

The Value of Health Information Technology: Filling the Knowledge Gap

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In 2010, the United States Congress enacted the Health Information Technology for Economic and Clinical Health (HITECH) Act, thereby dedicating roughly \$27 billion to eligible healthcare providers who demonstrate “meaningful use” of health information technology (HIT). This action motivated the purchase and installation of tens of thousands of HIT products across the US healthcare system and placed a national spotlight on HIT. The HITECH Act was justified, in part, by early studies that documented positive effects on healthcare quality, safety, and efficiency at a subset of institutions that were early to implement HIT, and by policy analyses that extrapolated the implications of these potential benefits throughout the US healthcare system.^{1,2} These studies suggested that HIT had the potential to create enormous value by facilitating improvements in the quality of healthcare and reductions in costs.

However, systematic reviews of HIT have found that the evidence for value is inconclusive and that existing studies suffer from major limitations.^{3,6} This finding is true even of the most recent literature reviews, despite a greatly increasing number of studies evaluating HIT.⁶ In this paper, we suggest a way to overcome these deficiencies and make HIT evaluations more relevant to the current needs of the healthcare system, by presenting a conceptual framework for measuring the value of HIT, examining how a sample of published HIT articles report the information needed to make meaningful assessments of value, and proposing a set of criteria for future evaluations that would make them more useful for policy makers.

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MEASURING THE VALUE OF HIT

Published studies have evaluated HIT using many different measures, including cost savings,⁷ time savings,^{8,9} utiliza-

ABSTRACT

Despite rapid growth in the rate of adoption of health information technology (HIT), and in the volume of evaluation studies, the existing knowledge base for the value of HIT is not advancing at a similar rate. Most evaluation articles are limited in that they use incomplete measures of value and fail to report the important contextual and implementation characteristics that would allow for an adequate understanding of how the study results were achieved. To address these deficiencies, we present a conceptual framework for measuring HIT value and we propose a checklist of characteristics that should be considered in HIT evaluation studies. The framework consists of 3 key principles: 1) value includes both costs and benefits; 2) value accrues over time; and 3) value depends on which stakeholder's perspective is used. Through examples, we show how these principles can be used to guide and improve HIT evaluation studies. The checklist includes a list of contextual and implementation characteristics that are important for interpretation of results. These improvements will make future studies more useful for policy makers and more relevant to the current needs of the healthcare system.

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Take-Away Points

Healthcare organizations all over the United States are adopting health information technology (HIT), yet recent studies of HIT are often unhelpful to these organizations or to those making policy decisions. Most studies fail to use adequate measures of value or to report key contextual and implementation characteristics. In this commentary, we:

- Demonstrate the problem in a sampling of published articles.
- Propose a conceptual framework and principles for measuring value in HIT.
- Present a checklist of key study characteristics.

Readers can use this article as a touchstone for assessing the utility and relevance of published research studies.

tion reduction,^{10,12} process adherence improvements,^{13,14} health outcomes,^{15,16} safety improvements,^{12,17} physician satisfaction,¹⁸ patient satisfaction,¹⁸ and many others. These outcomes are all components of value, but all are limited. It would be a mistake to make a general conclusion about the value of HIT by looking at only 1 of these measures. To make more general assessments, evaluations of HIT should take into account 3 principles: 1) value includes both costs and benefits; 2) value accrues over time; and 3) value depends on which stakeholder's perspective is used.

Principle 1: Value Includes Both Costs and Benefits

Value, by definition, includes both costs and benefits. Studies that report only costs (or proxies for cost, such as utilization) cannot be used to reach conclusions about value. For example, 1 study quantified the costs of implementing an electronic health record (EHR) system for a 5-physician practice, including direct financial expenditures and hours needed to implement.¹⁹ These estimates of cost are an important component of value to that physician practice, but cannot by themselves be considered an estimate of value, because they do not include an assessment of potential benefits, which could include reduced costs that may accrue downstream. Nor do they include health benefits to patients, which may accrue in the near or long term as a result of the HIT implementation.

In another example of the limited ability of costs-only studies to define value, a population-based clinical decision support system was shown to increase the use of outpatient services and total medical costs in the intervention group, whereas services and costs did not significantly change in the control group.²⁰ Again, without an assessment of benefits, these results are not a complete assessment of value, and general conclusions should not be made.

