California HealthCare Foundation

Patient Safety in the Physician's Office

Assessing the Value of Ambulatory CPOE

ihealthreports

Prepared by the Center for Information Technology Leadership
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Prepared for:

CALIFORNIA HEALTHCARE FOUNDATION

Prepared by:

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The Center for Information Technology Leadership (CITL), chartered by Partners HealthCare in Boston and supported by The Healthcare Information and Management Systems Society, is a nonprofit research organization that helps the health care community make more informed IT decisions. More information is available online at **www.citl.org**.

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About the Foundation

The **California HealthCare Foundation**, based in Oakland, is an independent philanthropy committed to improving California's health care delivery and financing systems. Additional copies of this report and other publications can be obtained by visiting **www.chcf.org**.

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Executive Summary

As health care leaders strive to reduce errors and improve efficiency, more providers are using computerized provider order entry (CPOE) to capture prescriptions and other order information. Research has shown that CPOE systems reduce serious medication error rates in inpatient settings. Yet in the growing outpatient arena, solid evidence about the value of ambulatory CPOE (ACPOE) has been sparse.

This report from the Center for Information Technology Leadership (CITL) seeks to address this disparity. This report assesses ACPOE's financial, clinical, and organizational value for the U.S. health care system, the state of California, and the average outpatient provider.

CITL projects substantial, long-term benefits from ACPOE, particularly when using sophisticated systems. Universal adoption of advanced systems, which offer clinical decision support at the patient level, would generate net savings of $34 billion annually and avoid more than 2.1 million adverse drug events (ADEs) in the United States each year. In California, statewide implementation of advanced ACPOE would save $3.2 billion after costs and prevent 249,000 ADEs annually. Individual outpatient providers in California would save nearly $29,000 and prevent nine ADEs each year using these systems.

Advanced systems offer the best long-term clinical and financial returns. However, intermediate systems, which include order-specific decision support but do not consider patient-specific information, have the best short-term financial returns among all ACPOE systems because they cost less to implement. Therefore, providers need to consider their investment time horizon and the trade-off between clinical and financial benefits when choosing an ACPOE system.

CITL's research found additional, less quantifiable benefits from ACPOE. Academic studies have shown improved disease management and better compliance with health maintenance guidelines from using ACPOE systems; trade publications have reported increased staff productivity. Early evidence also suggests ACPOE may contribute to provider job satisfaction.

Finally, CITL's research shows that other health care stakeholders realize most of the financial benefits from ACPOE, rather than providers. These systems are expensive to implement and maintain, suggesting the need for public debate on who finances this technology.

I. Introduction

INFORMATION TECHNOLOGY (IT) IS AN ESSENTIAL component of a transformed U.S. health care delivery system. In *Crossing the Quality Chasm,* the Institute of Medicine (IOM) called for a new health care system that is safe, effective, patient-centered, timely, efficient, and equitable.[1] In its 2002 report, *Fostering Rapid Advances in Healthcare,* the IOM describes how information technology infrastructure is fundamental to achieving all six of those quality aims.[2] Yet, many health care delivery systems and individual practitioners are uncertain about how to use IT to catalyze this transformation.

This report focuses on one critical component of health care's evolving IT infrastructure, ambulatory computerized provider order entry (ACPOE), and comprehensively analyzes its value and potential for vastly improving health care in the United States. ACPOE is crucial because it is the best available technology enabling providers to apply clinical evidence at the point of care. Its clinical decision support capabilities can alert providers to problems such as potential drug interactions, remind them about health maintenance screenings, and perform other tasks that improve the quality and efficiency of care. Providers often resist clinical information systems because they do not perceive the benefits to warrant the financial investment and workflow changes the systems require. This report compares those benefits and costs.

Most attention on CPOE to date has focused on inpatient care. A 1995 study led by David W. Bates, a co-author of this report, demonstrated that 28 percent of inpatient ADEs are preventable, and that 62 percent of errors occur at the ordering and transcription stages of medication delivery.[3] Another Bates study demonstrated that CPOE can decrease serious inpatient medication errors by 55 percent.[4] This finding contributed to a sense of urgency around implementing CPOE in inpatient care settings.

Most notably, The Leapfrog Group, a coalition of Fortune 500 health care purchasers that supports quality and safety measures in hospitals, made inpatient CPOE one of its top three priorities—resulting in some payers offering financial incentives for installing CPOE. California Senate Bill 1875 encourages hospitals and surgical clinics to consider CPOE as part of formal error reduction programs.

Yet a growing proportion of care is delivered in ambulatory clinical settings. Americans made 906.5 million outpatient visits to in 2000, up from 771 million in 1995. The sheer volume of outpatient encounters suggests that IT could have a profound impact on health care cost containment and quality improvement.To date, there is far less evidence for the value of clinical systems in ambulatory care, and payers do not yet provide incentives for clinics to install outpatient systems.

Should providers invest in ACPOE systems? Should vendors invest in developing them? Without a clear understanding of the value proposition of these systems—the financial, clinical, and organizational benefits—it is impossible to answer these questions confidently. CITL set out to fill part of this knowledge gap by assessing the value of ACPOE.

ACPOE Defined

ACPOE is a software application that supports the ordering of medications, diagnostic tests, interventions, and referrals by providers in ambulatory clinics and physician offices in both hospital and community settings. ACPOE augments or replaces more traditional order methods such as paper, telephone, and fax. ACPOE runs on multiple computer systems, both networked and free-standing, from workstations to handheld devices.

Clinical decision support is a core feature of ACPOE, providing clinicians with a range of diagnosis- and treatment-related information and tools to improve patient care and reduce medical errors and costs. Decision support includes a broad range of functionality—from simple references to generic clinical texts, to complex, automated treatment suggestions tailored to individual patients.

