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*Med Care Res Rev* 2010 67: 268S originally published online 30 July 2010  
DOI: 10.1177/1077558710373769

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# Health Information Technology and Quality of Health Care: Strategies for Reducing Disparities in Underresourced Settings

Medical Care Research and Review  
Supplement to 67(5) 268S–298S  
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DOI: 10.1177/1077558710373769  
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## Abstract

Health information technology (health IT) has potential for facilitating quality improvement and reducing quality disparities found in underresourced settings (URs). With this systematic literature review, complemented by key informant interviews, the authors sought to identify evidence regarding health IT and quality outcomes in URs. The review included 105 peer-reviewed studies (2004–2009) in all settings. Only 15 studies included URs, and 8 focused on URs. Based on literature across settings, most evidence was available for quality impact of order entry, clinical decision support systems, and computerized reminders. Study designs were predominantly quasi-experimental (37%) or descriptive (35%); 90% of the studies focused on the microsystem level of quality improvement, indicating a need for expanding research into patient experience and organizational and environmental levels. Key informants highlighted organizational partnerships and health IT champions and emphasized that for health IT to have an impact on quality, there must be an organizational culture of quality improvement.

## Keywords

health information technology, information systems, quality of health care, quality improvement, health disparities, safety net providers

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This article, submitted to *Medical Care Research and Review* on December 14, 2009, was revised and accepted for publication on May 4, 2010.

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## Introduction

In the past decade, reports from the Institute of Medicine (IOM) have brought attention to urgent gaps in the quality of health care in the United States (IOM, 2001) and called for elimination of the systematic racial/ethnic and socioeconomic disparities that plague American health care (Smedley, Stith, & Nelson, 2002). Clearly, there is a need to improve quality of health care, especially in underresourced settings (URs), such as the safety net settings that serve the poor, inner-city minority communities, rural residents, and other vulnerable populations that suffer from disparities. Health information technology (health IT) has the potential to play a transformative role in efforts to improve quality of health care. Health IT has been broadly defined as “a variety of electronic methods used to manage information about people’s health and health care, on both an individual and a group level” (Robert Wood Johnson Foundation, 2008, p. 3), and it encompasses an array of subcategories.

Current best practices of high-quality health care and quality improvement activities, which are most likely to be found in resource-rich academically affiliated health care settings, rely on the availability of health IT applications. There are various mechanisms through which health IT can improve quality, including more accurate documentation, rapid retrieval of information, management of complex information, and enhanced communication. Health IT also gives organizations the ability to exchange information across settings and accumulate data for quality monitoring, and it provides them with decision support and automated functions. Additional examples of health care functions that may improve as a result of health IT include continuity of care, functioning of multidisciplinary care teams, translation of scientific evidence into practice, adherence to treatment guidelines, and surveillance for adverse events or epidemics.

The IOM (2001) proposed an agenda with six aims for improvement of care: safety, effectiveness, patient centeredness, timeliness, efficiency, and equity. To achieve gains in these six focus areas, changes are needed at four levels: (a) the experiences of patients and communities, (b) microsystems of care (e.g., individual providers), (c) health care organizations (e.g., hospital systems), and (d) the health care environment, which encompasses outside systems such as reimbursement, litigation, and accreditation. Berwick (2002) has further described these levels as they relate to quality improvement efforts. The IOM/Berwick model provides a framework for categorizing quality improvement interventions, including those that use health IT.

An association between resource availability in health care settings and quality of care has been well documented (Jha, Zhongjie, Orav, & Epstein, 2005; Schuster, McGlynn, & Brook, 2005; Werner, Goldman, & Dudley, 2008). Our conceptualization of “under-resourced” stems from an Agency for Healthcare Research and Quality (AHRQ, 2010) initiative that examined health IT in URs through literature reviews and a national expert meeting held in October 2009. Dimensions associated with resource availability include communities and patient populations served, access to academic expertise, and degree of public safety net funding. In addition to community health centers,

critical access hospitals, public hospitals, and other “safety net” providers, URSs include providers in inner-city urban areas and rural areas.

The association of being underresourced, lagging behind in adoption of innovation, and quality of health care is complex. Resource availability correlates with diffusion of innovation, and there is evidence that poor and vulnerable patients are often the last to benefit from innovation (Glied & Lleras-Muney, 2008; Groeneveld, Laufer, & Garber, 2005). These disparities in innovation diffusion have been specifically documented for the adoption of health IT (Jha et al., 2009; Shields et al., 2007). URSs lag behind other settings in technology infrastructure and the availability of innovative health IT tools, and they face unique barriers to health IT adoption (Fiscella & Geiger, 2006). A digital divide, affecting the same vulnerable and underserved populations that suffer from health disparities, has opened up for access to information and communication technologies (Chang et al., 2004).

As diffusion of health IT, and electronic health records (EHRs) in particular, accelerates in the United States and receives significant fiscal support from the federal government, it is critical to include safety net providers and other URSs. Otherwise, there is a risk of widening quality disparities as a result of increasing disparities in health IT diffusion. A further challenge is to integrate investment in health IT infrastructure with broad-based health care system reform efforts (Clancy, Anderson, & White, 2009).

