

Costs And Benefits Of Health Information Technology: New Trends From The Literature

Since 2005, patient-focused applications have proliferated, but data on their costs and benefits remain sparse.

by Caroline Lubick Goldzweig, Ali Towfigh, Margaret Maglione, and Paul G. Shekelle

ABSTRACT: To understand what is new in health information technology (IT), we updated a systematic review of health IT with studies published during 2004–2007. From 4,683 titles, 179 met inclusion criteria. We identified a proliferation of patient-focused applications although little formal evaluation in this area; more descriptions of commercial electronic health records (EHRs) and health IT systems designed to run independently from EHRs; and proportionately fewer relevant studies from the health IT leaders. Accelerating the adoption of health IT will require greater public-private partnerships, new policies to address the misalignment of financial incentives, and a more robust evidence base regarding IT implementation. [*Health Affairs* 28, no. 2 (2009): w282–w293 (published online 27 January 2009; 10.1377/hlthaff.28.2.w282)]

THE USE OF HEALTH INFORMATION TECHNOLOGY (IT) has been promoted as having tremendous promise in improving the efficiency, cost-effectiveness, quality, and safety of medical care delivery. In a systematic review of the literature commissioned by the Agency for Healthcare Research and Quality (AHRQ) and performed in 2005, we assessed the published evidence regarding the costs and benefits of clinical health IT systems. We found that although predictive analyses suggest that health IT has the potential to enable a dramatic transformation in health care delivery, the empirical research evidence base supporting its benefits is limited.¹ The preponderance of the favorable evidence came from a few large organizations (which we dubbed the “health IT leaders”) that have implemented multifunctional, interoperable electronic health records (EHRs) that include computerized physician order entry (CPOE), decision-

Caroline Goldzweig (caroline.goldzweig@va.gov) is associate chief of staff, Clinical Informatics, at the Veterans Affairs (VA) Greater Los Angeles Healthcare System in California. Ali Towfigh is an assistant professor of medicine there. Margaret Maglione is associate director and Paul Shekelle is director of the Southern California Evidence-based Practice Center, at RAND in Santa Monica. Shekelle also is a staff physician at the VA Greater Los Angeles Healthcare System.

support systems, and other functions. Common features of these organizations are that they have developed IT systems locally; have spent years developing, implementing, and refining these systems; and have benefited from having local health IT champions who have driven the development, implementation, and evaluation of the IT systems.

However, we found limited published literature that could inform organizations seeking to implement commercial, multifunctional health IT systems. Additionally, we found almost no information about the contextual factors and process changes that organizational process experts believe are critical to successful broad-scale implementation of health IT systems. The paucity of information in these areas undoubtedly contributes to the slow progress that has been made in implementation.

Since 2005 there have been several policy initiatives to support health IT implementation—notably, the investment by AHRQ—and numerous new publications. Accordingly, we sought to update our prior review—in particular, investigating whether the literature provided greater insight into the implementation of “off-the-shelf” health IT systems or into factors related to such implementation (such as organizational characteristics, facilitators or barriers, and organizational readiness for change).

Study Data And Methods

■ **Data sources and searches.** We updated our original search with a series of searches that covered the period June 2004–June 2007, allowing for some overlap with our previous search (through 2005). Databases searched included PubMed, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Periodic Abstracts. We obtained references from key articles (known as “reference mining”). We used the same search terms that were used in our original report.²

■ **Selection of studies.** Articles were selected for more detailed review if they reported the effects of clinical health IT systems based on review by two independent reviewers with consensus resolution. We did not assess nonclinical health IT systems, such as back-office billing and administrative systems, nor did we assess technologies such as robotics. We classified articles as descriptive qualitative studies, descriptive quantitative studies, hypothesis testing studies, predictive analysis studies, reviews, and “other purpose” (generally editorials or opinion pieces). We excluded “other purpose” articles and nonsystematic reviews while including systematic reviews and meta-analyses. We also excluded descriptive qualitative studies (for example, case studies). We included descriptive quantitative studies, which in some way quantified an effect, if they used statistical tests to assess differences or to assess the impact of what was being described. We also included descriptive quantitative studies that reported on barriers to implementation, since this was a particular focus of our review. We excluded descriptive qualitative studies and some descriptive quantitative studies, because without any formal statistical analysis, they

could not inform our questions regarding the benefits of a health IT system. Without a way to quantify these benefits, any information about contextual factors or implementation could not be related to the success, or lack thereof, of the system.