As a third example, the United States as a whole spends far more on healthcare now than it did in 1950, in large part due to technological advances. A newborn in

1950 could expect to require \$8000 worth of medical care over the course of his or her lifetime (in 2001 dollars discounted to birth), whereas the comparable figure for a newborn in 1990 was \$45,000, a nearly 600% increase. Yet, as Cutler and McClellan argue, based on an analysis of 5 medical conditions (heart attacks, low birth weight babies, depression, cataracts, and breast cancer), despite the rapid rise in costs, the benefits of medical progress (in terms of quality-adjusted life years) more than justify the added costs (\$7 in benefits for every \$1 in increased spending for heart attack treatments, for example).²¹

While it may not be feasible to measure all the costs and all the benefits of a particular HIT functionality, studies that only measure one or the other cannot by themselves provide assessments about the value of the technology.

Principle 2: Value Accrues Over Time

Value accrues in various degrees over time. The costs of an EHR, for example, from the perspective of a medical group, may entail purchase costs for the hardware and software, installation expenses, and training fees. These are all short-term costs. In the longer term, the EHR may require varying levels of maintenance, replacement costs, and retraining. Costs in terms of time burden may also vary over time, as clinicians become more adept at using the user interface.

Benefits vary across time as well. From the perspective of a patient, in the near term, HIT may result in a reduction in errors. In the long term, HIT may facilitate many health benefits through clinical monitoring, reminders, and disease management and prevention. In many cases, HIT may have both short- and long-term benefits. A computerized alert prompting the measurement of fasting lipids in a 40-year-old male may set the patient on a healthier trajectory, which may accrue over decades in cardiovascular disease avoided.

It is not feasible for any particular study to capture all the effects (especially in the long term) of any particular HIT intervention. However, the time horizon should be long enough to reflect the differences between the benefits and costs of using the HIT intervention versus not using it.²²

Principle 3: Value Depends on Which Stakeholder's Perspective Is Used

There are many possible perspectives from which to view the value of HIT. For example, consider 2 physician

group practices, located across the street from each other, both of which have implemented the same HIT system. Through the use of physician-reminder prompts, the delivery of screening colonoscopies increased 2-fold among eligible patients for both practices. If one physician group practice were reimbursed under fee-for-service, the increase in services would be a source of revenue, and therefore an increase in value to the practice. If instead of fee-for-service the other physician group practice were paid by capitation, this increase in services would be a cost to the group (in the short term, at least) and therefore a decrease in value. Even if the benefits to patients were equal in the 2 practices, the perception of value to the practices would be very different.

As another example, from the perspective of a small provider operating under fee-for-service, an EHR may necessitate that the physicians see fewer patients because of the increased documentation burden. But from a patient's perspective, the improved documentation may result in better clinical decision making and improved health outcomes. From another patient's perspective, however, the decrease in visit volume may have a negative effect in that it may make it more difficult for him or her to book a visit. From the payer's perspective in this example, there may be a decrease in charges from the provider's office for a period of time during the transition to an EHR, saving the payer money. However, more expensive emergency care may end up substituting for some of those visits, in which case the costs may increase, at least in the short term.

Thus, in any application of HIT, there may be "winners" and "losers" in terms of certain aspects of costs or utilization. In the Veterans Health Administration (VHA), for example, it takes more time for the physicians to enter their progress notes into the electronic health record than it did when paper was used, so the physicians "lose" in terms of time. But the VHA "wins" via reductions in the costs of storing and retrieving all the paper-based records, and the patients "win" by getting more preventive care services delivered to them, because the EHR contains decision support that prompts providers to deliver these services to eligible people. In some situations, the "winner" and "loser" is the same entity, depending on what is being looked at: physicians "lose" because it takes more time to enter information into the EHR, but they also "win" because every other physician has also had to enter their notes into the EHR, which means that all the time lost trying to figure out what happened at the last hospitalization or visit to the subspecialist disappears when this information is instantly available in the same EHR. These kinds of

"transfers" can vastly influence conclusions about value, depending on the perspective.