The purpose of this study is to review evidence regarding health IT, quality of health care, and URSs. The evidence comes from a systematic literature review and key informant interviews. The scope of the literature review includes studies with health IT interventions and quality outcomes in all settings, regardless of resource availability. The findings are used to explore the potential role of health IT in improving quality of care in URSs, identify available evidence, and determine if that evidence allows for conclusions to be drawn about health IT in URSs. The key informant interviews were designed to illuminate lessons and strategies from projects that have implemented health IT in URSs and to capture unpublished work in this area.

### *New Contribution*

We did not identify any previous review of the literature on health IT and quality outcomes that covered studies published since 2004. The scope of a systematic review conducted by Chaudhry et al. (2006) is similar to ours, but they only included literature published through January 2004. Our review includes studies published between January 2004 and June 2009, a highly active period in this area of research. The timeliness of our literature review is particularly important in light of the need to inform the accelerating efforts to diffuse health IT across health care settings. Furthermore, the present study provides a new contribution in its focus on URSs and quality disparities. The literature on health IT and quality outcomes can be used to inform strategies for URSs. We also include perspectives of key informants on lessons learned about health IT implementation in URSs, allowing us to tap into information not available in the peer-reviewed literature.

## Method

### Scope of Literature Review

The systematic literature review had two objectives: (a) to examine evidence from studies of health IT and quality outcomes in URSs and (b) to review evidence from health IT and quality studies in all settings and use it to inform future directions for health IT in URSs. A review limited to studies within URSs would have been constrained by the small body of evidence, and it would not have allowed us to analyze the *potential* role of health IT in improving quality in URSs. We identified a previous systematic literature review (Chaudhry et al., 2006) that addressed health IT and quality of care in literature published through January 2004. Therefore, our review was restricted to studies published between January 2004 and June 2009. We only included studies published in peer-reviewed periodicals.

**Search strategy.** We searched a variety of databases to find relevant studies, beginning with PubMed using selected Medical Subject Headings (MeSH). After a review of search terminology, the following MeSH terms were chosen for the primary search: *information systems* and *quality assurance, health care*. These two headings incorporate a large number of MeSH subheadings relevant to our search. This primary search yielded 794 hits in PubMed.

We supplemented the primary search by using other search terms to capture health IT interventions (*health information technology, electronic health records, electronic medical records, electronic medical services, hospital information systems, clinical information systems, medical informatics, decision support*) and quality outcomes (*quality of health care, patient safety, effectiveness, outcomes, impact evaluation, quality improvement, guideline adherence*). To find studies not available through PubMed, we searched six additional databases using the same combination of terms: Science Direct, Scopus, Cumulative Index to Nursing and Allied Health Literature, Institute of Electrical and Electronics Engineers, Inc., PsycINFO, and the National Technical Information Service. Following the database searches, we searched five relevant journals: *Archives of Internal Medicine, Journal of Biomedical Informatics, Journal of the American Medical Association, Journal of the American Medical Informatics Association, and New England Journal of Medicine*, and we conducted reference mining of selected key articles.

**Inclusion criteria.** The results of the systematic search were subjected to title and abstract review by a trained research assistant. Abstracts were reviewed for articles first identified in title review. To be selected, studies had to include a health IT intervention and a quality outcome. Studies clearly not meeting these criteria were excluded in the title and abstract review, yielding 182 articles that were entered into RefWorks® (www.refworks.com), a web-based citation management system; copies of full articles were obtained.

The 182 studies identified in the title and abstract review were further screened using the selection criteria. The screening identified studies that investigated the impact of health IT on a quality of care outcome. Health IT included any electronic methods used

to manage information about people's health and health care, on both the individual and group levels (Robert Wood Johnson Foundation, 2008). We excluded review articles and studies that described implementation of health IT but did not include measurable quality of care outcomes. We also excluded studies of health IT-based health promotion interventions directed to consumers that did not measure quality of *health care* outcomes and were not related to health care settings. Finally, we excluded studies that examined the outcomes of psychotherapy delivered through health IT. After screening, 105 studies were found to meet the selection criteria.

**Data abstraction.** The primary units of analysis were the type of health IT intervention implemented and the observed quality outcomes. A study abstraction form and related definitions of coding terms were developed, reviewed, and tested by consensus of the coding team, which consisted of four research assistants and the lead author. The abstraction form included purpose of study, study design, study setting and populations served, type of health IT intervention, end users of the health IT, diseases addressed by the intervention, outcomes measured, and key findings. The categories of health IT were adapted based on a classification presented in an IOM (2003) report and refined after examination of the included studies by both authors. Definitions for types of health IT were obtained from the literature and from AHRQ's National Resource Center for Health IT (AHRQ, 2009). The studies were categorized under levels of the IOM/Berwick model: patient experience, microsystems of care, health care organizations, and health care environment (Berwick, 2002). Studies were coded as including URSs if they included one or more of the following: community health centers, public hospitals, safety net settings, rural communities, or inner-city communities. Using the standardized form, two reviewers independently reviewed and recorded relevant details from each selected article. All abstraction sheets were reviewed for discrepancies, and any coding discrepancies were discussed and resolved by the coding team.