■ **Data extraction.** All studies were reviewed by at least two researchers. We used a standardized data abstraction form to determine key variables about each article. We resolved disagreements about articles' content and quality through discussion. More-detailed structured abstracts were developed by one investigator using a standard template, and then data were validated by another investigator.

■ **Data synthesis.** Because of the variability in study designs and study topics, as well as the wide variability in study organizations, we determined that a synthesis of the results of the included studies could not be meaningfully accomplished using conventional methods for systematic reviews, such as meta-analysis. Instead, using the structured abstracts, we were able to identify and summarize evidence in five themes: (1) continuing results from health IT leaders, (2) evidence from commercial EHR systems, (3) the increase in health IT systems designed to be accessed directly by patients, (4) studies of implementation/barriers to implementation, and (5) cost and cost-benefit/effectiveness.³

Study Results

■ **Identification of evidence.** For this update, we identified 4,683 titles in our library search and screened 243 articles. Sixty-four of these articles were rejected for various reasons: fifteen were descriptive qualitative studies, twenty-three were other descriptive papers that did not quantify results or present information on barriers, five were nonsystematic reviews, four were "other purpose," two were robotics papers, and fifteen were "topic not health IT." We ultimately selected 179 articles, which contributed 182 studies for detailed review.⁴

■ **Description of the evidence.** Of the 182 studies included in the database, twenty-two pertained to decision support, thirty-nine assessed EHRs, and forty were about CPOE (categories are not mutually exclusive). Sixty-four of the studies assessed the effect of health IT systems in the outpatient or ambulatory setting, while seventy assessed their use in the hospital or inpatient setting. Forty-six studies used a randomized design; seven were other controlled clinical trials, thirty-four used a pre-post design, eighteen were time-series studies, and another twenty-seven were cross-sectional studies. Most studies assessed the impact of a health IT system on the effectiveness, efficiency, and use of health care; patient safety; and patient satisfaction. The health IT systems at the Regenstrief Institute and Partners were each assessed in five and twelve separate studies, respectively; six studies assessed the Veterans Affairs (VA) health information system; two studied Intermountain Health; six studied Kaiser Permanente; and five assessed the system at Vanderbilt.

We found many more studies evaluating stand-alone applications designed to be used outside of a traditional EHR. These included a substantial number of articles that evaluated applications accessed directly by patients, often outside of tra-

ditional health care settings. Although information about financial context, system sustainability, and other implementation factors was found more commonly in this review than in our prior review, information on these factors was only present in fewer than 10 percent of the studies.

■ **Studies from health IT leaders.** *Partners.* Among the twelve articles from Partners, three described computerized decision-support systems. One involved a quality improvement project related to blood product administration that used automated alert technology associated with CPOE; another involved electronic clinical reminders related to coronary artery disease and diabetes mellitus; and the third used patient-specific e-mail to providers regarding cholesterol levels.⁵ Although all demonstrated some improvements in care, in general the magnitude of the changes was small.

The VA. Of the six new studies from the VA, one evaluated the impact of provider education, electronic provider alerts, and patient education on blood pressure control.⁶ Although the electronic alerts provided a modest, non-statistically significant improvement over provider education alone, only the addition of patient education had a clinically significant impact on blood pressure control.

Indiana/Regenstrief. Of the four studies from Indiana/Regenstrief, one compared the impact on rates of influenza and pneumococcal vaccinations of computer-generated standing orders for nurses versus computerized physician reminders and found that immunization rates were significantly higher with the nurse standing orders.⁷ Two other studies evaluated computer-generated treatment suggestions for hypertension, and for asthma and chronic obstructive pulmonary disease (COPD), neither of which resulted in improvements in care.⁸

Vanderbilt. Of the five studies from Vanderbilt, three evaluated potential benefits of CPOE.⁹ Results were mixed but generally demonstrated improvements in patient safety with the introduction of CPOE as well as modest improvements in quality of care when CPOE was tailored to the management of patients with acute myocardial infarction (AMI).