Only 1 perspective is insensitive to such transfers when assessing the value of HIT, and it can be used as a summative evaluation for HIT as a whole: social value. Social value adds up all the costs paid directly or indirectly by patients (taxes, premiums through employers, premiums directly paid, direct payments as co-pays or self-pay) and benefits to patients (convenient access to providers, better health, longer lives). Any complete assessment of value of HIT for society must be from this social perspective.²³

Social value does not always align with the business value to providers. If a physician group or hospital operates more efficiently and saves money as a result of HIT but the quality of the healthcare it delivers is unchanged, the social value of healthcare is also unchanged. However, if market forces result in healthcare organizations lowering the costs they charge payers, and if the payer passes on those savings to patients through decreased premiums, the social value will increase as a result of HIT. Unfortunately, market forces are imperfect in healthcare, and cost savings often do not get passed back to the patient, or if they do, it takes many years. It is therefore important for studies of HIT value to state how they expect the market to respond to the effect of the technology, including the time frame in which these changes may be reasonably expected to occur.

Ideally, all evaluations of HIT would take the perspective of all relevant stakeholders, including all possible costs and benefits, and consider the downstream effects of the technology in future decades. Clearly, such studies would be infeasible. However, we believe that authors of studies could do a better job in specifying which stakeholder's perspective they are using as the lens for their evaluation, and in explaining the link to social value.

WHAT INFORMATION ABOUT VALUE IS CURRENTLY REPORTED IN STUDIES OF HIT?

Unfortunately, we have found that few studies include both costs and benefits in their definitions of value. Most studies look at only short-term time horizons, which ignore many of the downstream benefits of the HIT, and many studies don't even explicitly state to whom the value is accruing. To illustrate this, we present in **Table 1** a sample of recent HIT articles, and whether and how they reported information on value (columns A through D). These articles are a purposive sample to capture a diversity of study types, including those that focus on 1 par-

■ **Table 1.** Sample of Articles and Included Information

Author/Year	How is value being defined?		What is the perspective for value?		What is the health information technology (HIT)?		
	(A) What costs are reported?	(B) What benefits are reported?	(C) What is the time frame?	(D) To whom does the value accrue?	(E) What are the functionalities? What is the HIT system intended to do?	(F) Is there information about implementation?	(G) What contexts are reported? ^a
Connelly (2012)²⁴	Hospitalization, length of stay; number of tests, procedures, and medications ordered in the ED	Changes in mortality	1.5 years	Not clear; data reported are from 3 EDs	Not described other than that the study sites used an EHR, which offered the ability to access inpatient and ambulatory records from within a health system. Intended effects were only defined as reducing information gaps, improving clinical decision making, and achieving better and more efficient care.	No	No contextual data are reported
Furukawa (2010)²⁵	Total direct costs; length of stay	Nurse-sensitive patient outcomes: patient safety indicators, decubitus ulcer, failure to rescue, certain infections, changes in mortality	Costs per discharge or per patient stay, so measured in days, then over 3 years of implementation	Not clear, though from the analyses it appears to be from the perspective of the payer	EMR stage 1: Started implementation of 3 core ancillary department information systems: pharmacy, laboratory, and radiology; plus a clinical data repository. EMR stage 2: All EMR stage 1, + have started implementing nursing documentation and electronic medication administration records. EMR stage 3: All EMR stage 1 & 2, + have started implementing computerized order entry and decision support. Intended effects not stated.	No	No contextual data are reported
Himmelstein (2010)²⁶	Total Medicare spending costs, portion of Medicare spending devoted to administration	Quality composite score and quality scores for AMI, CHF, pneumonia	5 years	Not clear, though the authors' discussion presents this from the perspective of the payer	Hospital computerization score (from 0.0-1.0) computed from 24 clinical and administrative applications (eg, CPOE, patient billing, general ledger). Intended effects not stated	No	Size
Lau (2012)²⁷	Rate of visiting health service provider	Influenza vaccine administration rates	6 months	Not clear; data reported are from a single university health system	Patient portal with treatment protocols. Vaccine protocol includes description of vaccines available, steps to obtain vaccines, and online appointment booking. Intended effect is minimizing of knowledge-based (eg, lack of awareness) and system-based (eg, inconvenience) barriers associated with accessing health services, making consumers more likely to engage in preventive health measures such as influenza vaccination. In this context, increased visits to a health provider were considered a desired effect.	No	No contextual data are reported

