

Review ■

Computer-based Guideline Implementation Systems:

A Systematic Review of Functionality and Effectiveness

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Abstract In this systematic review, the authors analyze the functionality provided by recent computer-based guideline implementation systems and characterize the effectiveness of the systems. Twenty-five studies published between 1992 and January 1998 were identified. Articles were included if the authors indicated an intent to implement guideline recommendations for clinicians and if the effectiveness of the system was evaluated. Provision of eight information management services and effects on guideline adherence, documentation, user satisfaction, and patient outcome were noted.

All systems provided patient-specific recommendations. In 19, recommendations were available concurrently with care. Explanation services were described for nine systems. Nine systems allowed interactive documentation, and 17 produced paper-based output. Communication services were present most often in systems integrated with electronic medical records. Registration, calculation, and aggregation services were infrequently reported. There were 10 controlled trials (9 randomized) and 10 time-series correlational studies. Guideline adherence improved in 14 of 18 systems in which it was measured. Documentation improved in 4 of 4 studies.

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Despite the considerable effort and resources that have been invested in the development and dissemination of clinical practice guidelines, there continues to be considerable variation in the effectiveness of guidelines to bring about changes in the behavior of clinicians. A number of studies have found that, despite serious initiatives on the part of national organizations to develop and disseminate guidelines, practitioners may still ignore them.^{1–6}

Greco and Eisenberg⁷ devised a general taxonomy of methods that may be used to influence clinician behavior. These include education, feedback, participation by physicians in efforts to bring about change, administrative rules, financial incentives, and penalties. Several investigators have attempted to identify which factors in guideline implementation strategies are most efficacious. Davis and Taylor-Vaisey⁸ found that reminder systems, academic detailing, and the use of combined interventions were most effective.

Grimshaw and Russell⁹ found that the guideline implementation strategies most likely to be effective were those that delivered patient-specific advice at the time and place of a consultation. Computers can provide, concurrent with care, advice that is tailored to the needs of individual patients. A systematic review by Johnston et al.¹⁰ found that computer-based decision support can improve clinician performance.

Any computer-based tool is more likely to work if it is integrated with clinical activities. Elson¹¹ pointed out the critical role of workflow integration for effective guideline implementation. To be accepted, guide-

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line implementation applications should give back to the user something of value to offset the inconvenience of using the system.

In the course of developing a computer-based guideline implementation system to assist in the management of childhood asthma and in creating additional tools, we identified eight information management services that promote workflow integration—recommendation, documentation, registration, communication, calculation, explanation, presentation, and aggregation. Each service adds value to a computer application that should translate to an increased probability for success. In addition, the services provide a structure for comparison and evaluation of dissimilar implementations.

Because both successful and unsuccessful strategies have provided many of these services, we sought to perform a detailed analysis of the functionality delivered by current computer-based implementation systems. In this paper, we analyze which information management services have been delivered by recently described guideline implementations. We also review the effectiveness of the computer-based interventions in influencing clinicians' behavior and changing patient outcomes.

Methods

Using the OVID search engine, the MEDLINE and CINAHL databases from 1992 through January 1998 were searched. Search terms included the following MeSH headings—algorithm, computer-assisted decision making, computer-assisted therapy, consensus statement, guideline adherence, health planning guidelines, health services research, medical audit, practice guideline, process and outcome evaluation, quality assurance, quality of health care, and reference standard—and the following text words—remind\$, alert\$, guideline\$, implement\$, and computer\$. We also reviewed books and bibliographies of primary and review articles.