ACPOE is distinct from ambulatory electronic medical records (AEMRs), which provide "paperless" medical records and remote access to them, and practice management systems, which support administrative functions such as scheduling and billing.

CITL created a taxonomy of ACPOE features and functions and distinguished between five system classes, largely based on medication/diagnostic ordering and decision support capability: Basic Prescription Orders (Rx), Basic Prescription and Diagnostic Orders (Rx-Dx), Intermediate Rx, Intermediate Rx-Dx, and Advanced Rx-Dx (Figure 1). CITL found little published evidence on ACPOE's nursing intervention or referral ordering capabilities, and did not include them in its classification. CITL does not discuss basic systems in this report, because these systems lack decision support functionality and their benefits do not outweigh costs.

This report presents CITL's core findings on ACPOE's costs and benefits across system classes. The report first describes research methods and limitations, and the current state of the ACPOE marketplace. Summary analyses of ACPOE's clinical, financial, and organizational benefits follow, detailed on a national and California basis. A discussion of costs comes next, focusing on acquisition and annual costs for each class of ACPOE system. The report ends with a summary of general conclusions, including ACPOE cost-benefit projections.

Figure 1: ACPOE System Classification

	Basic Rx	Basic Rx-Dx	Intermediate Rx	Intermediate Rx-Dx	Advanced Rx-Dx
Medication Order Entry	Record prescription. Print prescription for patient.		Same as Basic Rx, plus fax or email to pharmacy or pharmacy benefit manager.	Same as Intermediate Rx.	Same as Intermediate Rx, plus electronic data interchange (EDI).
Medication Decision Support	Passive (user-initiated) references like click-through to electronic medical textbook. Not order- or patient-specific.		Active (system-initiated) order-specific decision support. • Simple interaction checks (drug-drug, drug-allergy) • Default doses and dose range checks • Cost data • Order sets		Same as Intermediate Rx, plus: • Complex interaction checks (drug-drug, drug-allergy, drug-disease) • Drug recommendations using calculated or inferred knowledge (drug choice guided by lab results, drug dosing) • Corollary orders
Diagnostic Order Entry	None	Record order. Print order for patient.	None	Same as Basic Rx-Dx, plus fax or email to lab or radiology. With or without result reporting.	Same as Intermediate Rx-Dx, plus EDI. With result reporting.
Diagnostic Decision Support Basic	None	Passive references like click-through to lab manual. Not order- or patient-specific.	None	Active order-specific decision support such as cost data, order sets, or pre-test preparation instructions.	Same as Intermediate Rx-Dx, plus: • Order and test recommendations using extensive patient information, including calculated or inferred knowledge • Corollary orders • Preventive screenings and alerts

II. Research and Analysis Methods

CITL ASSEMBLED AND SYNTHESIZED INFORMATION from several sources to project ACPOE value. The research depended on published sources for data on value and provider characteristics and relied on experts and market research to fill critical gaps. CITL completed a systematic review of academic literature and trade and general press publications. It also collected data from health care IT vendors about ACPOE systems. Finally, it convened a panel of six experts to advise throughout the project (see sidebar). The data collected from these sources were organized using CITL's Value Framework, which defines value as the sum of a technology's financial, clinical, and organizational benefits (Figure 2).

Figure 2: CITL Value Framework

Financial

- **Cost reductions** from decreased administrative, clinical, and other resource requirements (e.g., elimination of paper chart pulls and transcription services).
- **Revenue enhancements** from improved charge capture and time from charge entry to billing.
- **Productivity gains** from increased procedure volume, reductions in length of stay, and increased transaction processing rates.

Clinical

- **Care process advances** from better adherence to clinical protocols and improvements in the stages of clinical decision making (e.g., initiation, diagnosis, action, and monitoring).
- **Improved patient outcomes** from reductions in medical errors, decreases in morbidity and mortality, and expedited recovery times.

Organizational

- **Stakeholder satisfaction improvements** from improved access to health care information, decreased wait times, and more positive perceptions of care quality and clinician efficacy.
- **Risk mitigation** from decreases in malpractice litigation and increased adherence to federal, state, and accreditation organization standards.

Using these data and the Value Framework structure, CITL created a software model to project ACPOE's value for the U.S. health care system, California, and outpatient providers.

CITL based its projections on the sources described above, and then applied two discount factors. First, for clinical and financial value projections, CITL factored in an ACPOE coverage rate. The expert panel pointed out that even with nationwide implementation of ACPOE, not all orders would be written with this technology. On average, the panelists thought 81 percent of orders would be written with ACPOE.

Second, for financial projections, a standard capitation rate was applied to help account for provider-specific cost savings. When providers avoid costs, they pocket savings only for those expenditures for which they are at risk, i.e., their capitated patients. The average capitation rate in California is 14.4 percent,[8] and the projections assume California providers would accrue 14.4 of the full savings projected by CITL's model. In contrast, the national average capitation rate is 11.6 percent.[8]

CITL used statistics from *2000–2002 AMA Physician Socioeconomic Statistics* and other published sources to describe an average provider.[8] In this model, an average California provider maintains a population of 1,953 patients and conducts 3,776 visits per year.