(Continued)

■ **Table 1.** Sample of Articles and Included Information (*Continued*)

Author/Year	How is value being defined?		What is the perspective for value?		What is the health information technology (HIT)?		
	(A) What costs are reported?	(B) What benefits are reported?	(C) What is the time frame?	(D) To whom does the value accrue?	(E) What are the functionalities? What is the HIT system intended to do?	(F) Is there information about implementation?	(G) What contexts are reported? ^a
Ling (2010) ²⁸	Phone calls to clinic asking for test results	Proportion of patients receiving test results	17 months	Not clear; data reported are from a single clinic	Online result system; otherwise not specified. Intended effects were increasing number of patients receiving test results and decreasing phone calls to clinic asking for results	No	Size
McCormick (2012) ²⁹	Utilization of radiologic imaging	None	This is a cross-sectional study, so the time frame is undefined but ≤1 year	Not clear, though the authors' discussion presents this from the perspective of the payer	"Computerized system for viewing imaging results" and whether "electronic images [were] returned"; otherwise not specified. Intended effects not stated.	No	Financial status/payer mix (but only aggregate data are presented)
Palen (2012) ³⁰	Rates of office visits, telephone encounters, after-hours clinic visits, ED encounters, and hospitalizations	None	2 years	Not clear, though authors' discussion presents this from the perspective of the integrated payer-provider (Kaiser Permanente)	Online patient portal that allows patients to have secure access to their health records, including test results, immunization records, active medications, medical problem list, and care plans. Patients can also schedule or cancel non-urgent appointments, request medication refills, and send and receive secure messages to and from clinicians. Intended effect is to give patients the opportunity to manage their own health information.	Yes	Size; financial status/payer mix
Shapiro (2010) ³¹	Cost data for capital outlay and operation of the HIT system; revenue as charges, receipts, and collections from patients for both professional care and facility	None	Between 2 and 3 years	A single urban academic ED	Commercial ED information system, which includes triage; patient tracking; physician and nurse documentation; retrieval of prior ED encounter; access to additional historical hospital data; computerized provider order entry; results review; discharge instructions; and prescription writing. For the purposes of this study, an intended effect of the HIT system was to improve charting and billing.	Yes	Size; organizational complexity
Virga (2012) ³²	None	Quality and health status indicators for HIV	3 years	Not clear; data reported are from 3 clinics	Clinical summarization tools, ability to share summaries across providers, alerts and reminders sent to providers. Intended effects not stated.	No	No contextual data are reported

(Continued)

■ **Table 1.** Sample of Articles and Included Information (*Continued*)

Author/Year	How is value being defined?		What is the perspective for value?		What is the health information technology (HIT)?		
	(A) What costs are reported?	(B) What benefits are reported?	(C) What is the time frame?	(D) To whom does the value accrue?	(E) What are the functionalities? What is the HIT system intended to do?	(F) Is there information about implementation?	(G) What contexts are reported? ^a
Zlabek (2011) ³³	Transcription costs, costs of reams of paper, laboratory tests, hospitalizations, length of stay, readmissions	Reduction in medication errors and near-misses; reduction in duplicate radiology exams; changes in mortality	1 year	Not clear; data reported are from a single hospital	Hospital EHR with CPOE; otherwise not specified. Intended effects not stated.	No	Size

AMI indicates acute myocardial infarction; CHF, congestive heart failure; CPOE, computerized provider order entry; ED, emergency department; EHR, electronic health record; EMR, electronic medical record; HIV, human immunodeficiency virus.

^aThe following contexts were searched for in each paper: size, organizational complexity, financial status/payer mix, regulatory requirements, external payments or penalties, leadership.

ticular HIT installation as well as broader cross-sectional studies.

In this sample of 10 articles, 3 reported only on costs, without mention of any benefits, while 1 reported only on benefits, with no reporting on costs (which can include utilization). Thus, 4 of the 10 studies do not report both costs and benefits, and therefore cannot provide information about value (since value includes both costs and benefits). All of the studies are relatively short term, most having a time horizon of 1 to 3 years, and thus any downstream benefits or costs that might accrue due to better care today will not be captured. Only 1 study was explicit about “To whom does the value accrue?”, although in 3 others this could be inferred. These studies clearly show room for improvement in terms of how they measure value.