We limited the review to papers published in or after 1992 for three reasons: 1) The U.S. Agency for Health Care Policy and Research (AHCPR) began its dissemination of evidence-based clinical practice guidelines in 1992, leading a vanguard of new interest in guideline implementation. 2) Several information management services are delivered optimally with a graphical user interface. The first broadly successful operating system that supported the interface (Windows 3.1, Microsoft Inc., Redmond, Washington) was released early in 1992. 3) Two influential systematic literature reviews on similar topics covered papers that had been published prior to 1992.^{9,10}

We selected studies for review if computers were used as part of an implementation strategy for clinical practice guidelines; the authors specifically indicated an intent to implement guideline recommendations—not simply to provide computer-based decision support; the implementations were intended to influence health care providers (thereby excluding systems that provided recommendations directly to patients); and the studies included an evaluation component that objectively studied some aspect of the effectiveness of the system in a practice setting.

Information Management Services Model

We have devised an *information management services* model for the implementation of clinical practice guidelines. Briefly, the model comprises eight components, defined as follows:

- Recommendation: the determination of appropriate, guideline-specified activities that should occur under specific clinical circumstances
- Documentation: the collection, recording, and storage of observations, assessments, and interventions related to clinical care
- Explanation: the provision of background information on decision variables and guideline-specified actions (e.g., definitions, measures of quality or cost) and the rationale that supports guideline recommendations, including evidence and literature citations
- Presentation: the creation of useful output from internal data stores
- Registration: the recording and storage of administrative and demographic data to uniquely identify the patient, provider(s), and encounter
- Communication: the transmission and receipt of electronic messages between the clinician and other information providers
- Calculation: the manipulation of numeric or temporal data, or both, to derive required information
- Aggregation: the derivation of population-based information from individual patient data

A variety of methods may be used to incorporate each service in a computer-based guideline implementation. Although their inclusion should result in a more comprehensive, workflow-integrated system, individual services may be excluded from any specific application.

Each pertinent article was scrutinized by at least two of the authors for evidence that the system described

there did or did not provide each information management service. Disagreements between the authors were settled by discussion. In addition, evidence of effectiveness was extracted and summarized. We determined the types of studies that were performed to evaluate each system (using the classification system used by Grimshaw and Russell⁹) and then ascertained the effectiveness of the system with regard to guideline adherence and other process measures (such as documentation and user satisfaction) and patient outcome measures when available. Because of the wide variety of study types and outcome variables, no quantitative meta-analysis of the results was possible.

Table 1 ■

Computer-based Guideline Implementation Systems

Study (year)	Domain; System; Site	Source of Guideline	Recommendation	Explanation
Bouhaddou et al. ¹² (1994)	Three procedure preauthorizations (cholecystectomy, cataract extraction, knee arthroscopy); ILIAD; IHC Health Plan and University of Utah Medical Center, Salt Lake City, Utah	Locally developed	Surgical preauthorization; delayed	Logic and deviations from preauthorization criteria
Burack et al. ¹³ (1994) Burack and Gimotty ¹⁴ (1997)	Mammography screening; multiple practice sites in Detroit, Mich.	USPSTF and other authorities	Mammography reminder; concurrent	Breast cancer risk factors
Day et al. ¹⁵ (1995)	Low back pain; Emergency Department Expert Charting System; UCLA Emergency Medicine Center, Los Angeles, Calif.	AHCPR with local adaptation	Advice about appropriate tests, treatment, and disposition; prompts for missing history or physical exam items; concurrent	Nd
Dexter et al. ¹⁶ (1998)	Advanced directives; Regenstrief Medical Records System; General Medicine Practice, Indianapolis, Ind.	Nd	Reminders to discuss advanced directives; concurrent	Nd
Goethe and Bronzino ¹⁷ (1995) Goethe et al. ¹⁸ (1997)	Pharmacotherapy in psychiatry; Clinical Evaluation and Monitoring System; Institute of Living, Hartford, Conn.	Locally developed	Alerts for appropriate psychotropic medications based on diagnosis, appropriate baseline and followup laboratory testing and drug monitoring, potential for drug-drug interactions; concurrent	Summary information about medications, potential for drug-drug interactions
Litzelman et al. ¹⁹ (1993)	Preventive care (fecal occult blood, mammography, Pap smear); Regenstrief Medical Records System; Indianapolis, Ind.	Canadian Task Force on the Periodic Health Exam, Lifetime Health Monitoring, American Cancer Society	Reminders about fecal occult blood testing annually if age >50, mammography for women over age 50, Pap testing based on age and previous test results; concurrent	Explanation of rule that generated reminder
Lobach and Hammond ²⁰ (1997)	Diabetes; CAMP; Duke University Medical Center, Durham, N.C.	American Diabetes Association with local adaptation	Care recommendations regarding which studies or procedures are currently due and due at next visit; concurrent	Nd
Margolis et al. ²¹ (1992)	Six common pediatric problems; CHARTS; Community Pediatrics Clinic, Olfaqqeem, Israel	Nd	Advice from clinical management algorithms; concurrent	Nd