The new literature from these health IT leaders demonstrates continued refinement of their existing systems, by adding new applications or enhancing existing functionalities. These studies provide evidence for the potential and the limitations of health IT in improving clinical care. Many of the new studies report modest or even no benefits of the new applications or changed functionalities. Also, even the best-performing applications frequently report results far short of perfection, highlighting the fact that although health IT systems are an important (and likely necessary) component of achieving quality improvement, they are nevertheless only one spoke in a complicated health care wheel and cannot be viewed as the sole solution to problems of quality and costs.¹⁰

■ **Studies of commercial health IT systems.** We found more descriptions of commercial health IT applications in this updated review than in our previous review, although the absolute numbers were still low. Of the fifteen studies, two re-

ported on the experiences of implementing commercially available or developed EHRs—at two different Kaiser-affiliated institutions and at a rural hospital. The Kaiser study compared outcomes before and after implementation of a home-grown EHR developed with IBM at Kaiser Colorado and of the implementation of EpiCare at Kaiser Northwest.¹¹ Numbers of ambulatory visits and radiology studies decreased after implementation, while telephone contacts nearly doubled. Limited measures of quality (immunizations and cancer screening) did not change, which was interpreted to indicate that the EHRs had no negative impact on quality of care.

The second study assessed the effect of implementing a commercial EHR in a rural family practice in upstate New York.¹² This “case study” describes the process for selecting a vendor for the EHR (in this case, Medant); the stages of EHR implementation; the impact on job responsibilities; and the financial impact. The authors report that average monthly revenue increased 11 percent in the first year and 20 percent in the second year, and the charge-capture ratio increased 65–70 percent, all because of better billing practices. Lastly, the authors report that three years after making the switch to the EHR, “the practice was quite satisfied with the new system. ...While [it] had a positive financial impact, its main benefit was on supporting the core mission of providing care.”

Other studies of commercial health IT systems included twelve that studied the effect of adding new functionalities (for example, CPOE and decision support) to existing EHRs.¹³ These study results were similar to those reported by the health IT leaders—most studies demonstrated modest benefits, some demonstrated no benefits, and a few demonstrated marked benefits. This supports the contention that findings from health IT leaders regarding the effect of adding functionalities to existing EHRs are probably generalizable to other institutions. However, this conclusion is limited by the near-certainty of publication bias regarding commercial implementations. For example, the failed EHR implementation at Cedars-Sinai Medical Center some years ago was never reported in a peer-reviewed journal, only in the lay press.¹⁴

Two of the studies associated health care quality with the level of community EHR use, and one study was on the effect of converting to an EHR on organization culture. In this latter study, the authors, contrary to their expectations, found that implementing an EHR resulted in perceptions of a more hierarchical organization. This supports the hypothesis that an organization's culture and health IT implementation interact in complex ways.¹⁵

■ **Studies of stand-alone applications.** In this review, we found many more studies of clinical health IT applications designed to run externally to an EHR, including many available directly to patients via the Internet. We identified twenty-eight such studies.¹⁶ These included evaluations of telemedicine innovations, including e-health systems that link patients with their care providers and are intended to improve the management of chronic diseases; computer/video decision aids for use by patients and providers; Short Message Service (SMS) text messaging systems for

appointment reminders; electronic devices for use by patients to improve care; and patient-directed applications for use outside traditional health care settings. The published evaluations of these interventions are mixed, with some showing no or only modest effects, and many more studies with insufficient descriptions to reach conclusions on the interventions' effects.

Web-based care management. One example of an adequately described e-health system was a study from the VA comparing Web-based care management with usual care for patients with diabetes and an HbA1c value of 9.0 percent or greater.¹⁷ Intervention patients received a notebook computer that was programmed to connect to a diabetes education and management Web site, which accepted uploads of blood pressure and glucose monitoring values. An advanced practice nurse reviewed the data and used treatment algorithms to provide individualized recommendations to patients and primary care providers. Compared with control patients, intervention patients had a statistically significant, modestly greater decrease in HbA1c values at twelve months (decrease of -1.6 versus -1.2 percentage points, $p < 0.05$). Similar-size greater declines in systolic blood pressure were also found for the intervention patients. There was no difference between groups in low-density lipoprotein (LDL) measurement changes.