Even when information on costs, benefits, and perspective are presented, studies of HIT must then present sufficient information for readers to know what the intervention is, if readers are to be able to reach conclusions about whether the HIT system is something that could be implemented in another context. However, most evaluations of HIT do not adequately report such information. Few studies explain how the technology works, let alone how it was implemented. Furthermore, most studies don’t even report basic contextual information such as under what payment system the users were paid.

Studies need to open up the “black box” of HIT and do a better job explaining how HIT contributed to the results, including the role of key contextual factors. The need for particulars about the intervention details and implementation details has been noted by others for several years.^{4,34,35} All of these authorities recommend including at least 3 descriptors of the intervention: what

the functionality does, contextual information, and implementation information. HIT evaluation studies need to describe this information so that a reader can understand what was being evaluated and assess whether or not they might be able to realize that value if they were to try to implement the same intervention in a different context.

To show how studies currently achieve this benchmark, we assessed the same 10 studies as above along these dimensions (Table 1, columns E, F, and G). All the studies had some description of the HIT functionalities, although for some this was at a very general and basic level (“a hospital EHR with CPOE [computerized physician order entry],” otherwise unspecified). Four studies report no contextual information at all, while in another 3, the only contextual data are the size of the organizations (usually a hospital). Only 3 studies reported some aspect of the financial status or payer mix. In 8 studies, there was no information about implementation. These data support, broadly, conclusions similar to those reached in a recent systematic review of HIT covering the years 2010-2013. In that review of 225 studies, only about a third of studies reported any information about context and implementation beyond the simplest measures.⁶

A PROPOSAL TO IMPROVE FUTURE HIT EVALUATIONS OF VALUE

Without more attention to the necessary measuring and reporting of the data needed to assess value, we risk the possibility of 3 more years’ worth of published studies, which we estimate would be more than 300 hypothesis-testing articles,⁶ that do not give us appreciably better

■ **Table 2. Checklist for Health Information Technology (HIT) Evaluation Studies**

<input type="checkbox"/>	Describe the HIT intervention in sufficient detail, including the technology and expected roles of clinical and administrative staff, so that it can be replicated.
<input type="checkbox"/>	Explicitly state the way value is being defined in terms of costs and benefits, the metrics used, and the time frame under study.
<input type="checkbox"/>	Explicitly state the stakeholder to whom the type of value under study would accrue.
<input type="checkbox"/>	Explicitly describe the theory behind the chosen HIT intervention components, or present an explicit logic model for why it should work and how it is expected to improve value.
Detail the implementation process, including:	
<input type="checkbox"/>	Degree and type of practice redesign
<input type="checkbox"/>	Training
<input type="checkbox"/>	Leadership support for intervention
<input type="checkbox"/>	The intervention's effects on staff roles
<input type="checkbox"/>	How the implementation or intervention changed over time
Measure and report the following high-priority contexts:	
<input type="checkbox"/>	Organization's size in terms of patient volume and number and type of clinicians
<input type="checkbox"/>	Organization's resources
<input type="checkbox"/>	Complexity of organization (eg, number of sites, specialty lines, standardization of HIT infrastructure across organizations)
<input type="checkbox"/>	Explicit organizational goals
<input type="checkbox"/>	Financial status (for-profit or nonprofit)
<input type="checkbox"/>	Payer mix (eg, portion of patients under Medicaid, Medicare, private insurance, private payers)
<input type="checkbox"/>	Method of payment (eg, fee-for-service, capitation, pay-for-performance, penalties)
<input type="checkbox"/>	Alignment of organization's financial incentives with goals of HIT functionality
<input type="checkbox"/>	Public reporting requirements relevant to intervention
<input type="checkbox"/>	Regulatory requirements relevant to intervention
<input type="checkbox"/>	Culture of teamwork among users and managers
<input type="checkbox"/>	History and culture of using HIT
Describe prior expectations of results based on previous studies of similar functionalities, implementations, and contexts	
Provide an explicit reason for why the findings may or may not generalize to other forms of health HIT functionalities and contexts.	

knowledge about this crucial aspect of HIT: how best to realize value. We propose in **Table 2** criteria that should be met by all reports of HIT studies that are intended to improve our understanding of value. These include using evaluations to include both costs and benefits, using longer time horizons, considering the perspectives of different stakeholders, and reporting implementation details and contextual variables.

