 2005 and focuses on three primary domains: quality, efficiency, and cost.

Chaudhry and colleagues found that studies typically focused on three types of systems: decision support, EHRs, and computerized physician order entry (CPOE). They noted very few instances of studies addressing consumer-oriented applications or health information exchange. The studies reviewed by this group demonstrated five key effects of health IT:

1. Increased delivery of care in adherence with clinical guidelines and protocols
2. Enhanced capability for surveillance and monitoring of disease conditions and care delivery
3. Decreased rates of medication errors
4. Decreased rates of utilization of care
5. Mixed effects on time utilization

Findings were most often positive, with the caveat that positive findings are more likely to be published. One key study that documented negative outcomes (increased errors as the result of an electronic ordering system) included instructive information on contextual factors, suggesting that limited training for physicians (2–4 hours versus 8–16 hours for other staff) played a role.(10)

Further, Chaudhry and colleagues noted that a substantial number of the studies (25%) were completed by researchers at four organizations, referred to as “benchmark institutions” or “leaders”: the Regenstrief Institute, Brigham and Women’s Hospital/Partners HealthCare, the Department of Veterans Affairs, and LDS Hospital/Intermountain Health Care; the findings at these institutions might not apply in other care settings or in organizations lacking the same depth of experience and expertise.

The authors noted that there was a significant lack of information about the costs associated with implementing and maintaining health IT systems, and that the costs incurred at the benchmark institutions may not apply to other organizations because the benchmark organizations had built their systems slowly over time. These systems were “homegrown,” and the authors documented on a dearth of information about the cost of commercial off-the-shelf (COTS) products. Finally, the authors identified the need for more information regarding organizational change, workflow redesign, human factors, and project management, and for a standardized approach to health IT research that would benefit the field overall.

Goldzweig et al., 2009. Published just before the passage of ARRA and HITECH, this review assessed the state of the field in the intervening 4 years since the review of Chaudhry et al., and assessed whether the literature had expanded to include additional assessments of COTS products, implementation context, and factors determining failure or success.

Goldzweig and colleagues reported that the findings from the leaders remained generally positive; they noted, however, that the improvements were often modest in scale, and focused on refinements to existing systems or new applications designed to work alongside existing systems. They summarized these findings by noting, “Most studies demonstrated modest benefits, some demonstrated no benefits, and few demonstrated marked benefits.”

They added Kaiser Permanente and Vanderbilt University to Chaudhry's list of health IT leaders, and noted a modest decrease in the percentage of articles emerging from the now six leaders (20% in 2009 versus 25% in 2006), suggesting that more organizations were adopting and evaluating health IT, and contributing to the literature.

Like Chaudhry and colleagues, Goldzweig and colleagues noted a paucity of data on the implementation context; fewer than 10% of the studies reviewed included more than basic information (such as name or number of hospital beds). In a change from the 2006 review, they found more studies addressing standalone applications designed to accompany an EHR or to be used in addition to an EHR, including telemedicine, secure text messaging programs, and various medical devices. The findings about the value and impact of these products and services were mixed. Goldzweig and colleagues also found a substantial increase in the number of consumer-focused applications, but limited "solid evaluation" of those applications. Like Chaudhry et al., they noted a lack of data on costs and cost effectiveness. They concluded that there was a need for more robust evaluations of COTS products and more theory-driven work to support future health IT adopters.

Buntin et al., 2011. The review by Buntin and colleagues was published in March 2011, by which time the HITECH programs, including the incentive programs to encourage providers and hospitals to adopt EHRs, were fully operational. Departing from the methodology used by Chaudhry and Goldzweig, they included descriptive qualitative studies and excluded systematic reviews.