NOTE: ACQUIP indicates Ambulatory Care Quality Improvement Program; AHCPR, Agency for Health Care Policy and Research; CAMP, computer-assisted management protocol; COSTAR, Computer-stored Ambulatory Record; DHCP, decentralized hospital computer system; EMR, electronic medical record; JNC V, Joint National Committee on Detection, Evaluation and Treatment of High Blood Pressure; Nd, not discussed; USPSTF, U.S. Preventive Services Task Force; VA, Veterans Administration.

Results

A total of 25 papers that described 20 discrete systems were identified. We included more than one report on a single system if descriptions and evaluations of a single system were segregated into more than one report or if the authors investigated more than one guideline implementation strategy on the same system. Features of the guideline implementation systems are summarized in Table 1.

Eleven systems were based on national guidelines, including those published by AHCPR; the American Di-

abetes Association; the National Cholesterol Education Program; the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure (JNC V); and the U.S. Preventative Services Task Force (USPSTF). In several cases, the authors commented on the need for local modifications of the guidelines. Four systems implemented locally developed guidelines. In five systems, the guideline source was not described.

Thirteen of the guideline implementations addressed patient management issues and therapy, including one system that provided pre-authorization for sur-

gical procedures¹² and another system that was intended to improve discussion of advance directives.¹⁶ The other seven systems provided guidance with screening and health maintenance activities.

Services

All systems provided patient-specific *recommendations*. The scope of the recommendations encompassed a broad range of clinical activities, including appropriate tests and treatments, alerts about at-risk states, and reminders of appropriate physical assessments and screening activities. With one exception, all systems provided recommendations concurrently with

Documentation	Registration	Communication	Calculation	Presentation	Aggregation
Surgical indications documented on paper and phoned or faxed to central office; prompted, noninteractive	Nd	None	Nd	Paper: status of preauthorization; full report of guideline compliance/deviations	Nd
Procedure indication (screening or diagnostic) initiator; patient response to referral; prompted, noninteractive	Yes	Nd	Age	Paper: reminder form, previous mammography results, appointment postcard	Nd
Core history and physical examination items; clinician's rationale for deviation from recommendations; prompted, interactive	Nd	None	Nd	Paper: after-care instructions for patients, laboratory and treatment orders, prescriptions On-screen: color-coded suggestion prompts and order screens	Nd
Paper-based encounter sheet allows choice of discussed, deferred, or rationale for deviation; prompted, noninteractive	EMR	EMR (Regenstrief system)	Age	Paper: reminders on encounter forms	Nd
Documentation checklists for key symptoms and behavioral issues; rationale for deviation; prompted, interactive	Nd	Laboratory, pharmacy, and diagnostic data	Nd	On-screen: alerts, historical laboratory values, medications, medical problems	Nd
Clinic visit notes handwritten on encounter forms; rationale for deviation; prompted, noninteractive	EMR	EMR (Regenstrief system)	Age	Paper: indicated tests on the encounter form, reminder report	Nd
Handwritten documentation that a recommended action was performed, declined, or never to be done; data entry by clinic personnel; prompted, noninteractive	EMR	EMR, scheduling, accounting, laboratory orders, results (TMR system)	Age, intervals	Paper: recommendations on encounter form, prescriptions, orders	Nd
Clinical observations recorded on clinical algorithm serve as visit form; prompted, interactive	Nd	Nd	Nd	On-screen: clinical algorithm Paper: record of the visit	Nd