Behavioral therapy packages. Three of the studies evaluated "Beating the Blues," described as an interactive, multimedia, computerized cognitive behavioral therapy package consisting of a fifteen-minute introductory videotape followed by eight therapy sessions.¹⁸ In two of the studies, statistically significant improvements of modest size were found for patients in the intervention groups compared to usual care, although the differences were no longer significant at three or six months. Other studies evaluated the use of interactive computer programs to obtain sexual histories or to educate patients on specific topics prior to visits with clinicians.

Direct-access applications. We identified four studies involving Internet or Web-based applications that could be accessed directly by the patient. They involved topics as disparate as advance care planning and health care proxy designation, weight control, complicated grief, and problem drinking.¹⁹ Three studies were randomized trials.²⁰ In the first randomized trial, patients already participating in an online personal health record system created at the Beth Israel Deaconess Medical Center were randomized. Half received an electronic message containing a hyperlink to the Massachusetts Medical Society's health care proxy Web site, which provided opportunities to complete an online health care proxy form and view an educational program on end-of-life care preferences. The 430 people randomized to receive the intervention were more likely than control subjects were to know what a health care proxy was and to have a plan to complete one in the future but were not more likely to have completed a health care proxy (four intervention, six control patients).²¹ In the second trial, German researchers reported the successful translation and implementation of a U.S.-developed, Internet-based psychological intervention for young women at high risk for eating disorders.²²

The third trial assessed the effect of an Internet-enhanced cognitive behavioral therapy program for patients with complicated grief.²³ Patients in the intervention group communicated with the psychologist and received feedback and further instructions exclusively via e-mail. Compared to patients in a waiting-list control, intervention patients had statistically significant improvements in a number of mental health measures, including those related to anxiety, depression, and adaptability.

The other Internet-based study was a pre-post analysis and a preliminary report of the feasibility and three-month follow-up of a small number of patients who completed new modules regarding their drinking patterns as part of an on-line service called the Alcohol Help Center (<http://www.alcoholhelpcenter.net>), which describes itself as “an interactive cognitive behavioral therapy program with a support group monitored by trained professionals.” Subjects that accessed the new modules found them useful, and at three months they reported less drinking than at baseline. The authors caution about drawing inferences, because of the potential for selection bias and attrition.²⁴

Self-help programs. In the field of Internet-based health applications designed directly for patients, there is far more innovation and implementation than there is evaluation. A simple Internet search of “self-help” combined with common chronic conditions (such as depression, diabetes, heart failure, panic disorder, fibromyalgia, back pain, and so forth) turns up multiple Web sites for each condition. We did not identify strong evaluation studies of any of these Internet-based self-help sites.²⁵

■ **Studies of implementation facilitators and barriers.** In the updated review, we found a modest increase in the number of studies that described factors critical to the successful implementation of health IT systems, but still relatively few that provided in-depth descriptions of the implementation strategy, the financial context into which the system was being deployed, the wider system penetration of the IT application, facilitators of and barriers to implementation, and the sustainability of the IT system or application.

General assessments. We identified fourteen articles that described barriers to health IT adoption, some of which were surveys of adoption rates or factors related to adoption. David Cutler and colleagues assessed the adoption of CPOE as of 2003 by examining data from the Leapfrog Group’s Hospital Patient Safety Survey.²⁶ Despite the literature on CPOE’s benefits in terms of helping to prevent adverse drug events, full implementation of CPOE was achieved by only 2.7 percent of respondents. Hospital ownership was strongly correlated with CPOE, with government hospitals (other than VA hospitals) being most likely and for-profit hospitals being least likely to have implemented CPOE. A survey of U.S. pediatric practices found that in 2005, 21 percent of practices had an EHR and that the proportion increased with increasing practice size (32 percent in large practices versus 3.5 percent in solo practices).²⁷ About half of the other practices had plans to