The software model, as well as detailed descriptions of the data sources and calculations used in the projections in this document, are published in *The Value of Computerized Provider Order Entry in Ambulatory Settings.*[9]

Members of the CITL Expert Panel

- **Joseph E. Bisordi, M.D., F.A.C.P.,** associate chief medical officer, Geisinger Health System; clinical associate professor of Medicine, Thomas Jefferson Medical College.
- **John J. Janas III, M.D., F.A.A.P.,** president/CEO, Clinical Content Consultants; assistant professor, Department of Community and Family Medicine, Dartmouth Medical School.
- **Rainu Kaushal, M.D., M.P.H.,** staff physician, Brigham and Women's, Boston Children's, and Massachusetts General Hospitals; instructor in Medicine, Harvard Medical School.
- **J. Marc Overhage, M.D., Ph.D.,** investigator, Regenstrief Institute for Health Care; assistant professor, Indiana University School of Medicine.
- **Thomas H. Payne, M.D.,** medical director, Academic Medical Center Information Systems, University of Washington; clinical associate professor of Medicine, Health Services, Medical Education, and Biomedical Informatics, University of Washington.
- **Gordon Schiff, M.D.,** director of Clinical Quality Research, Department of Medicine, Cook County Hospital.

III. Limitations

CITL UNDERTOOK THIS PROJECT KNOWING THAT evidence for the benefits of ambulatory CPOE would be incomplete. Some national statistics fundamental to the projections are not reported, and information about system costs is practically inaccessible. This section describes these and other limitations.

CPOE in ambulatory settings is a relatively new application, and there are few peer-reviewed articles on its value. Consequently, this report's projections rely upon a small number of studies, sometimes extrapolating to statewide and national figures from a single data point.

Some statistics about U.S. ambulatory care that are important to national projections are not reported, and as a result, the model uses some general rather than specific data points. The benefit to providers is heavily dependent on capitation rates, and providers may face different risks for different aspects of care such as medication, laboratory, and radiology services. Ideally, CITL would have applied national average service-specific risk profiles to national average service-specific expenditures. Nonetheless, the organization could locate none of these data, though many experts referred them to multiple sources.

Despite these obstacles, both CITL and the California HealthCare Foundation concluded that the importance of making an initial contribution towards documenting the potential impact of ambulatory CPOE systems outweighed any shortcomings in the data. Moreover, the relative prevalence of capitated health care in California suggests that it offers an ideal proving ground for the potential value of ambulatory CPOE systems. Because medical groups in California hold more financial risk than those in other markets, they have the most to gain from any savings produced by improved quality of care, the elimination of redundant tests, and the prevention of unnecessary hospitalizations.

CITL was able to obtain average outpatient medication, laboratory, and radiology expenditures from a 2003 cost-benefit analysis of outpatient EMRs,[10] and applied the national average capitation rate to those expenditures in provider savings calculations. There was no attempt to model population growth or care pattern changes in the analysis.

Similarly, many important statistics about California ambulatory care are not available. As California's Office of Statewide Health Planning and Development reported, data on common aspects of outpatient health services are not routinely collected on a statewide basis.[11] CITL extrapolated some characteristics of the California health care system from national estimates.

ACPOE system cost data were difficult to gather. With a single exception, vendors were unwilling to share pricing or cost data. Therefore, many of the model's cost assumptions are based on expert panel estimates. In a few instances, published data came from non-vendor sources, and these often confirmed the panelists' estimates. In addition, CITL did not incorporate any assumptions about volume pricing discounts. Large practices would probably pay lower prices per provider than smaller ones.

Finally, there were no savings projections for pharmacies, laboratories, or other affiliated providers who would presumably benefit from improved efficiencies with better orders. Their service mix might also change with ACPOE, as providers adhere more closely to care guidelines.

IV. The State of Ambulatory CPOE

By any measure, ACPOE adoption in the United States is low. The expert panel estimated that between 1 and 10 percent of practicing outpatient physicians use some form of ACPOE system. In one study, ACPOE vendors reported that a combined total of 5,100 to 9,100 U.S. outpatient providers currently use the order-entry features of their systems.[12]

A few large California providers, like Kaiser Permanente, have committed to enterprise-wide implementation of EMRs with ACPOE over the next three years.[13] Other smaller outpatient sites, like Citrus Valley Medical Center in Covina, already use ACPOE in patient care. While not mandated by California Senate Bill 1875,[14] ambulatory care sites across the state—especially hospital-based outpatient clinics—will likely continue to implement order-entry systems as part of comprehensive patient safety programs.

A review of the literature, discussions with expert panelists, and a survey of ACPOE vendors indicate that physicians who adopt advanced ACPOE use either proprietary systems developed by large academic medical centers or heavily customized commercial systems. Generally, standard commercial systems currently concentrate on intermediate or basic functionality. Systems that feature advanced clinical decision support have appeared only in the past three to five years, usually as modules of sophisticated AEMR systems. Specialized electronic prescribing applications or Web-based electronic prescribing services that offer passive decision support capability have appeared during the same time frame.

Vendors offer ACPOE either as licensed applications or, less commonly, application service provider subscriptions, and typically target large group practices with 30 or more physicians. Most systems feature many of the same ordering and order transmission capabilities, but differ slightly on the sophistication of decision support. Most ACPOE systems are capable of ordering medications (new and refills), laboratory tests, radiology studies, and referrals through some form of electronic data interchange (EDI) or direct system-to-system transmission. Few are limited to paper- or fax-based transmission.

ACPOE supports access to patient demographic and clinical data like diagnoses, problem lists, medication history, and allergies. Most products feature standard knowledge bases like drug reference and laboratory and radiology costs. Drug-drug interaction checking is a standard feature, and drug-diagnosis and drug-laboratory checking are included in many systems.

Three classes of vendors define the current ACPOE system marketplace. Electronic medical record vendors are traditional vendors offering a wide range of clinical and administrative applications in addition to ACPOE; electronic prescribing vendors focus on automating only one type of order, namely those for prescription drugs; clinical decision support vendors often provide clinical knowledge bases and rule sets that, when integrated with ordering capabilities, enable more sophisticated ACPOE systems. While this last class of vendor does not offer order entry systems per se, they provide critical ACPOE functionality.