Buntin and colleagues reported predominantly positive outcomes associated with health IT. Of the 154 studies reviewed, 62% showed uniformly positive outcomes and another 30% showed mixed-positive outcomes (generally positive, but at least one negative outcome reported), for a total of 92% rated as positive. Several studies documented notable improvements in safety outcomes. As examples, a study of 41 Texas hospitals found that both complications and mortality were reduced in centers with advanced EHRs,⁽¹¹⁾ and a study of 3 large dialysis centers documented a 48% reduction in mortality after adopting EHRs.⁽¹²⁾

In addition, Buntin and colleagues added the U.S. Department of Defense to the list of health IT leaders and a further decline in the percentage of studies coming from those organizations (down to 18%, versus 20% in 2009 and 25% in 2006). They further noted that the study findings of leaders and non-leaders were converging; studies from both groups were now more similar in terms of robustness and positive outcomes.

Like Chaudhry and Goldzweig, Buntin et al. commented on "the 'human element' being critical to health IT implementation. That is, an understanding the interactions among people, the technology, and their organizations is essential to successful implementation.

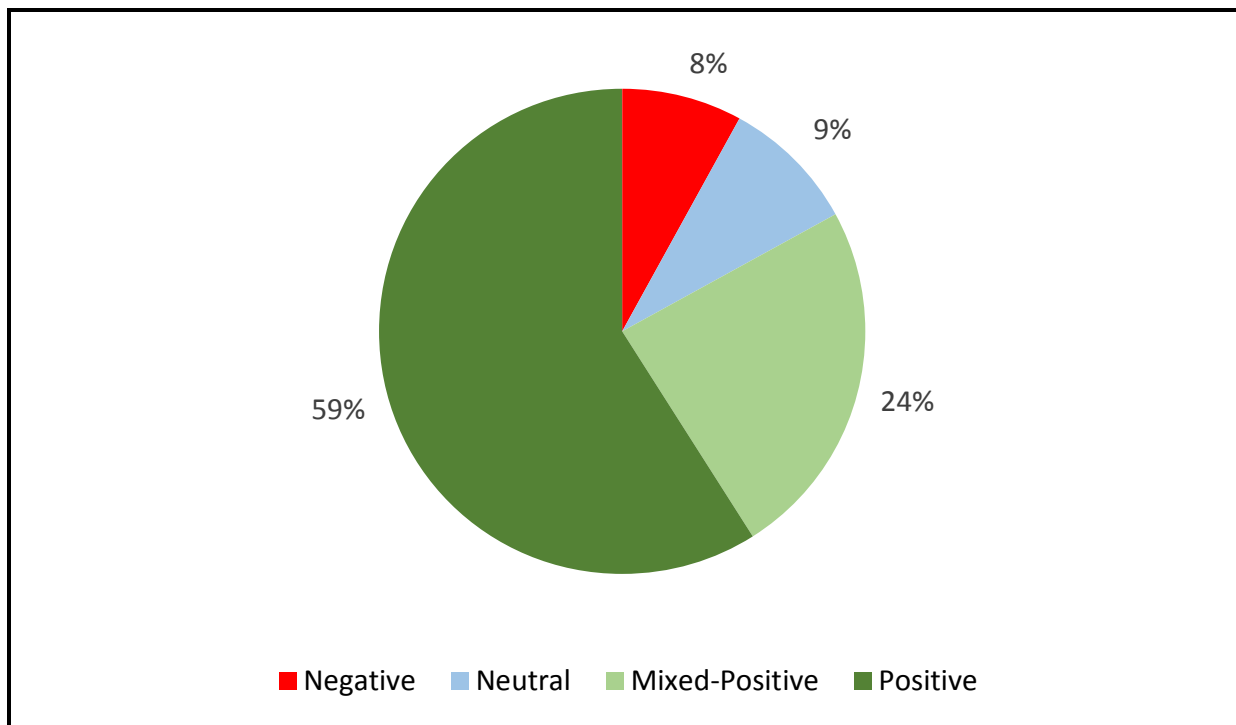
Jones et al., 2014. This most recent review, published in January 2014, focused on health IT functionalities required to achieve meaningful use. Although the authors used the same overall classification system as Buntin et al. (positive, mixed-positive, neutral, or negative) to classify findings, their scoring was more conservative, resulting in somewhat fewer overall studies being classified as positive or mixed-positive (77% versus 92% in Buntin et al.) There had been a marked increase in the number of evaluations of commercial products, a change that had been called for by the authors of the previous reviews. The key conclusion of Jones et al. was that most published studies reported that health IT had positive effects on quality, safety, and efficiency. Moreover, given that so many studies had demonstrated the positive impact of clinical decision support (CDS) and CPOE, the authors concluded that researchers should move beyond the basic question of the efficacy of these functionalities and focus instead on refinements. As in the earlier reviews, Jones and colleagues called for additional research on the contextual and implementation factors relevant to why some implementations are successful and others are not.