continued

Table 1 ■

Computer-based Guideline Implementation Systems, *continued*

Study (year)	Domain; System; Site	Source of Guideline	Recommendation	Explanation
Nilasena et al. ²² (1994) Nilasena and Lincoln ²³ (1995)	Diabetes; University of Utah Medical Center and the VA Medical Center, Salt Lake City, Utah	American Diabetes Association with local adaptation	Alerts about high-risk aspects of clinical profile; concurrent	Nd
Ornstein et al. ²⁴ (1993) Ornstein et al. ²⁵ (1995)	13 preventive services; Division of Family Medicine, Medical University of South Carolina, Charleston, S.C.	USPSTF	Reminders of deficient preventive services, e.g., dental, diet, injury prevention counseling, immunizations, screening of blood pressure, fecal occult blood, Pap smears, mammograms; concurrent	Explanation and citations for each preventive service tracked
Overhage et al. ²⁶ (1996)	22 adult preventive care in hospitalized patients; Regenstrief Medical Record System; Wishard Memorial Hospital, Indianapolis, Ind.	USPSTF	Preventive care reminders, suggested orders; concurrent	Citations of literature to support recommendations
Robbins et al. ²⁷ (1993)	Lipid Management Program; private practice, Norfolk, Va.	National Cholesterol Education guidelines with local adaptation	Reminders about patients for whom laboratory data are due; concurrent	Nd
Rossi and Every ²⁸ (1997)	Pharmacotherapy with calcium channel blockers in hypertension; DHCP and ACQUIP; Seattle VA Medical Center, Seattle, Wash.	JNC V	Advice regarding use of diuretic and beta blocker for at-risk patients; concurrent	Cardiovascular risk associated with calcium channel blockers
Safran et al. ²⁹ (1995)	HIV management; Center for Clinical Computing, Beth Israel Hospital, Boston, Mass.	Locally developed	Alerts and reminders regarding HIV patients, including laboratory results, recommended medications and dosages, referrals, immunizations; concurrent	Nd
Schriger et al. ³⁰ (1997)	Occupational exposure; Emergency Department Expert Charting System; UCLA Emergency Medicine Center, Los Angeles, Calif.	Locally developed	Tests and treatments recommended, optional, not recommended; concurrent	Computer's reasoning for each recommendation
Tape and Campbell ³¹ (1993)	Health maintenance; COSTAR medical record system; University of Nebraska Internal Medicine Clinic, Omaha, Neb.	Nd	Reminders about health maintenance deficiencies based on age, sex, chronic disease, and past health maintenance records; concurrent	Nd
Turner et al. ³² (1994)	Preventive care; private practices in eastern North Carolina	Nd	Reminders about influenza vaccine, Pap smears, breast exams, and mammography; concurrent	Nd
Vincent et al. ³³ (1995)	Disease prevention, cancer detection, immunization; Quality Care Program; Swedish Hospital, Seattle, Wash.	Nd	Recommended health maintenance procedures based on individual risk factors; concurrent	Nd
Willson et al. ³⁴ (1995)	Pressure ulcer prevention and treatment; LDS Hospital, Salt Lake City, Utah	AHCPR	Reminders to nurses to perform Braden assessments; stage appropriate treatment recommendations; concurrent	Nd
Zielstorff et al. ³⁵ (1996) Zielstorff et al. ³⁶ (1997)	Pressure Ulcers; Pressure Ulcer Prevention & Management System; Massachusetts General Hospital, Boston, Mass.	AHCPR	Treatment plan, risk status; concurrent	Definitions of individual data items