Making these changes may require especially imaginative study designs, and research teams that have both quantitative and qualitative expertise. For example, more qualitative research will be required to assess such questions as: *How were users of the HIT trained? Was the training likely effective? What kind of support was provided from organizational leadership? What exactly was the HIT product intended to do? To what extent were the end users involved in*

the design of the technology? Details like these are critical to determining the applicability of any particular study's results to other settings. While an extensive body of qualitative literature shows how HIT may achieve benefits or result in unintended consequences, this literature is almost completely distinct from studies that assess value in terms of quantitative measures of efficiency, quality, and safety. It is therefore largely impossible, using the current literature, to both identify the successful implementations of HIT and understand how to replicate them.

Making such changes will not be easy, as ideas about what constitutes HIT research are entrenched. However, if research is to align with the current needs of the health-care system, researchers should take on this challenge and produce results that not only prove what is possible, but also show how to achieve it.

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REFERENCES

- Hillestad R, Bigelow J, Bower A, et al. Can electronic medical record systems transform health care? potential health benefits, savings, and costs. *Health Aff (Millwood)*. 2005;24(5):1103-1117.
- Walker J, Pan E, Johnston D, Adler-Milstein J, Bates DW, Middleton B. The value of health care information exchange and interoperability. *Health Aff (Millwood)*. 2005;Suppl Web Exclusives:W5-10-W5-8.
- Buntin MB, Burke MF, Hoaglin MC, Blumenthal D. The benefits of health information technology: a review of the recent literature shows predominantly positive results. *Health Aff (Millwood)*. 2011;30(3):464-471.
- Chaudhry B, Wang J, Wu S, et al. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. *Ann Intern Med*. 2006;144(10):742-752.
- Goldzweig CL, Towfigh A, Maglione M, Shekelle PG. Costs and benefits of health information technology: new trends from the literature. *Health Aff (Millwood)*. 2009;28(2):w282-w293.
- Shekelle PG, Jones SS, Rudin RS, et al, of the Southern California Evidence-based Practice Center of the RAND Corporation. Health Information Technology: An Updated Systematic Review with a Focus on Meaningful Use Functionalities. Washington, DC: Office of the National Coordinator for Health Information Technology; 2014.
- Pettit RS, Zimmerman CR, Alaniz C, Dorsch MP. Cost analysis before and after implementation of a computerized physician order entry order form for enoxaparin. *PT*. 2012;37(2):107-111.
- Devine EB, Hollingworth W, Hansen RN, et al. Electronic prescribing at the point of care: a time-motion study in the primary care setting. *Health Serv Res*. 2010;45(1):152-171.
- Duffy WJ, Kharasch MS, Du H. Point of care documentation impact on the nurse-patient interaction. *Nurs Adm Q*. 2010;34(1):E1-E10.
- Furukawa MF. Electronic medical records and efficiency and productivity during office visits. *Am J Manag Care*. 2011;17(4):296-303.
- Mäenpää T, Asikainen P, Gissler M, et al. Outcomes assessment of the regional health information exchange: a five-year follow-up study. *Methods Inf Med*. 2011;50(4):308-318.
- Stenner SP, Chen Q, Johnson KB. Impact of generic substitution decision support on electronic prescribing behavior. *J Am Med Inform Assoc*. 2010;17(6):681-688.
- Bell DS, Cima L, Seiden DS, Nakazono TT, Alcouloumre MS, Cunningham WE. Effects of laboratory data exchange in the care of patients with HIV. *Int J Med Inform*. 2012;81(10):e74-e82.
- Herrin J, da Graca B, Nicewander D, et al. The effectiveness of implementing an electronic health record on diabetes care and outcomes. *Health Serv Res*. 2012;47(4):1522-1540.