implement an EHR in the future. Perceived barriers to adoption included resistance from physicians (77 percent of practices without an EHR reported this barrier), system downtime (72 percent), increase in physicians' time (64 percent), providers' having inadequate computer skills (60 percent), cost (94 percent), and an inability to find an EHR that met the practice's requirements (81 percent). Interestingly, among practices without an EHR, 22 percent reported a "bad previous experience with an EHR" as a barrier, indicating a failed implementation. Another U.S. survey included physicians who already subscribed to an Internet-based service that has since become part of WebMD (1,004 respondents, or only about 3.7 percent of physician members).²⁸ Physicians using electronic prescribing were more likely than their peers not using it to be generalists and to work within academic medical centers or publicly funded health centers, and were modestly younger. Nonusers were significantly less likely than users to believe that electronic prescribing could save time, reduce errors, or improve monitoring of drug therapy. Cost was the number-one identified barrier to adoption. Lastly, a national survey of U.S. health care organizations with at least twenty physicians (response rate: 70 percent) found that only about half of organizations had a registry for even one chronic illness, and half of these registries were not linked to clinical data.²⁹ Factors associated with registry use included public recognition for quality, size (200 or more physicians in the organization), ownership of the organization, and being a medical group, among other factors.

Regional assessments. A second group of papers assessed more regional samples. A survey of physicians belonging to the Connecticut State Medical Society Independent Practice Association found that in 2006, 16 percent of physician offices used an EHR, 9 percent of offices used e-laboratory systems, and 7 percent used e-prescribing systems.³⁰ The most commonly stated barrier was cost (72 percent); other barriers were time necessary to train staff (40 percent), lack of proficiency among staff (26 percent), and lack of an IT culture within the office (18 percent). A survey of primary care physicians at Kaiser Northwest (49 percent response rate) designed to assess explanations for low rates of appropriate responses to computerized clinical decision support embedded in their EpicCare EHR system reported that most clinicians thought that the decision support helped them provide better care and was worth the time; however, 80 percent said that they were less likely to accept alerts if they were behind schedule—a situation that 84 percent of clinicians admitted to being in "some," "most," or "all of the time." A survey of physicians at two Massachusetts hospitals regarding CPOE (response rate: 71 percent) found that only 22 percent of respondents thought that the system's user interface supported their workflow, only 37 percent believed that it was faster to use CPOE than to handwrite orders, and only 41 percent believed that CPOE helped carry out orders more rapidly.³¹ However, a majority of respondents recognized that CPOE had safety advantages. A survey in Florida regarding adoption of EHRs and barriers (response rate: 28 percent) found that "imminent adopters"—that is, phy-

sicians planning to adopt an EHR within the coming year—were more likely than other physicians to work in larger practices, be in a multispecialty practice, and be slightly younger.³²

The number-one barrier to adoption was cost among those physicians not considering EHR adoption. The last paper in this set was a description of the views of many staff at a Norwegian hospital that had gone “near-paperless.”³³ Compared to a survey done when both the EHR and paper-based record coexisted, after going “near-paperless” (a process that included scanning all old paper-based medical records), nurses reported increased use of the EHR, and fourteen of nineteen tasks they did were now more effective. Medical secretaries were most satisfied with the EHR, followed by nurses and then physicians.

Case studies. The last two studies in this theme were case studies of adoption of health IT. The first study assessed the use of an Internet-based decision-support system for prescribing antibiotics (that is, not part of an EHR). Compliance with use of the decision-support system for patients admitted with community-acquired pneumonia was less than hoped for in three of five rural hospitals examined.³⁴ Further examination revealed that existing cultural differences strongly discouraged the questioning of physician orders by nonphysicians (pharmacists or nurses, in this case, who consulted the decision-support system). Use of a nonphysician intermediary was tested because an earlier study found that physicians were reluctant to access the Internet-based system because of the perceived length of time required and lack of terminals in the patient care areas. It was felt that using a nonphysician to do the task of running the system would overcome this problem, but local cultural issues prevented any uptake at three of the five hospitals.