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Documentation	Registration	Communication	Calculation	Presentation	Aggregation
Seven data entry forms, self-contained database; data entry by clerical personnel from paper forms; prompted, non-interactive	Demographics	None	Nd	Paper: health maintenance report with demographics, preventive health status, schedule of upcoming and past-due preventive activities	Nd
Integrated with EMR (problem lists, progress notes, social history); tracks preventive services; some notes dictated and transcribed; prompted, interactive	EMR	EMR system, laboratory results	Age, intervals	Paper: reminders to physicians, annual letters to patients to alert them about preventive services On-screen: reminders to physicians	Nd
Integrated with Regenstrief inpatient and outpatient EMR; prompted, interactive	EMR	Order entry for laboratory and pharmacy; EMR (Regenstrief system)	Age, creatinine clearance	Paper: reminder on daily rounds reports On-screen: reminders displayed during order entry	Nd
Lipid results and current therapy; prompted, noninteractive	Nd	Nd	Nd	Paper: reminders of laboratory tests due; results sent to patients and referring physicians	Nd
Paper-based form documents appropriate indications for calcium channel blocker therapy; data entry by clerical personnel; prompted, noninteractive	EMR	EMR (DHCP, ACQUIP systems)	None	Paper: reminder attached to prescription refill form	Nd
Integrated with EMR that includes problems, medications, preventive screenings, progress notes; prompted, interactive	EMR	EMR, scheduling, test ordering (Clinical Computing System)	Nd	On-screen: alerts, reminders (appear only when patient record is accessed)	Laboratory, scheduling, demographics, dates of admission and discharge and alerts triggered
History of exposure event, exposed worker, and source; rationale for deviation; prompted, interactive	Nd	Nd	Nd	Paper: after-care instructions for patients (modifiable by clinician), prescriptions	Deviation rates by decision
Paper-based document; prompted, noninteractive	EMR	EMR (COSTAR system)	Age, intervals	Paper: problem list, medication list, and most recent progress note	Nd
Nd	Nd	Nd	Age	Paper: reminder	Nd
Paper-based worksheet completed at encounter and entered into system by clerical staff; prompted, noninteractive	Yes	Nd	Age, intervals	Paper: worksheet attached to medical record; health maintenance reminder letters for patients	Nd
General screening and Braden scale; prompted, interactive	EMR	EMR (HELP system)	Nd	On-screen: alerts	Nd
Data entry screens provide explicit cues for assessment data; prompted, interactive	Nd	Nd	Nd	Paper: patient-specific treatment plan	Nd

care.¹² A variable number of factors were evaluated by the systems to determine appropriate intervention recommendations.

Nine reports documented that some *explanation* functionality was provided. These services provided background information, definitions, and risks as well as the rationale that supported specific recommendations. One system offered literature citations.

Most systems provided prompts for *documentation* of relevant findings that served a reminder function for the clinician-user. In many cases, these data were supplemented by complete medical record capabilities. Documentation services were provided in a variety of ways. Several systems relied on paper-based recording of clinician observations, which were later entered into the computer by clerical personnel. Others made use of online data entry, particularly those that were part of larger electronic medical record (EMR) systems. In nine systems the documentation process was interactive.*

Several of the reports described systems that were integrated with institutional EMR systems.† Documentation services for these systems tended to make use of the functionality of the EMR. Other systems were essentially stand-alone systems and not integrated with an EMR.

Like the data entry services, *presentation* services also varied considerably. Presentation modalities included paper-based display of reminders that were attached to patient charts, on-screen reminders and alerts, on-screen display of algorithms, patient summaries, customizable after-care instructions, and annual birthday letters to patients regarding appropriate preventive services. Seventeen of the systems made use of paper-based output of some kind.

Electronic *communication* services most frequently provided interfaces to the EMR and to order-entry functions. Interfaces existed in some systems to pharmacy, scheduling, and laboratory results reporting. Stand-alone systems, by definition, offered no electronic communication services.