V. Clinical Benefits

ACPOE SYSTEMS CAN PROVIDE A BROAD RANGE of clinical benefits—from increased compliance with guidelines to better management of patients with chronic disease. In this section, we focus on ACPOE's impact on medication safety, adherence to disease management and health maintenance guidelines, and resource utilization.

Medication Errors, Medication Safety

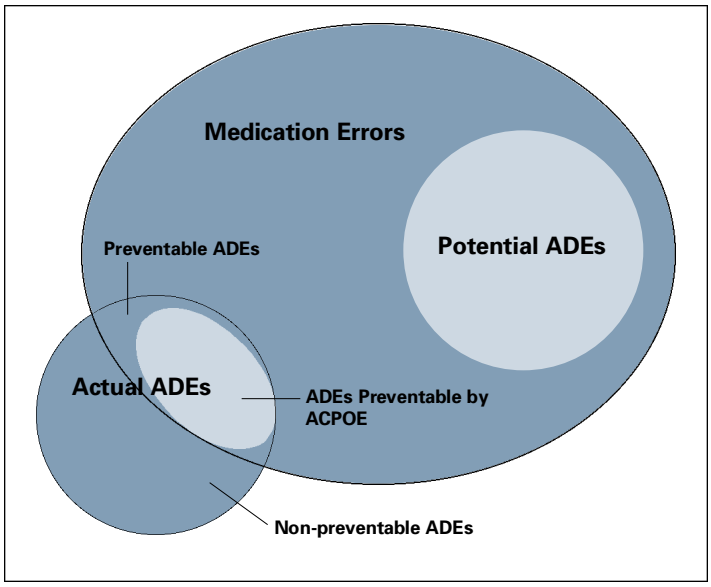
Medication safety is an important national health care quality and patient safety issue. Efforts by the Institute of Medicine and The Leapfrog Group to promote wide adoption of patient safety strategies—including CPOE—have focused national attention on medication safety. ACPOE systems can help providers improve medication safety by avoiding a common type of medication error: preventable ADEs (Figure 3).

Figure 3: Medication Error Terminology

- **Medication Error**—a mistake during the medication process, including prescribing, transcribing, dispensing, consuming, and monitoring. Examples include misspelling the medication name during prescribing, incorrectly transcribing the prescription, dispensing the wrong medication, consuming the wrong dose, and failure to monitor patients for side effects.
- **Medication Complication**—undesirable consequences from a drug intervention, including normal side effects.
- **Adverse Drug Event (ADE)**—an injury resulting from an intervention related to a drug. ADEs represent the subset of medication complications that were not anticipated during medical decision making, e.g., unintentional adverse outcomes from medication therapy.
- **Potential ADE**—a drug intervention that normally would have resulted in an injury, but did not. Examples include medication overdoses that did not result in detectable injuries.
- **Preventable ADE**—an ADE caused by medication error. Examples include patients receiving medications they are allergic to, or an overdose event due to transcription errors.
- **Non-Preventable ADE**—an ADE that is unrelated to a medication error. An example includes idiosyncratic reactions.

Defined as injuries resulting from interventions related to drugs, ADEs are one type of medication error (Figure 4). ADEs can be classified as preventable and non-preventable.[15] They are considered preventable if an error can be identified in any part of the medication process. An example of a preventable ADE is a penicillin-allergic patient who, because of incomplete allergy documentation, is prescribed penicillin and suffers an allergic reaction after consuming the drug. Preventable ADEs do not include injuries from known medication side effects—such as compromised hepatic functioning in patients taking HMG-CoA reductase inhibitors (statins)—or from idiosyncratic reactions.

Figure 4: Medication Errors



While advanced ACPOE systems could theoretically avert most prescription-related preventable ADEs, the real world impact is typically much less. ACPOE's effectiveness is compromised due to human factors such as providers ignoring ACPOE warnings or patients ignoring medication instructions, system factors such as providers' verbal orders not making it into the system, or data factors such as incomplete allergy documentation or outdated drug interaction databases.

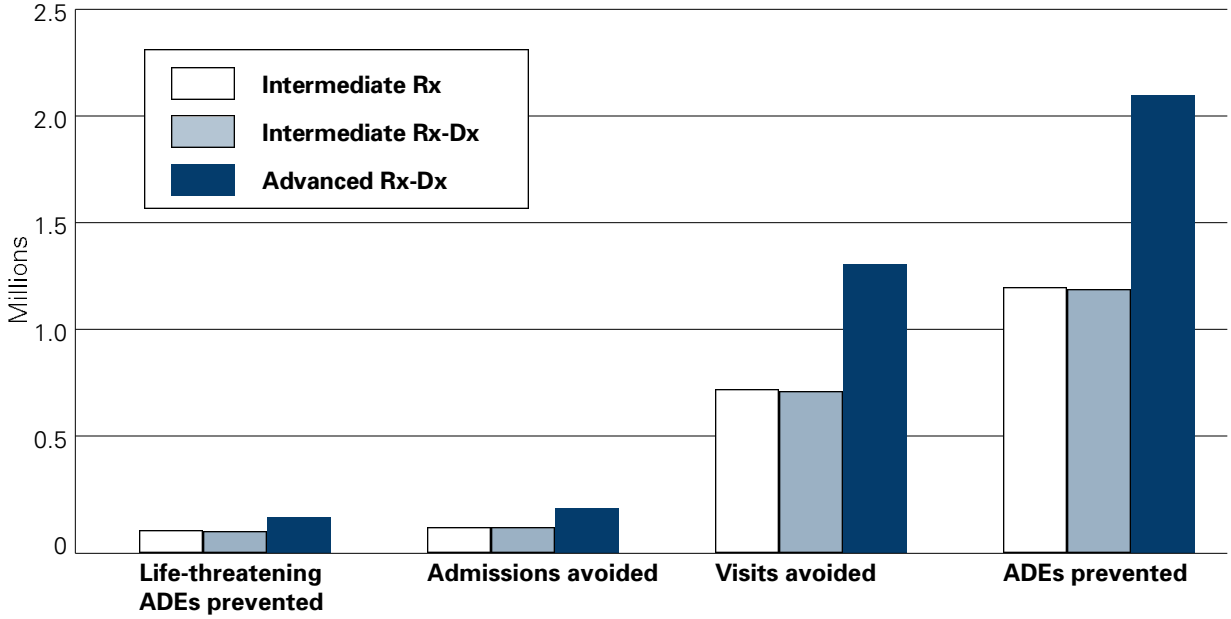
Some providers and other health care stakeholders are even concerned that ACPOE systems may *cause* medication errors and ADEs. However, CITL's literature review identified little evidence demonstrating negative impacts of ACPOE, though future research should study this issue. In determining projections for preventable ADEs using ACPOE, the expert panelists accounted for any potential negative outcomes.