Across the three key areas reviewed (quality outcomes, safety, and efficiency), the authors identified positive results in more than three-quarters of studies. They firmly suggested that future needs are for research on “the mediating effects of contextual and implementation factors” and asserted that “study questions, research methods, and reporting of study details have not sufficiently adapted to meet the needs of clinicians, health care administrators, and health policymakers.”

Summarizing the trends identified in these reviews, it is apparent that the body of relevant evidence on the effectiveness of health IT has expanded greatly. A summary of the evidence presented in recent years shows that the number of studies showing positive effects of health IT substantially exceed the number of negative studies or studies with mixed effects (**Figure 2**). The evidence for improvement is widespread. For example, the findings demonstrated benefits in medication safety and dosing, increased adherence to clinical guidelines and protocols (including screenings and vaccinations), and the efficiency of care. The literature now includes a wide range of evaluations of both commercial and homegrown health IT systems.

The HITECH Act and meaningful use regulations have added increased urgency to the need for robust evaluations, and more remains to be learned about the environments in which these implementations occur and the factors that support or inhibit success.

Figure 2. Meaningful Use Functionality Has Positive Effects on Health Care Quality, Safety, and Efficiency. Fraction of Studies Published 2007-2013 on Health IT Outcomes



Source: ONC, 2014.

Additional Recently Published Evidence

Although the systematic review of Jones et al. includes publications up through August 2013, several notable studies published in the past 18 months further support the conclusion that advanced EHRs can improve safety, as described below.

Hydari, Melang, and Marella (2014) This study examined the incidence of adverse patient safety events reported from some 231 Pennsylvania hospitals from 2005 to 2012 in relation to their level of health IT use, as judged from survey data from the Healthcare Information and Management Systems Society (HIMSS).(4) After controlling for a number of possibly confounding factors, the authors found that hospitals adopting advanced EHRs experienced a 27% overall reduction in reported patient safety events. Using advanced EHRs was associated with a 30% decline in medication errors and a 25% decline in procedure-related errors. To control for factors that might have improved patient safety outside of health IT improvements, the authors looked at the rate of adverse events related to skin-integrity, which showed no association with advanced EHR adoption, as expected.

Appari, Johnson, and Anthony (2015) Using a similar approach, they evaluated surgical safety in relation to health IT use. Among the 3,002 hospitals studied, safety improved by

7–26% for seven of eight safety indicators in hospitals using surgical health IT functionality. (13)

Encinosa and Bae (2014) studied the rate of medication errors in Florida hospitals in 2010, and whether use of health IT affected these rates.(14) Although only 9.9% of Florida hospitals had adopted all five of the core meaningful use measures, these facilities saw adverse drug events (ADEs) rates drop by one-third. Physician buy-in was found to be a dominant factor: ADEs increased by 14% at hospitals reporting physician resistance to meaningful use versus a 52% ADE reduction at facilities where the health IT measures were better accepted.