The last study in this group, and the most sophisticated and influential one, was a case study of the implementation of an EHR in a Swedish hospital.³⁵ This study was informed by Roger’s Theory of the Diffusion of Innovation, plus a prior study of Kaiser in the United States. Its findings suggest that key lessons for successful EHR implementation include choosing a system that meets a range of needs and is tried and tested in a similar setting; that works for clinical personnel and saves time; that is intuitive and thus requires little training; and that is relatively easy to customize for different departments and uses. Although the selection of the system should be participatory, implementation needs to be directed and driven, with clear and appropriate parameters about which decisions can be made locally and which require higher-level input.³⁶

■ **Studies of cost and cost-effectiveness.** As in our previous review, cost and cost-effectiveness analyses of health IT interventions were very limited, with few new articles since the prior review; this likely reflects the difficulty of conducting these types of analyses and the often incremental nature of health IT adoption. These studies added limited new information to our previous conclusions: although there is some empirical evidence to support the positive economic value of an EHR

system and the component parts of EHRs, projections of large cost savings assume levels of health IT adoption and interoperability that we are nowhere near achieving, and therefore realizing the projected benefits will require proper alignment of the health care financing system, strong leadership, effective implementation strategies, and focused efforts to successfully adapt the EHR system.

Discussion

Compared to our prior review (completed in 2005), our findings can be grouped into three categories: what is new, what has changed, and what has stayed the same.

■ **New finding: proliferation of patient-focused applications.** The most important new finding is the proliferation of patient-focused applications, many of which are designed for use by patients on their own, without significant oversight by traditional health care providers. There are likely many reasons that these applications appear to be on the rise, given the broad range of types available. Some may be anticipated to increase efficiency (text-message appointment reminders, Internet-based cognitive behavioral therapy), some to improve quality (Web-based diabetes management), and some to provide more accessible care for difficult-to-treat problems (alcohol abuse and eating disorder sites). However, the striking finding from our review is that there has been so little solid evaluation of these applications. This is an area of much-needed future research, in terms of descriptive epidemiology (such as, How many such sites are there? How many people use these sites?), content analysis (How accurate is the information?), and more formal evaluation studies, such as effectiveness and potential for adverse outcomes, as well as the potential consequences of using an advertising-supported medium to deliver medical care.

■ **Changes: numbers and types of studies.** We identified several changes since our prior review. For one, we found many more relevant publications than we expected for this relatively short time frame (179 in the three years covered by this update, compared to the 257 found in the ten years covered by the prior review). This is almost certainly a reflection of the greater interest in policy and delivery circles over the potential for health IT to transform health care. Second, the proportion of relevant studies that come from the “health IT leaders” has fallen modestly, from 25 percent of the total to 20 percent. Third, we found more studies of the implementation of commercial, off-the-shelf applications, although compared to the need in this area, the number of publications is still minuscule. Policymakers should expand existing programs to support the kind of public-private partnerships that will foster collaboration between hospitals and health plans seeking to implement commercial health IT systems, on the one hand, and the academic experts in evaluation, on the other. Bringing together the academic research communities in IT and in quality improvement should also be a goal. For example, theory-driven evaluation is one promising quality improvement evaluation tool that can be used to produce useful knowl-

edge from real-world implementations. As explained by Kieran Walshe, theory-driven evaluation would start with a theory about how implementation might work, and then design an evaluation to test the theory.³⁷ The study evaluating implementation in the Swedish hospital discussed above is an example of a theory-driven evaluation.³⁸ Many more studies like this are needed, examining implementations at large and at small hospitals, rural and urban sites, and so forth, to build a useful evidence base about the factors important for health IT implementation.

■ **What has not changed: paucity of cost-benefit data.** What has not changed since our prior review is the paucity of meaningful data on the cost-benefit calculation of actual IT implementation. This makes creating the business case for health IT adoption a challenge, and costs still remain the number-one barrier cited by all surveys assessing adoption. It is not a coincidence that organizations that both pay for and deliver health care have adopted health IT at greater rates than organizations that only deliver care. Without a better alignment between “who pays” and “who benefits” from health IT adoption, we can expect it to proceed at an exceedingly slow pace. Since one substantial beneficiary is the payer, and most providers deal with a multiplicity of payers, a mechanism that partially shares the cost of adoption in practices and hospitals across this multiplicity of payers (including Medicare) would dramatically ease one of the main barriers to adoption. Decreasing the financial barriers and providing a much more robust evidence base regarding health IT can be expected to greatly accelerate its adoption.