None of the reports on stand-alone systems described provision of *registration* processes. Some mechanism for identification of patient demographics, provider, and the encounter was assumed to have been present in all cases, but specific mechanisms were not described. The EMR-related systems presumably have the capability to integrate demographic and administrative data.

Calculation services were used to calculate patient ages and intervals between tests and to trigger rules related to preventive services. The Lipid Management Program calculated lipid fractions.²⁷

Aggregation services were described for only a few systems. In many cases, it is clear that database capabilities would allow aggregation of individual patient data, but only two reports explicitly described aggregation services. Schriger et al.³⁰ noted that the database could be used to calculate deviation (non-adherence) rates by physicians. The Beth Israel Clinical Care System captured data about laboratory tests, demographics, dates of admission and discharge, and response to alerts that were used to generate aggregate reports.²⁹

Evaluations

The methodologies used to evaluate the effectiveness of the 20 guideline implementations included ten controlled trials (nine of which were randomized) and ten time-series studies (none of which incorporated external controls; one applied a switchback design). The outcome variables that were measured also varied considerably and are summarized in Table 2.

Four studies looked at documentation and found improvement in each case. The average number of relevant data items for surgical pre-authorization increased from 4.0 to 28.8¹²; the mean percentage increase for documentation of common pediatric problems was 58 percent,²¹ for management of back pain 30.2 percent,¹⁵ and for management of exposure to body fluids 42 percent.³⁰

Eighteen of the 20 studies evaluated provider adherence to the guidelines. In 14 of the 18, some level of improved adherence was described. In several reports, adherence improvements occurred for some of the measured outcomes but not for all.

Failure to improve adherence using computer-based strategies was reported in four studies. An attempt to improve preventive care guideline adherence for hospitalized patients failed because of functional and systemic barriers that interfered with providing preventive care to inpatients.²⁶ One study of prevention and management of pressure ulcers was unable to show any effect of the computer-based intervention on nursing decision making.³⁶ In that case, the authors concluded that there was not enough gain for the effort of data entry. A system designed to influence decision making in emergency room patients with back pain failed because of general confusion regarding the utility of plain x-rays in these patients and the fact that recommendations were not enforced.¹⁵ Finally, in a study of diabetes management guidelines, compliance improved to the same degree in both control and

*References 15, 17, 21, 24, 26, 29, 30, 34, 35.

†References 20, 22, 25, 26, 28, 29, 31, 34.

intervention groups; the authors questioned study design issues.²³

Clinician satisfaction was addressed in four studies. Two investigators found that users were satisfied with computer-based guideline interventions.^{12,36} On the other hand, physician-users of a clinical algorithm system found data entry so tedious that they refused to continue,²¹ and Nilasena et al.²² found that 70 percent of users complained that data entry forms were difficult to use and inefficient.

Eight studies examined patient outcomes. A study of an intervention for low-back pain found no effect on cost,¹⁵ whereas costs increased in both a system for management of health care workers exposed to body fluids and another that pre-authorized surgery.^{12,30} Use of a lipid tracking system was associated with improvements in patients' cholesterol and lipid fractions.²⁷ A system for prevention of pressure ulcers was associated with a decreased incidence of decubiti,³⁴ and Dexter et al.¹⁶ reported a significant improvement in the completion of advance directives (15 percent vs 4 percent for a control group) using a computer-based reminder system. An intervention to substitute appropriate antihypertensives for calcium channel blockers did not have any effect on patients' blood pressure,²⁸ and alerts about appropriate HIV management did not change admission rates, emergency department visits, survival, or pneumocystis admissions.²⁹

Discussion

To better understand the design factors responsible for the success or failure of computer-based guideline intervention strategies, we analyzed reports on 20 systems that were intended to implement guideline recommendations in clinical practice. Specifically, we assessed the use of eight information management services, which we believe may be useful in integrating computerized systems into clinical workflow. Many reports failed to describe the systems in sufficient detail to ascertain the presence or absence of some of these services. Therefore, we were unable to create meaningful summary ratings of individual systems that might correlate with the outcomes described. However, we were able to describe qualitatively many aspects of the reported design of current computer applications used as guideline intervention tools and to summarize measures of their effectiveness.