Different classes of systems have varying decision support capabilities and therefore prevent a larger or smaller proportion of ADEs. The capacity for prevention may even differ between systems within the same ACPOE class, due to variations in functionality.

National Estimates

Advanced ACPOE systems have a tremendous impact on medication safety. Based on the total U.S. outpatient visit volume of more than 900 million visits, the authors estimate there are more than 8.8 million outpatient ADEs per year in the United States. CITL projects that more than three million of these ADEs are preventable. Even after adjusting for incomplete ACPOE coverage, nationwide adoption of these advanced systems is still likely to eliminate nearly 2.1 million ADEs per year in the United States. This would prevent nearly 1.3 million ADE-related visits, more than 190,000 hospitalizations, and more than 136,000 life-threatening ADEs (Figure 5).

Figure 5: Annual Impact of ACPOE on ADE Prevention in the United States

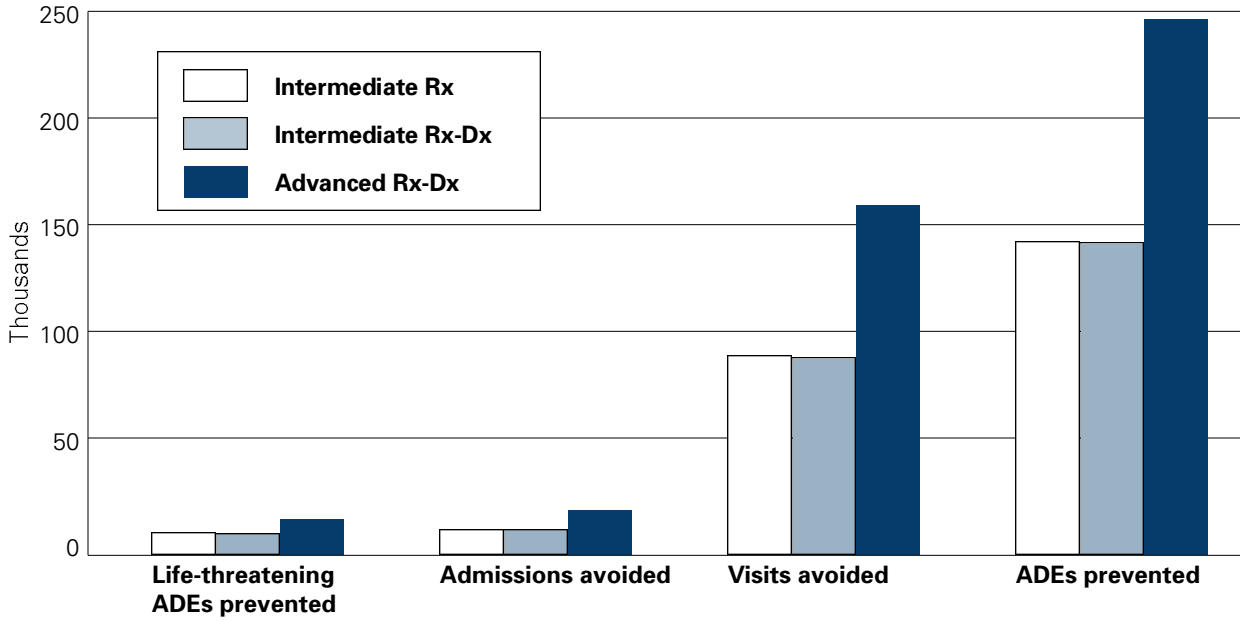


While intermediate ACPOE systems would also prevent substantial numbers of ADEs if adopted nationally, their impact is 40 percent less than advanced systems. Advanced systems prevent more ADEs and associated hospitalizations and patient visits, because they feature more sophisticated clinical knowledge bases and drug interaction checking.

California Estimates

Implemented statewide, advanced ACPOE would provide California residents with a substantially safer health care system. Based on the total estimated California outpatient visit volume of 109 million visits, CITL estimates there are nearly 1.1 million outpatient ADEs per year

Figure 6: Annual Impact of ACPOE on ADE Prevention in California



statewide. Close to 405,000 of these ADEs are preventable. Even after adjusting for incomplete ACPOE coverage, statewide adoption of these systems is still likely to avert nearly 249,000 preventable ADEs annually. Adoption of advanced systems would also avoid approximately 156,000 visits and nearly 23,000 admissions, as well as prevent more than 16,000 life-threatening ADEs over the same period (Figure 6).

Similar to national ADE prevention projections, intermediate ACPOE systems adopted across California would prevent 40 percent fewer ADEs than advanced systems.