.....
An earlier version of this paper was presented at the Fifteenth Princeton Conference, “Can Payment and Other Innovations Improve the Quality and Value of Health Care?,” sponsored by the Council on Health Care Economics and Policy, 27–29 May 2008, in Princeton, New Jersey. Funding for this research was provided by the Health Foundation in London, England.

NOTES

1. B. Chaudhry et al., “Systematic Review: Impact of Health Information Technology on Quality, Efficiency, and Costs of Medical Care,” *Annals of Internal Medicine* 144, no. 10 (2006): 742–752.
2. Southern California Evidence-based Practice Center, *Costs and Benefits of Health Information Technology*, April 2006, Pub. no. 06-E006, <http://www.ahrq.gov/downloads/pub/evidence/pdf/hitsyscosts/hitsys.pdf> (accessed 9 December 2008).
3. The structured abstracts are available to readers on the Web site of the Agency for Healthcare Research and Quality (<http://www.healthit.ahrq.gov/tools/rand>) and can be accessed from an interactive database that allows users to select the clinical or health IT context specific to their needs and interests and rapidly find the relevant evidence.
4. A graphic showing the flow of article selection is available in the online appendix, <http://content.healthaffairs.org/cgi/content/full/hlthaff.28.2.w282/DC2>.
5. Space considerations precluded a complete bibliographic listing of the articles that were included in our study. Complete citations are available in the online appendix, as in Note 4. See Rothschild 2007, Sequist 2005, and Lester 2006.
6. See Roumie 2006.
7. See Dexter 2004.
8. See Murray 2004 and Tierney 2005.
9. See Potts 2004, Butler 2006, and Ozdas 2006.

10. Additional details regarding studies described in this section can be found in Evidence Table 1 online, as in Note 4.
11. See Garrido 2005.
12. See O'Neill 2007.
13. See Han 2005, Del Beccaro 2006, Palen 2006, Steele 2005, Smith 2006, Galanter 2004, Asaro 2006, Feldstein 2006, and Toth-Pal 2004.
14. C. Ornstein, "Hospital Heeds Doctors, Suspends Use of Software," *Los Angeles Times*, 22 January 2003.
15. Additional details regarding studies described in this section can be found in Evidence Table 2 online, as in Note 4.
16. See McMahon 2005, Tideman 2007, Jacobi 2007, Robertson 2006, Cintron 2006, Schinke 2006, Sheridan 2006, Harno 2006, Cunningham 2006, Glanz 2006, Pretty 2007, Boldrick 2007, Holden 2007, Ozanne 2007, Kaner 2007, Downer 2006, Cavanagh 2006, Boissy 2006, Downer 2005, Vilella 2004, Grime 2004, Proudfoot 2004, Wagner 2006, Gustafson 2005, Glasgow 2005, Fung 2006, Glasgow 2006, and Green 2004 in the online supplementary materials.
17. See McMahon 2005.
18. See Cavanagh 2006, Grime 2004, and Proudfoot 2004.
19. See Cunningham 2006, Cintron 2006, Jacobi 2007, and Wagner 2006.
20. See Jacobi 2007, Cintron 2006, and Wagner 2006.
21. See Cintron 2006.
22. See Jacobi 2007.
23. See Wagner 2006.
24. See Cunningham 2006.
25. Additional details regarding studies described in this section can be found in Evidence Table 3 online, as in Note 4.
26. See Cutler 2005.
27. See Kemper 2006.
28. See Pizzi 2005.
29. See Schmitt diel 2005.
30. See Mattocks 2007.
31. See Lindenauer 2006.
32. See Menachemi 2006.
33. See Lium 2006.
34. See Stevenson 2005.
35. See Ovreteit 2007.
36. Additional details regarding studies that addressed barriers can be found in Evidence Table 4 online, as in Note 4.
37. See Walshe 2007.
38. See Ovreteit 2007.