### **Key Informant Interview Method**

Eight key informant interviews were conducted with individuals who work in leadership roles in recent or current health IT implementation projects in URSs across the country. Potential participants were selected based on the investigators' knowledge of appropriate projects, projects identified in the literature and via the Internet, and additional snowball sampling based on suggestions from participants.

The key informant interview component of this study was approved by the Columbia University Medical Center Institutional Review Board. Potential participants were approached by e-mail and telephone, and 30-minute interviews were scheduled at their convenience. The lead author conducted all eight interviews. The interview questions focused on challenges and successes experienced by the participants and lessons they had learned regarding health IT implementation to improve quality of care in URSs. The interviews were audiotaped and transcribed, and the transcripts were coded systematically to identify themes.

**Table 1.** Studies by Publication Year

Publication Year	Number of Studies	Percentage of Studies <sup>a</sup>
2004	12	11
2005	21	20
2006	27	26
2007	15	14
2008	13	12
2009	17	16
Total	105	100

a. Column may not add to 100% because of rounding.

**Results**

*Description of Studies in Systematic Literature Review*

Our review identified 105 studies published between January 2004 and June 2009 that examined the impact of health IT on quality of care. Citations for the studies included in the review are listed in the appendix. Table 1 shows the distribution of the studies by publication year. The studies were published in a wide variety of journals in health, medicine, and informatics. A total of 54 journals were included, 42 of which yielded only one study. The largest number of studies was found in the *Journal of the American Medical Informatics Association*, which published 19 (18%) of the studies included in the review.

The included studies represent a mix of study designs; 37% were quasi-experimental studies, 35% were descriptive studies, and 28% were randomized experimental designs. The descriptive studies did not present any analyses that compared either study groups or time points before and after intervention. A total of 38 studies (36%) included a clinical patient outcome, while 60 studies (57%) included only a provider level outcome, such as provider adherence to care guidelines.

*Type of health IT.* Each study was coded under one primary type of health IT. As shown in Table 2, the most frequently studied type of health IT was order entry (32% of studies), followed by clinical decision support systems (CDSS; 18%) and computerized reminders (10%). Ten studies (10%) investigated the impact of EHRs in general—that is, the EHR itself was considered the intervention as opposed to a specific function of the EHR. It should be noted that most other types of health IT can be subcomponents embedded in EHRs as specific functions. The right-hand column of Table 2 shows the percentage of studies in each health IT category that investigated interventions embedded in EHR systems. Overall, 46% of studies assessed interventions that were either EHRs or functions embedded in EHRs. Table 2 further shows that emerging bodies of evidence regarding quality impact were identified for patient self-management applications (Earnest, Ross, Wittevrongel, Moore, & Lin, 2004; Glasgow et al., 2005; Grant et al., 2008; Harno, Kauppinen-Makelin, & Syrjalainen, 2006; Kim, Yoo, & Shim, 2005; Porter,

**Table 2.** Studies by Type of Health Information Technology and Whether Embedded in an Electronic Health Record

Type of Health IT	Total Studies	Percentage of Studies <sup>a</sup>	Percentage Embedded in EHR
Order entry	34	32	32
CDSS	19	18	53
Computerized reminders	11	10	55
EHR general	10	10	n/a
Patient self-management	8	8	38
Medication reconciliation	6	6	33
Registry	4	4	25
Documentation	3	3	100
e-Prescribing	2	2	0
Telemedicine	2	2	0
Pharmacy system	2	2	0
Multiple health IT	4	4	50
Total	105	100	46

Note: CDSS = clinical decision support system; EHR = electronic health record; Health IT = health information technology.

a. Column may not add to 100% because of rounding.

Kaushal, Forbes, Goldmann, & Klish, 2008; Rasmussen, Phanareth, Nolte, & Backer, 2005; Ross, Moore, Earnest, Wittevrongel, & Lin, 2004), medication reconciliation (Agrawal & Wu, 2009; Bails, Clayton, Roy, & Cantor, 2008; Kramer et al., 2007; Schnipper et al., 2009; Stock, Scott, & Gurtel, 2009; Turchin et al., 2008), and disease registries (Jones et al., 2008; Lester et al., 2009; Pollard et al., 2009; Ugolini et al., 2009).

Table 3 displays selected indicators of study quality and study results for each type of health IT. Study design (randomized controlled trial [RCT], quasi-experimental, descriptive) and presence of patient clinical outcome are shown as methodological indicators of study quality. Presence of at least one positive statistically significant finding is included to provide an indication of study results. We found variation in distributions of study designs among the most frequently studied types of health IT. Most order entry studies were either quasi-experimental (56%) or descriptive (38%), while most CDSS studies (74%) were RCTs. In addition, 42% of CDSS studies included a patient clinical outcome, compared with 32% of order entry studies. Most computerized reminder studies were RCTs, while there were no RCTs that examined the impact of EHRs in general. Figure 1 shows distributions of study designs for the most frequently studied types of health IT.