Provider Estimates

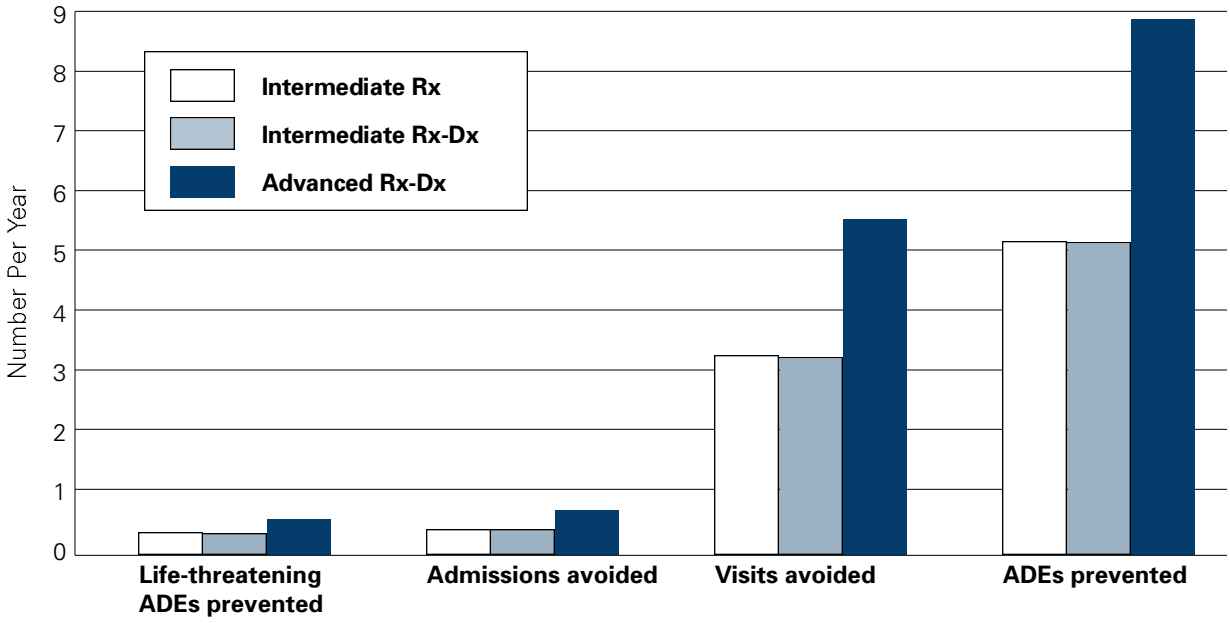
ACPOE's clinical value is also striking on a per provider basis. The typical outpatient provider should eliminate nine ADEs per year with an advanced ACPOE system and nearly six additional ADE-related visits per year. In addition, in every five years of use, a provider can expect to avoid four hospital admissions and three life-threatening ADEs (Figure 7). As with national estimates, intermediate systems prevent about 40 percent fewer ADEs per outpatient provider than advanced systems.

Care Process Advances

Some of the evidence for ACPOE clinical value could not be used to project quantitative benefits. However, a comprehensive picture of ACPOE clinical value requires examining what other clinical benefits are possible. There is a small but growing body of evidence that ACPOE can improve provider compliance with disease management programs and health maintenance guidelines, and optimize use of medical resources. CITL found several studies of targeted interventions showing striking results.

For instance, one study found that computer-generated reminders targeting diabetic patients increased cholesterol test compliance rates by 96 percent, ophthalmologic examination referral rates by 74 percent, and Hemoglobin A1c test compliance rates by 30 percent.[16] A study at Kaiser Permanente in California reported that

Figure 7: Annual Impact of ACPOE on ADE Prevention per Outpatient Provider



providers reduced the number of upper GI series tests per member annually by more than 47 percent, and increased the number of upper GI requests in compliance with care guidelines by 60 percent when using ACPOE with advanced decision support capability.[17,18]

In the absence of larger general studies, CITL did not project ACPOE's impact on disease management, health maintenance, or resource optimization. However, CITL believes that ACPOE will improve and protect the health of Californians and all U.S. residents if widely adopted.

VI. Financial Benefits

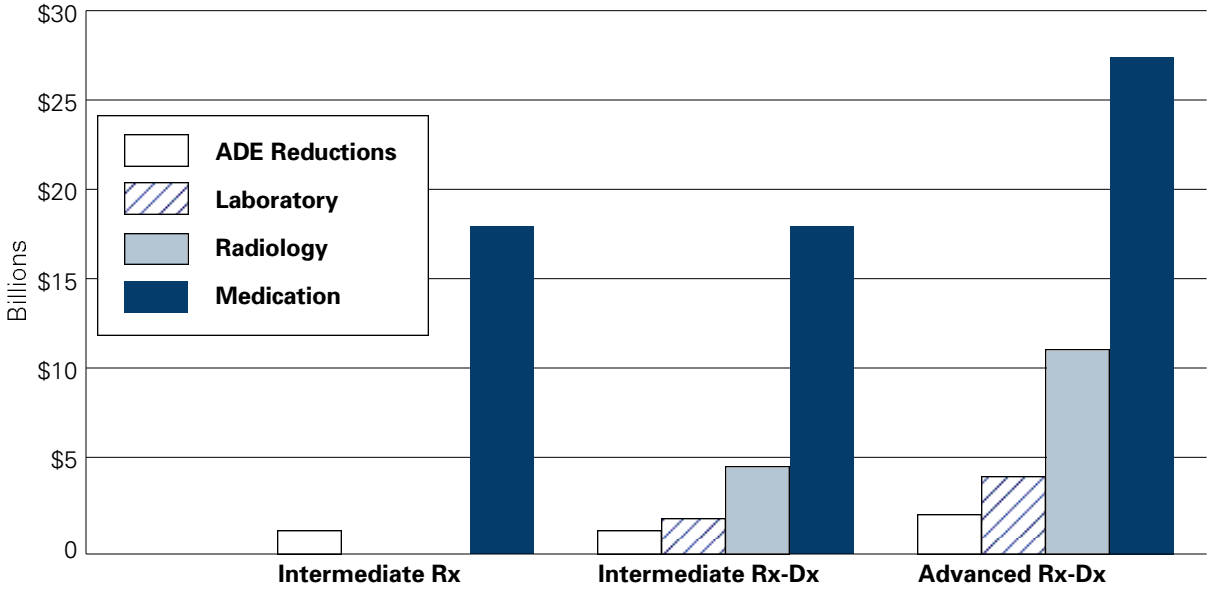
OUTPATIENT ORDER ENTRY SYSTEMS REDUCE medication, laboratory, and radiology costs and ADE-related expenditures such as office visits and hospital admissions.