All systems delivered patient-specific recommendations, and in most cases the advice was made available concurrently with care, thus meeting Grimshaw and Russell's criteria for implementations with a high probability of success.⁹ However, providing recom-

mendations in this manner was neither necessary nor sufficient to ensure adherence. Several authors were unable to influence guideline adherence with concurrent reminders. Even providing delayed feedback was associated in one case with increased procedure authorization rates, although this system's influence may have been related to financial incentives and disincentives.¹²

The level of specificity of the advice varied considerably, as evidenced by the number of factors that were weighed by the programs to trigger relevant recommendations. Some systems simply checked a patient's age and gender to discern appropriate preventive interventions, whereas others monitored ongoing clinical transactions and considered multiple factors (e.g., diagnoses, laboratory results, and medications) in arriving at recommendations for changing medications or dosages and for planning treatment.

Somewhat surprisingly, fewer than half the reports documented provision of explanation services. More than 15 years ago, Teach and Shortliffe³⁷ showed the importance of providing explanation for computer-based advisories.³⁷ One noteworthy benefit of the use of computers for implementation of guideline recommendations is their capability to link recommendations dynamically to the evidence that supports them.

Most reports described the use of on-screen and paper-based prompts to remind users of critical information that should be documented. Clinicians entered data into computers directly and interactively in fewer than half the systems. Even some long-established EMR systems depended on completion of paper forms with subsequent data entry by clerical personnel. Likewise, paper-based output was described for 17 of the 20 systems. It seems clear that the paperless office remains a vision of the future.

Registration, calculation, communication, and aggregation services were infrequently described. These components offer tremendous potential benefit for well-designed computer-based guideline implementation. Providing communication services requires networked systems. Registration services may seem mundane, but an interface to an administrative database that contains this information may be vital to the success of a computer-based initiative by diminishing the clerical workload for clinicians. Calculation and aggregation services are basic functions of many computer systems that were rarely reported in these guideline implementation systems.

The evaluations of system effectiveness varied markedly in design, implementation, and level of descrip-

Table 2 ■

Effectiveness of Guideline Implementation Systems

Study	Methodology	Documentation	Adherence	Satisfaction	Outcomes
Bouhaddou et al. ¹²	Time series without external control	Improved; indication of surgery	Improved; rate of request for surgery, mixed; increased pre-authorization approval rate	Improved	Cost increased
Burack et al. ¹³ Burack and Gimotty ¹⁴	RCT by patient	Nd	Increased use of mammography in health department setting, but not in HMO setting	Nd	Nd
Day et al. ¹⁵	Time series without external control	Improved after-care instructions	No effect	Nd	No effect on cost
Dexter et al. ¹⁶	RCT by provider team	Nd	Increased discussion with intervention (24% vs. 4% without)	Nd	Improved rate of advance directive completion, 4% vs. 15%
Goethe et al. ¹⁸	Time series without external control	Nd	Improved response to alerts	Nd	Nd
Litzelman et al. ¹⁹	RCT by provider team	Nd	Improved mammography and fecal occult blood testing; no effect on Pap testing	Nd	Nd
Lobach and Hammond ²⁰	RCT by clinician	Nd	Two-fold increase in compliance with guidelines for 3 of 8 standards; failure for 5 of 8	Nd	Nd
Margolis et al. ²¹	Time series without external control	Improved; 3 of 6 diseases	Improved for 2 of 6 diseases; decreased inappropriate use of antibiotics for 2 diseases	Too tedious, physicians refused to continue	Nd
Nilasena et al. ²² Nilasena and Lincoln ²³	RCT by physician	Nd	Improved average total compliance score for both control and intervention	70% found forms difficult to use and did not reduce time to provide care	Nd
Ornstein et al. ²⁵	Time series without external control	Nd	Improved compliance with counseling, screening tests, breast exams, and thyroid function tests; no change for immunizations, fecal occult blood, Pap smear, mammography	No improvement in patient's perceived preventive services delivery	Nd
Overhage et al. ²⁶	RCT by provider team	Nd	No effect: control, 24% compliance rate; intervention, 23%	Nd	Nd
Robbins et al. ²⁷	Time series without external control	Nd	Nd	Nd	Cholesterol, LDL, and triglycerides levels decreased; HDL increased
Rossi and Every ²⁸	RCT by provider	Nd	Improved: 11.3% of patients changed to first line antihypertensive drugs	Nd	No significant change in BP
Safran et al. ²⁹	RCT by site	Nd	Improved: response time to alerts, 52 vs. 11 days	Nd	No change in admission rates, ER visits, survival or pneumocystis admissions