To capture a rough indicator of study outcome in terms of impact of health IT on quality of health care, we identified whether a study had a positive and statistically significant finding for at least one quality of care outcome. It should be noted that there were also some studies that found *negative* impacts of health IT on quality outcomes (Ash et al., 2007; Campbell, Sittig, Ash, Guappone, & Dykstra, 2006; Crosson et al., 2007;

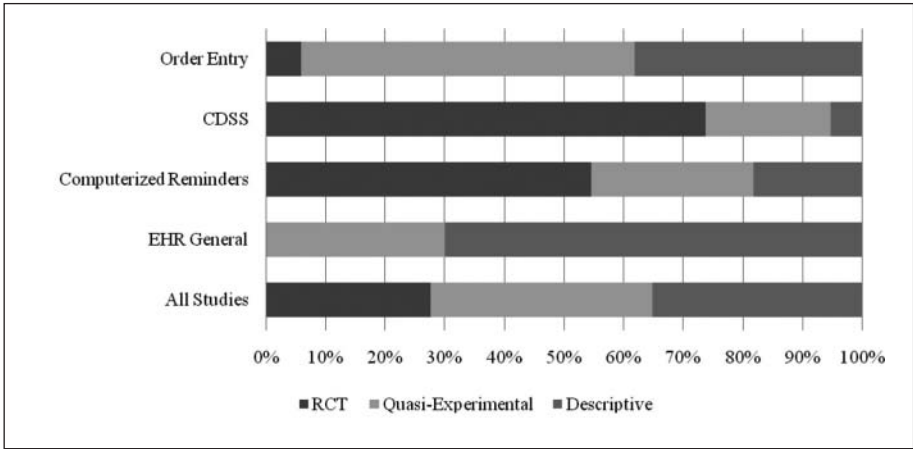


**Table 3.** Type of Health Information Technology by Study Characteristics

Type of Health IT	Total Studies	Study Design			Reports Patient Clinical Outcome (% Studies)	Positive Impact <sup>a</sup> (%)
		RCT	Quasi Exp.	Descr.		
Order entry	34	2	19	13	32	71
CDSS	19	14	4	1	42	74
Computerized reminders	11	6	3	2	9	91
EHR, general	10	0	3	7	40	60
Patient self-management	8	5	1	2	88	88
Medication reconciliation	6	1	2	3	0	100
Registry	4	0	1	3	50	100
Documentation	3	0	3	0	0	100
e-Prescribing	2	0	0	2	0	50
Telemedicine	2	1	1	0	100	100
Pharmacy system	2	0	0	2	0	50
Multiple health IT	4	0	2	2	75	100
Total	105	29	39	37	36	78

Note: CDSS = clinical decision support system; Quasi Exp. = quasi-experimental; Descr. = descriptive; EHR = electronic health record; Health IT = health information technology; RCT = randomized controlled trial.

a. Positive statistically significant finding reported on at least one quality of care outcome.



**Figure 1.** Major types of health IT by study design

Health IT = health information technology; CDSS = clinical decision support system; EHR = electronic health record; RCT = randomized controlled trial.

Eslami, Abu-Hanna, de Keizer, & de Jonge, 2006; Han et al., 2005; Hsieh et al., 2004; Koppel et al., 2005; Nebeker, Hoffman, Weir, Bennett, & Hurdle, 2005; Singh et al., 2009; van den Bemt, Idzinga, Robertz, Kormelink, & Perls, 2009; Walsh et al., 2006), and other studies that found mixed results. The right-hand column of Table 3 shows the percentage

**Table 4.** Percentage of Studies Including Different Types of End Users

Type of End User	Number of Studies	Percentage of Studies
Physicians <sup>a</sup>	94	90
Residents	41	39
Nurses	41	39
Pharmacists	23	22
Support staff	14	13
Patients	11	11
Dentists	0	0
Other	15	14
Multidisciplinary	54	51

Note: One study may be counted multiple times in this table.  
a. Sometimes mid-level providers (physician assistants or nurse practitioners) were included with physicians.

of studies of each type of health IT that had at least one positive outcome finding. Across all studies, 78% showed at least one finding that indicated positive impact of health IT on quality of care. Among more frequently studied types of health IT, computerized reminders (91%) and patient self-management applications (88%) had particularly high rates of positive findings, while the rates were somewhat lower for CDSS (74%) and for order entry (71%).

For a significant proportion of the studies (16%), we were unable to determine whether the health IT was a commercial off-the-shelf (COTS) product or a homegrown system. The remaining studies were about evenly divided between COTS and homegrown systems: 43 studied COTS products, 42 studied homegrown health IT, and 3 investigated both types of health IT. Almost all studies (90%) included physicians as end users of the health IT; however, a multidisciplinary set of users was included in about half (51%) of the studies. Table 4 shows the proportion of studies that included different types of end users.

**Type of setting.** Among the 105 studies we examined, 60 (57 %) were conducted at a single site, and 44 were multisite studies (one article provided insufficient information). The most frequent type of setting was a hospital inpatient ward. Table 5 presents the distribution of settings. Only 15 of the 105 studies included URSs, and among those, 8 focused on URSs. The URS studies are described further below.