National Estimates

Decision support tools that help avoid ADEs and suggest cost-effective medication, laboratory, and radiology ordering are important sources of direct cost savings from ACPOE. Nationwide adoption of advanced ACPOE will save approximately $44 billion per year in reduced medication, radiology, laboratory, and ADE-related expenditures, while intermediate systems would yield between $20 and $26 billion in savings (Figure 8).

Reductions in medication expenditures account for the largest portion of savings. These savings occur through switches from brand-name to generic medications, changes from expensive medications to less expensive alternatives in the same therapeutic class, and more appropriate drug utilization. However, ACPOE systems that only support drug ordering have no impact on laboratory and radiology expenses, and consequently produce lower aggregate cost savings.

Figure 8: Annual ACPOE Cost Savings, United States



California Estimates

Implemented statewide, advanced ACPOE would save California $4.3 billion annually (before costs) in reduced medication, radiology, laboratory, and ADE-related visits and admissions (Figure 9). Intermediate systems would save substantially less, between $1.7 and $2.5 billion annually.

Provider Estimates

Provider savings are calculated through analyzing the proportion of baseline expenditures avoided by the ACPOE system and the provider's capitation rate. For the average U.S. outpatient provider with an 11.6 percent capitation rate, CITL predicts total annual medication, laboratory, radiology, and ADE-

Figure 9: Annual ACPOE Cost Savings, California

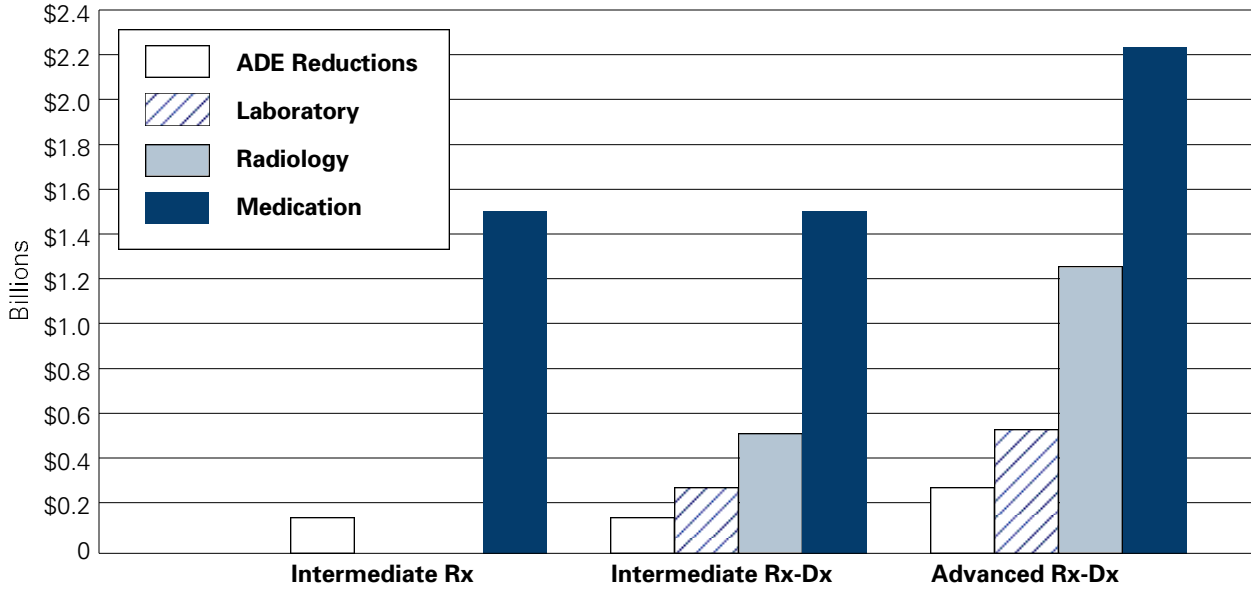
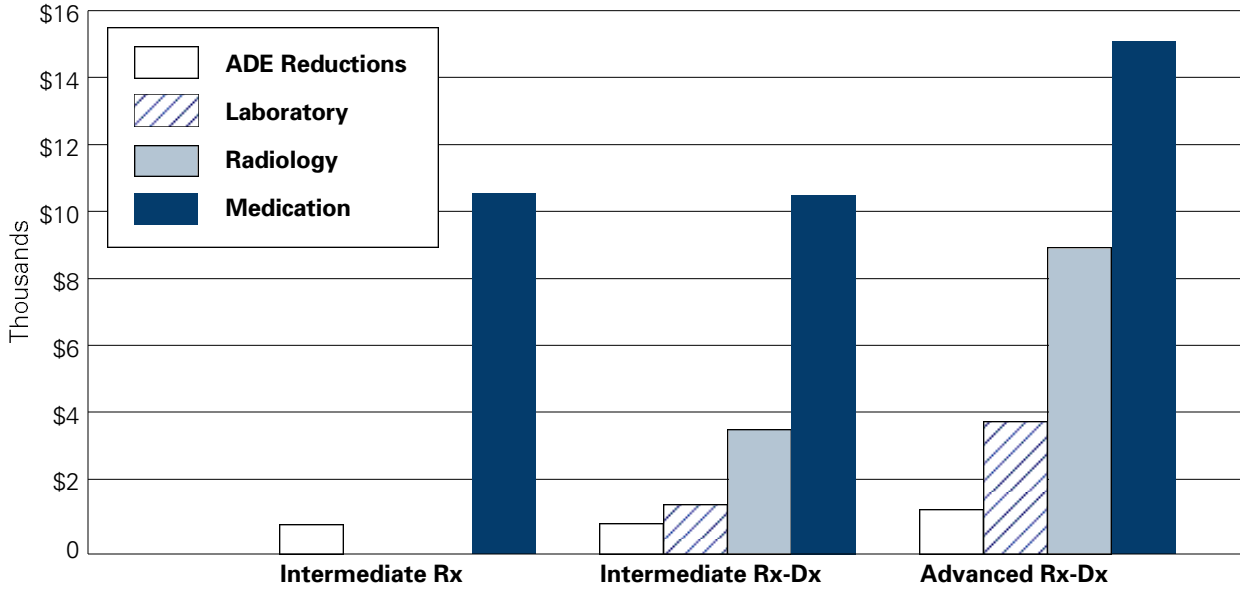