- Quinn CC, Shardell MD, Terrin ML, Barr EA, Ballew SH, Gruber-Baldini AL. Cluster-randomized trial of a mobile phone personalized behavioral intervention for blood glucose control. *Diabetes Care*. 2011;34(9):1934-1942.
- Gustafson D, Wise M, Bhattacharya A, et al. The effects of combining Web-based eHealth with telephone nurse case management for pediatric asthma control: a randomized controlled trial. *J Med Internet Res*. 2012;14(4):e101.
- Abramson EL, Barrón Y, Quaresimo J, Kaushal R. Electronic prescribing within an electronic health record reduces ambulatory prescribing errors. *Jt Comm J Qual Patient Saf*. 2011;37(10):470-478.
- Duffy RL, Yiu SS, Molokhia E, Walker R, Perkins RA. Effects of electronic prescribing on the clinical practice of a family medicine residency. *Fam Med*. 2010;42(5):358-363.
- Fleming NS, Culler SD, McCorkle R, Becker ER, Ballard DJ. The financial and nonfinancial costs of implementing electronic health records in primary care practices. *Health Aff (Millwood)*. 2011;30(3):481-489.
- Eisenstein EL, Anstrom KJ, Edwards R, Willis JM, Simo J, Lobach DF. Population-based clinical decision support: a clinical and economic evaluation. *Stud Health Technol Inform*. 2012;180:343-347.
- Cutler DM, McClellan M. Is technological change in medicine worth it? *Health Affairs*. 2001;20(5):11-29.
- Weinstein MC, O'Brien B, Hornberger J, et al; ISPOR Task Force on Good Research Practices—Modeling Studies. Principles of good practice for decision analytic modeling in health-care evaluation: report of the ISPOR Task Force on Good Research Practices—Modeling Studies. *Value Health*. 2003;6(1):9-17.
- Gold M. Panel on cost-effectiveness in health and medicine. *Med Care*. 1996;34(12 suppl):DS197-DS199.
- Connelly DP, Park YT, Du J, et al. The impact of electronic health records on care of heart failure patients in the emergency room. *J Am Med Inform Assoc*. 2012;19(3):334-340.
- Furukawa MF, Raghu TS, Shao BB. Electronic medical records, nurse staffing, and nurse-sensitive patient outcomes: evidence from California hospitals, 1998-2007. *Health Serv Res*. 2010;45(4):941-962.
- Himmelstein DU, Wright A, Woolhandler S. Hospital computing and the costs and quality of care: a national study. *Am J Med*. 2010;123(1):40-46.
- Lau AY, Sintchenko V, Crimmins J, Magrabi F, Gallego B, Coiera E. Impact of a web-based personally controlled health management system on influenza vaccination and health services utilization rates: a randomized controlled trial. *J Am Med Inform Assoc*. 2012;19(5):719-727.
- Ling SB, Richardson DB, Mettenbrink CJ, et al. Evaluating a web-based test results system at an urban STI clinic. *Sex Transm Dis*. 2010;37(4):259-263.
- McCormick D, Bor DH, Woolhandler S, Himmelstein DU. Giving office-based physicians electronic access to patients' prior imaging and lab results did not deter ordering of tests. *Health Aff (Millwood)*. 2012;31(3):488-496.
- Palen TE, Ross C, Powers JD, Xu S. Association of online patient access to clinicians and medical records with use of clinical services. *JAMA*. 2012;308(19):2012-2019.
- Shapiro JS, Baumlin KM, Chawla N, et al. Emergency department information system implementation and process redesign result in rapid and sustained financial enhancement at a large academic center. *Acad Emerg Med*. 2010;17(5):527-535.
- Virga PH, Jin B, Thomas J, Virodov S. Electronic health information technology as a tool for improving quality of care and health outcomes for HIV/AIDS patients. *Int J Med Inform*. 2012;81(10):e39-e45.
- Zlabek JA, Wickus JW, Mathiason MA. Early cost and safety benefits of an inpatient electronic health record. *J Am Med Inform Assoc*. 2011;18(2):169-172.
- Wears RL, Berg M. Computer technology and clinical work: still waiting for Godot. *JAMA*. 2005;293(10):1261-1263.
- Talmon J, Ammenwerth E, Brender J, de Keizer N, Nykänen P, Rigby M. STARE-HI—statement on reporting of evaluation studies in Health Informatics. *Int J Med Inform*. 2009;78(1):1-9. ■