**IOM/Berwick model.** In terms of the IOM/Berwick levels (Berwick, 2002), the evidence concentrates on the microsystems level of quality improvement. When each study was categorized into one primary level, 95 of 105 studies (90%) were on the microsystems level. The remaining studies focused on the levels of patient experience ( $n = 9$ ) and organizations ( $n = 1$ ). No studies focused on the environmental level. When allowing each study to be characterized by multiple categories, we found that 99% addressed the microsystems level, 19% the patient experience level, and 16% the organizational level, while none addressed the environmental level.

**Table 5.** Studies by Type of Setting

Type of Setting	Number of Studies	Percentage of Studies <sup>a</sup>
Hospital inpatient	49	46
Outpatient care	39	37
Emergency room	6	6
Other	5	5
Multiple types of settings	6	6
Total	105	100

a. Column may not add to 100% because of rounding.

*Representation of URSs in the systematic literature review.* We identified 15 studies (14% of all studies included in the review) that fit our definition of URS. We categorized many of these studies under URSs because *some* of the settings in a multisite study represented URSs. Five studies included community health centers (Hicks et al., 2008; Jones et al., 2008; Lester et al., 2009; Pollard et al., 2009; Steele, Eisert, Davidson, et al., 2005), three included rural settings (Amarasingham et al., 2007; Pollard et al., 2009; Samore et al., 2005), three included public hospitals (Bails et al., 2008; Dexter, Perkins, Maharry, Jones, & McDonald, 2004; Jones et al., 2008), and three were conducted in a safety net health care delivery system (Jones et al., 2008; Steele, Eisert, Davidson, et al., 2005; Steele, Eisert, Witter, et al., 2005). Two studies included inner-city or low-income urban practices (Grant et al., 2008; Murray et al., 2004), and one included safety net hospitals (Amarasingham, Plantinga, Diener-West, Gaskin, & Powe, 2009). In addition, there were two nationwide studies that included various URSs among other settings (Keyhani et al., 2008; Zhan, Hicks, Blanchette, Keyes, & Cousins, 2006).

Seven of the 15 studies did not focus on URSs and therefore did not provide significant evidence about health IT and quality in URSs. Table 6 summarizes findings from the remaining eight studies in our review that focused on URSs. Two of the eight were conducted in public hospitals (Bails et al., 2008; Dexter et al., 2004), three in a safety net institution (Jones et al., 2008; Steele, Eisert, Davidson, et al., 2005; Steele, Eisert, Witter, et al., 2005), two in rural communities (Pollard et al., 2009; Samore et al., 2005), and one in an inner-city medical practice (Murray et al., 2004). The eight studies investigated the following: an online medication reconciliation system (Bails et al., 2008); computerized physician standing orders versus reminders (Dexter et al., 2004); a combination of immunization registry, CDSS, and standing orders (Jones et al., 2008); computerized treatment suggestions using an EHR (Murray et al., 2004); levels of basic registry utilization (Pollard et al., 2009); CDSS coupled with community intervention (Samore et al., 2005); decision support with guided web-based documentation (Steele, Eisert, Davidson, et al., 2005); and alerts of drug–laboratory interaction (Steele, Eisert, Witter, et al., 2005). Three of the eight studies were RCTs (Dexter

**Table 6.** Studies in Underresourced Settings

First Author, Publication Year, Journal	URs Included, State	Health IT Intervention	Quality Outcomes	Study Design	Study Populations and Sample Sizes	Key Findings
Bails, 2008, <i>Joint Commission Journal on Quality and Patient Safety</i>	Public hospital, NY	Online medication reconciliation at hospital discharge	Provider compliance with medication reconciliation	Descriptive; pilot study served as baseline; focused on implementation	Urban public hospital staff and inpatients (25,000 discharges/year)	Compliance with completing medication reconciliation increased from 20% to 95%
Dexter, 2004, <i>Journal of the American Medical Association</i>	Public hospital, IN	Computerized physician standing orders compared with reminders	Inpatient vaccination rates (influenza and pneumococcal)	RCT; randomized by physician team ( $n = 8$ ) to reminder or standing order	Urban public hospital with 52% African American patients; study $n = 3,777$	Patients with computerized standing orders received vaccines more often than those with reminders (42% vs. 30% for influenza and 51% vs. 31% for pneumococcal vaccine); age, race, sex were not significant in covariate-adjusted model
Jones, 2008, <i>Nursing Economics</i>	Safety net institution; includes a public hospital and community health centers, CO	Immunization registry, CDSS, and standing orders	Older adult pneumococcal vaccination rates	Descriptive; data shown over time but no statistical comparisons; focused on implementation	Urban health care system with 360,000 visits/year; no sample size information available	"Notable" immunization rate improvements postintervention (limited quantitative information available and no statistical comparisons)

(continued)