The five core meaningful use measures regarding medication management include:

1. Using CPOE systems for medication orders
2. Implementing decision support systems to check for drug–drug and drug–allergy interactions
3. Having the capability to electronically exchange key clinical information (such as medication lists, medication allergies, and test results) with other providers
4. Maintaining an active medication list, and
5. Maintaining an active medication allergy list

Leung et al. (2013) studied adverse drug events in five hospitals and correlated these rates with scoring on a Leapfrog tool that measures the functionality of the CPOE. Both real and potential adverse drug events were highly correlated with scores on the CPOE instrument, with a 43% relative risk reduction for every 5% increase in CPOE score.(15)

Looking to the Future

Acknowledging that every new technological advance brings with it unintended consequences, increasing evidence shows that the benefits of health IT outweigh the disadvantages. There are good reasons to believe this trend will accelerate going forward, given that a great deal of work is taking in place, in parallel, to reduce risks, improve safety outcomes, and improve the way technology is used as it evolves. However, it will be important to monitor for those unintended consequences to ensure that the full potential of the technology is realized.

Reducing risk. Information is emerging from a wide range of sources on adverse and unintended consequences of health IT. This includes data from case reports,(16) claims databases,(17) reports through patient safety organizations,(18, 19) electronic surveillance (event triggers),(20) and adverse and sentinel event reports to The Joint Commission(21) and the Veterans Health Administration(22). Identifying the spectrum of problems and the specific types and characteristics of safety events related to health IT is a critical step in being able to identify and prioritize the health IT issues that need to be addressed. Equally

important, the ability to acquire these data validates that the reporting pathways are functional, and that tools designed to facilitate reporting, such as the health IT-specific Agency for Healthcare Research and Quality (AHRQ) Common Format,(23) are helpful in providing the appropriate detail.

Improving safety. At the same time, a host of drivers are in place to use health IT as a way to improve the quality and safety of health care, and to focus on the safety of health IT *itself*. The Federal Health IT Strategic Plan 2015–2020 clearly identifies the goal of improving safety through health IT,(24) a theme echoed in the vision statement from the Office of the National Coordinator (ONC).(25) ONC’s Patient Safety and Surveillance Plan identifies the twin goals of 1) using health IT to make care safer and 2) continuously improving the safety of health IT.(26) The plan also outlines the specific objectives and strategies that will be used to meet these goals. Reports from the Institute of Medicine(3) and the AHRQ echo the strong desire to help health IT achieve its full potential as a means of improving quality, safety, and value in health care. AHRQ has sponsored health research aimed at studying how to best achieve these goals, with early progress reported in some areas.(27) Finally, the criteria for meaningful use provide both explicit measures aimed at improving safety and the incentives to implement these measures in practice.(28)

Beyond creating the mandate for change, these documents create a path forward for achieving these goals, complemented by suggestions from the private sector and industry. (29) New tools, such as the SAFER guides, provide clear guidance on optimizing safety in using EHRs.(30)

The potential for health IT to improve safety was underlined in a recent study of 477 malpractice claims involving seven different hospitals. The authors concluded that over half of these could have been effectively prevented through existing decision support tools that were not in use.(31) Thus, beyond its current role to improve quality and safety, health IT functionality has substantial potential to reduce the risk of adverse events. Finally, another area that can be greatly improved through health IT innovation will be the prevention of diagnostic errors.(32, 33) By improving documentation, communication and coordination of care, EHR systems can help ensure that information is fully available at the point of care and that test results are seen and acted on.(34)

Summary. Recent studies continue to support the findings of the systematic reviews that health IT improves quality and safety. However, at this point in the maturation of health IT, many more nuanced research issues still need to be examined:

- What new areas, such as interoperability, will provide the most impact in producing further improvements in safety?
- What contextual factors determine whether implementations succeed or fail?

- What can be learned from the perspective of human factors engineering that can improve provider uptake and system usability? What are the important linkages among the technology itself, the providers using the technology, and the settings and systems where care is delivered?
- How can health IT itself be made more safe? Can we make progress in minimizing the unintended consequences?

What seems obvious is that the ongoing efforts to address unintended consequences, combined with refinements and extensions of existing functionalities, will further tip the scales in the direction of net benefit. The ONC is involved in a number of initiatives in support of this goal, including plans for a new national Health IT Safety Center to coordinate these efforts. Combined with the active engagement from the private sector, there is every reason to be optimistic that health IT will continue to improve the quality and safety of health care beyond the accomplishments realized to date.

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