Schriger et al. ³⁰	Time series with switchback	Improved for 6 of 7 history items	Improved: 4 laboratory tests; 4 of 5 treatments	Nd	Cost: charges decreased for laboratory and prescriptions
Tape and Campbell ³¹	Nonrandomized controlled trial by provider team	Nd	Improved sigmoidoscopy and immunization rates; no change in thyroxine, Pap, mammography, fecal occult blood screening	Nd	Nd
Turner et al. ³²	RCT by physician	Nd	Small improvement in health maintenance activities	Nd	Nd
Vincent et al. ³³	Time series without external control	Nd	Improved provider compliance; patient compliance improved for some	Nd	Nd
Willson et al. ³⁴	Time series without external control	Nd	Improved for both prevention and treatment protocols	Nd	Decrease in incidence of pressure ulcers
Zielstorff et al. ³⁶	Time series with control	Nd	No effect: clinical decision making	Positive for instructional adequacy and user satisfaction	Nd

NOTE: BP indicates blood pressure; Nd, not discussed; HDL, high-density lipoprotein; LDL, low-density lipoprotein; RCT, randomized controlled trial.

tion. In many, the evaluations of effectiveness were methodologically weak. In addition, the guidelines that were implemented differed considerably in content, from health maintenance reminders to alerts for active management of specific disease states. There were also notable variations in clinical settings—inpatient, emergency room, ambulatory clinic, private office, and public health department—and in evaluation methodology.

Fourteen studies reported some improvement in adherence to guidelines, seemingly independent of the information management services provided. Clearly, adherence to guideline recommendations can be improved in many cases using computer-based interventions. Likewise, documentation is regularly assisted with computers, but user satisfaction may be affected adversely by tedious data entry requirements in the absence of offsetting system benefits. In both studies with negative evaluations of user satisfaction,^{21,23} arduous data entry was suggested as a reason for poor system acceptance. Few studies examined patient outcomes to validate the effectiveness of the systems.

Conclusions

Many factors influence the success or failure of guideline implementation systems. While provision of a wide array of information management services may be important, it may not be sufficient to ensure success. To adequately evaluate the effect of those services on the success or failure of a computer-based guideline implementation, more of the confounding variables need to be controlled. In the studies described here, different types of guidelines, different settings, and different system implementations make conclusions about the relationship between information management services and outcomes difficult. In addition, a component of publication bias is likely to be present, in that the generally favorable results may represent a biased subset of system implementations.

Our information management services model was designed to provide a checklist for providing solutions that maximize workflow integration. Although this model may not cover exhaustively all factors responsible for implementation acceptance, we believe that it can be used profitably for the design of computer-based guideline implementation strategies and can serve as a framework for system evaluation. Future system developers should learn from the successes and failures of past systems.

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