**Table 6. (continued)**

First Author, Publication Year, Journal	URGs Included, State	Health IT Intervention	Quality Outcomes	Study Design	Study Populations and Sample Sizes	Key Findings
Murray, 2004, <i>Pharmacotherapy</i>	Inner-city medical practice, IN	Evidence-based computerized treatment suggestions made to physicians and pharmacists using a comprehensive EHR system	Hypertension guideline adherence, quality of life, symptoms/ side effects, blood pressure, drug compliance, patient satisfaction, ED visits and hospitalizations, charges	RCT; 2 × 2 factorial design of physician and pharmacist interventions; randomized by practice session ( $n = 32$ )	Inner-city practice with four sites, 150+ providers, 13,000 adult patients; 58% African American; study $n = 712$ patients with uncomplicated hypertension	25%-30% of suggestions implemented; no differences in patient outcomes
Pollard, 2009, <i>Journal of Rural Health</i>	Six rural community health centers, WV	Diabetes registry	Frequency of 13 care processes (e.g., annual exam) and six clinical diabetes outcomes (e.g., HbA1c)	Quasi-experimental; pre- and postcomparisons among three groups with different levels of registry utilization	Rural community health centers; study $n = 661$ patients with diabetes	Improvement in 12 of 13 care processes and three of six clinical outcomes (HbA1c, LDL, and cholesterol) for patients exposed to at least medium levels of registry utilization; for example, eye exams (38% in high utilization vs. 11% in low utilization)

(continued)

Table 6. (continued)

First Author, Publication Year, Journal	URs Included, State	Health IT Intervention	Quality Outcomes	Study Design	Study Populations and Sample Sizes	Key Findings
Samore, 2005, <i>Journal of the American Medical Association</i>	18 rural communities, UT and ID	CDSS (on handheld computers) coupled with a community intervention	Appropriate prescribing of antimicrobial drugs for acute respiratory tract infections	RCT; communities matched by size and randomized to CDSS and community intervention, community intervention only and nonstudy control	12 rural intervention communities; population 407,460, with 334 primary care clinicians; 13,081 visits abstracted	Relative decrease in antimicrobial prescribing for visits in the "never-indicated" category (32% in CDS communities vs. 5% in community intervention-alone communities)
Steele, 2005, <i>American Journal of Preventive Medicine</i>	Two community health centers in safety net institution, CO	CDSS using alerts and guided web-based documentation	Screening rates for latent tuberculosis infection (LTBI)	Quasi-experimental; pre-post comparison	Community health centers with 70% racial/ethnic minority and 40% uninsured patients; 610 patients met high-risk criteria for LTBI; 249 randomly selected charts reviewed	Adherence to LTBI screening improved from 8.9% to 25.2%
Steele, 2005, <i>PLoS Medicine</i>	Primary care clinic in safety net institution, CO	Alerts of drug- laboratory interaction in a CPOE	Stopping orders and ordering lab tests when indicated; adverse drug events related to drug-laboratory interactions	Quasi-experimental; pre-post comparison	Clinic with 19,076 patients and 54,206 visits during study period; 82% Hispanic, 41% uninsured, 42% Medicaid	With alerts, providers were more likely to stop ordering (5.6% vs. 10.9%) and order appropriate lab tests (39% vs. 51%) when indicated; no difference in adverse drug events

Note: CDSS = clinical decision support system; CPOE = computerized provider order entry; ED = emergency department; EHR = electronic health record; health IT = health information technology; LTBI = latent tuberculosis infection; RCT = randomized controlled trial; URs = underresourced settings; LDL = low-density lipoprotein. Postal abbreviations used to identify states.

et al., 2004; Murray et al., 2004; Samore et al., 2005), three were pre-post studies (Pollard et al., 2009; Steele, Eisert, Davidson, et al., 2005; Steele, Eisert, Witter, et al., 2005), and two were descriptive (Bails et al., 2008; Jones et al., 2008). Given the small number of studies, it is difficult to identify trends or aggregate findings about health IT and quality in URSSs.

### *Findings From Key Informant Interviews*

The eight key informants represented eight different projects that used health IT to improve health care quality in a variety of URSSs. The projects were located in six different states across the United States, and two were in rural settings. Four of the projects were EHR implementations, and the others involved patient safety reporting or information networks within communities. Most of the projects were partnerships of several organizations, including community health centers, hospitals, and local health departments.

Overall, qualitative analysis of the interviews focusing on successes, challenges, and lessons learned yielded 31 themes that were each brought up by at least two key informants. Here, we briefly describe several of the key themes that informants emphasized as particularly important to URSSs.

**Health IT as tool.** Several key informants expressed that the goals of the project should be about quality of care and not technology. They underscored the importance of viewing health IT as a means to an end to improve quality: "The goals and objectives are around patient care. How can the technology support that?" For some, health IT was an important way to combat particular challenges of URSSs: "We are using it as a tool in our arsenal because we have such staggering problems here in our community."

**Competing priorities.** Because of resource constraints, URSSs are often strained to fulfill all requirements of quality care. It can be challenging to introduce new technology interventions in settings that are overwhelmed with provision of daily services. One informant stated, "Health care providers are very busy doing a lot of different things, and this project has to fit in with many other things." To overcome this challenge, informants suggested that it is critically important for the leaders of health care organizations to make quality and health IT high priorities. Furthermore, it is important to understand how health IT introduces changes to workflow.

**Partnerships.** Most informants emphasized the importance of partnering among organizations, including among URSSs, to implement health IT projects. One interviewee described the benefits of collaborating with other health care organizations in the community to implement a common technology:

None of us had enough money on our own to do all of those things or even to bring in someone to train others on how to support the system. In partnering we're able to address that financial and that human resource need.

Establishing mutually beneficial relationships with health IT vendors, a particular type of partnership, was also discussed as critical to success.

*Champions.* The concept of “champions for health IT” was spontaneously brought up by most key informants. One described champions the following way:

They’re the ones who are really excited about it. They’re the ones who are not intimidated by the new technology. They are the ones asking all the questions, that want to know more, that want to know, well, how is this process going to work?

Another informant commented how, instead of training champions, they must be identified and supported: “I can’t create a champion, but if there is the potential for a champion, we nurtured them, and we supported them.” Champions, as well as dedicated project staff, were frequently offered as explanations behind the success of health IT. In the words of one informant:

If people expect major improvements in care, they are going to have to invest more than just buying the hardware and software. They’re going to have to invest in staff people who are going to use the data and information that’s contained in the system now to improve quality.

*Underlying culture of quality improvement.* Several key informants emphasized that bringing in health IT alone cannot improve quality and that if quality gains are to be expected, health IT must be implemented on a foundation of an organizational culture supporting quality improvement. Following are examples of how informants articulated the importance of the quality improvement culture: “We had a strong quality improvement program before all this started, which you know sort of formed the basis of what we were doing.” “I think the most important thing is that organizations have to commit themselves to a culture of improvement before they put their IT in. The IT only facilitates it. It doesn’t create improvements magically out of the system.”

## Discussion

Our systematic search of literature published during 2004 to 2009 identified 105 studies of the impact of health IT on quality of care. Seventy-eight percent of the studies reported a positive, statistically significant finding for at least one quality of care outcome. However, this high proportion should be interpreted in light of a likely publication bias toward positive findings. A substantial proportion of the studies (28%) used a randomized design, but more often, the study design was quasi-experimental (37%) or descriptive (35%). As discussed below, types of study design varied across types of health IT.

Order entry was the most frequently studied type of health IT (32% of studies) but was subjected to only two RCTs. CDSS was the focus of 18% of studies and computerized reminders of another 10% of studies. In contrast to order entry studies, most CDSS and computerized reminder studies were RCTs. This is probably a result of the relative ease of implementing randomization with health IT components such as CDSS or reminders, compared with randomly assigning an entire health IT system, such as an order entry



system or EHR. The most frequently studied types of health IT (order entry, CDSS, and reminders) have amassed a body of literature that may be ready to move toward effectiveness studies that examine their generalizability (Glasgow, Vogt, & Boles, 1999). Their evidence base may then also better inform relevance in URSs and other settings.

When categorizing studies by type of health IT, we encountered the complexity of overlapping health IT categories and had to consider the inconsistencies of terminology in the field of health IT. For example, computerized reminders are sometimes viewed as a subcategory of CDSS, and furthermore, they include various types of alerts, reminders, and prompts that could be broken down further into subcategories. We turned to a 2003 IOM report (IOM, 2003), AHRQ's National Resource Center for Health IT (AHRQ, 2009), and literature in the field for guidance on categorizing and defining types of health IT. However, our categorizations are gross and should be interpreted accordingly.

Each health IT system functions in its own context that determines its effectiveness in fundamental ways. Evidence from literature may apply in different ways, depending on context of the health IT. Establishing a practice of including specific contextual factors as part of the way health IT evaluations are reported in the literature may help explain how these factors determine effectiveness. "Homegrown" systems, often the focus of health IT research, are specifically adapted to particular environments and may not be as readily generalizable across settings, unless it is made clear which features of health IT should be made local and customized to fit a given environment.

EHRs present a unique challenge for categorization of health IT. We identified 10 studies in which the health IT intervention was best characterized as "EHR general," with designs comparing quality outcomes before and after EHR or across settings with and without EHR. Notably, none of those studies were RCTs, and most were descriptive. In addition to those studies, EHRs were present in many other studies that examined the quality impact of more specific health IT applications embedded in EHR environments. Forty-six percent of all studies investigated either EHRs in general or health IT embedded in EHRs. Because EHRs are complex and vary in terms of their components, it may be more meaningful to study quality impact of individual EHR functions than to try to determine whether EHRs as a whole have an impact on quality (IOM, 2003; Keyhani et al., 2008).

Literature is emerging in support of the quality impact of several specific types of health IT that may be of particular interest to those working in quality improvement and URSs. Computer-based patient self-management interventions (Earnest et al., 2004; Glasgow et al., 2005; Grant et al., 2008; Harno et al., 2006; Kim et al., 2005; Porter et al., 2008; Rasmussen et al., 2005; Ross et al., 2004), medication reconciliation (Agraval & Wu, 2009; Bails et al., 2008; Kramer et al., 2007; Schnipper et al., 2009; Stock et al., 2009; Turchin et al., 2008), and disease registries (Jones et al., 2008; Lester et al., 2009; Pollard et al., 2009; Ugolini et al., 2009) potentially offer innovative approaches to quality improvement. Our review indicates promising evidence of quality impact of each of these health IT types.

When examined in light of the IOM/Berwick model (Berwick, 2002), the recent evidence on health IT is heavily concentrated on a narrow segment of the quality improvement spectrum. Research on health IT and quality of health care is almost exclusively

focused on the microsystems level—that is, individual providers and teams. Microsystems are the predominant unit of interest in health IT studies because most health IT interventions are viewed as tools for providers and teams. However, to have evidence available that is compatible with the full range of quality improvement processes and structures, at least some health IT research should expand into the patient experience, organizational, and environmental levels. As care coordination receives increasing attention, we are likely to see growth in such research.

Similar to other advanced innovations, state-of-the-art health IT is diffused to high-resource settings first, and furthermore, academically affiliated high-resource settings have better access to resources that enable publishable research. Our review included a very limited number of studies in URSSs. Fifteen studies included URSSs, and eight of those focused on URSSs. This evidence base is not sufficient to draw general conclusions, and more research is needed to investigate the impact of health IT on quality in URSSs. Similarly, a systematic review of the impact of health IT published in 2006 (Chaudhry et al., 2006) concluded that future research on health IT should be targeted to nonacademic settings because practically all studies reviewed were conducted in academically affiliated settings and were highly concentrated in a handful of organizations. Furthermore, Chaudhry et al. observe that the impact of health IT on quality is highly specific to context. Contextual dimensions such as setting, clinical issue, and patient population influence the impact of health IT on quality. This conclusion clearly applies to the case of URSSs, which, as a group and as subcategories of settings, present unique characteristics that must be considered when assessing the impact of health IT. This means that the evidence base drawn largely from high-resource settings needs to be interpreted cautiously when generalizing into URSSs.

The key informants provided insights into health IT in URSSs from the contextual and implementation perspectives that have not reached the published literature. They emphasized that health IT is only a tool in service of the goal of improving quality. They described the competing priorities of URSSs as a significant challenge and suggested leadership action and analysis of workflow as solutions. Most of the projects described by the informants used effective organizational partnerships as a powerful strategy to leverage resources for URSSs. Furthermore, champions and dedicated staff were cited as critical to success for most projects. Finally, informants agreed that an underlying organizational culture of quality improvement is a necessary foundation if health IT is expected to realize its potential for quality gains.

### *Limitations*

We may not have identified all relevant published studies, and furthermore, there are limitations to the nature, quantity, and quality of the evidence we identified. In addition, some critical information relevant to our topic probably resides in unpublished sources. Also, publication bias leaves out studies with no significant results. As research on health IT and quality expands and evolves over time, fueled by rapid diffusion of health IT, our evidence base will become outdated. Finally, abstracting and coding data from

research articles requires some level of subjective judgment that may bias the findings, even when reliability measures—such as using two coders per article and resolving discrepancies by discussion—are in place.

## Conclusions

Our findings highlight four major gaps in evidence regarding health IT, quality, and URSs.

One, there is a lack of research conducted in URSs. Furthermore, research needs to investigate the barriers URSs face when implementing health IT to improve quality. Two, the quality impact of several types of health IT is supported by evidence and needs to be investigated in effectiveness studies that examine generalizability (Glasgow et al., 1999). Other types of health IT with limited numbers of studies will require more efficacy research. Three, some levels in the health care system are largely untapped in health IT research. Research needs to expand to the patient, organizational, and environmental levels. Furthermore, quality outcomes should be measured on the patient level, reflecting Berwick's (2002) call for the primacy of patient experience in quality of care. Four, there is a need for research that incorporates clinical quality improvement methods and health IT to improve quality. Most health IT and quality studies are aimed at demonstrating the benefits of a particular health IT application. Many of these studies choose quality of care as their main outcome; however, the focus is not on quality improvement activities but on showing that the "independent variable"—that is, the health IT—is effective and valuable. More research that integrates health IT within the context of quality improvement efforts in health care settings is needed. This approach is more likely to lead to robust quality gains.

Overall, the evidence indicates that health IT is a promising avenue toward gains in health care quality and a potential tool for addressing health disparities. However, health IT alone is not sufficient to improve quality. For example, Linder, Ma, Bates, Middleton, and Stafford (2007) found that among the estimated 1.8 billion ambulatory visits in 2003 and 2004, the presence of EHR did not translate to significantly higher quality of care. To improve quality, health IT must go hand in hand with changes in health care delivery structure and process.

## Authors' Note

The opinions expressed herein are those of the authors and do not necessarily represent the views of the U.S. Department of Health and Human Services or the Agency for Healthcare Research and Quality.

## Acknowledgment

We thank the following people for their important contributions: our research assistants Madeleine Gondek-Brown, Melda Uzun, Joseph Nicholson, and Rachel Ferat; key informants who participated in interviews; and staff at the Agency for Healthcare Research and Quality.

## Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

## Funding

The author(s) disclosed receipt of the following financial support for the research and/or authorship of this article: This review was supported by the Agency for Healthcare Research and Quality through Contract P233200900421P.

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