Figure 10: Annual ACPOE Cost Savings per Outpatient Provider in California



related cost savings of $28,000 for advanced ACPOE, and between $12,300 and $16,600 for intermediate systems.

California outpatient providers have slightly higher capitation rates and slightly lower medication expenditures than the national average. For the average California outpatient provider with a capitation rate of 14.4 percent, CITL predicts total annual ADE-related cost savings of nearly $29,000 for advanced ACPOE, and between $11,000 and $16,500 for intermediate systems (Figure 10).

Because of their higher capitation rates, California providers accrue more radiology and laboratory savings than national providers. Lower average medication expenditures result in California physicians saving less in medication costs than do their national counterparts. The interaction between these factors in the model accounts for the difference between California and national savings.

Productivity Implications

Providers, researchers, and managers are interested in ACPOE's impact on order entry time and productivity. Provider order entry time is the time required to complete all fields involved in the process of ordering laboratory testing, radiology procedures, or medications. Most order entry systems contain structured entry fields, which result in more comprehensive documentation of patient encounters and order requests.

Despite the extra work sometimes required by order entry systems, recent studies have shown that order entry speed is improving. In 1995, two researchers performed a time-series analysis of physicians from the Northwest Region of Kaiser Permanente.[19,20] Their data showed that physicians spent 130 seconds more per visit after ACPOE implementation. In 2000, a separate study by David W. Bates reported that physicians using an electronic medical record with ACPOE spent 35 seconds and 92 seconds, respectively, completing paper-based orders and electronic orders.[21] Electronic ordering may also take longer to complete because of the additional capabilities these systems offer, such as creating discharge instructions for patients.

When providers become more familiar with systems, there is little difference between paper-based and computer-based order entry times. In separate studios, S. I. Allen and J. M. Overhage reported that time requirements decreased significantly after increased experience with computers and order entry functions.[22,23,24] In Allen's study, average medication order entry time for a new user was 82 seconds, but only 18 seconds for an experienced user. Overhage reported that physicians using ACPOE spent 140 seconds more per patient as compared to a control group without ACPOE. However, once administrative and duplicate tasks were accounted for, order entry-related tasks accounted for only 55 seconds of the additional time. And, after 40 to 50 visits, physicians were able to reclaim all 140 seconds of extra time that was required during the initial implementation phase.

Aside from affecting provider order entry times, ACPOE affects others in the health care system by producing downstream time savings, chiefly from electronic data transmission and more thorough order entry (resulting in fewer pharmacy callbacks for clarification and revision).

Cap Gemini Ernst & Young analyzed implementation of a personal digital assistant (PDA)-based ACPOE system and reported that nurses saved 2.87 minutes per faxed prescription compared to paper and phone methods.[25] K. J. Anderson and P. M. Malone reported on a survey of 37 pharmacists that estimated that EDI would save 97 seconds per prescription.[26] Finally, a 30-physician practice in Illinois reported a 50 percent reduction in pharmacy callbacks as a result of implementing a PDA-based order entry system.[27] These studies give examples of the time-saving potential of ACPOE. However, evidence is not yet strong, and CITL did not project savings from these data.

VII. Organizational Benefits

CITL found little evidence on ACPOE's organizational benefits, such as improving patient and provider satisfaction and corporate compliance, and decreasing malpractice risk. What evidence there is suggests physicians and other clinicians are more accepting of ACPOE as they gain experience with it, and patients seem to accept clinician use of computers during clinical encounters.

In terms of compliance, providers often need to meet payers' medical necessity guidelines to ensure reimbursement. Some ACPOE systems are capable of alerting providers about procedures or other expenses that are not reimbursed. CITL found little evidence for ACPOE's effect on compliance with payer reimbursement guidelines. However, given that several studies have demonstrated improved clinical guideline compliance through computer-generated reminders, CITL believes ACPOE could achieve similar improvements for administrative guidelines.

CITL believes that ACPOE and associated clinical decision support systems will reduce providers' malpractice risk and lead to lower malpractice insurance premiums because of their ability to improve patient care and safety. Though there was not enough evidence to project savings, this could be a source of significant additional return on ACPOE investment, particularly for specialists in high-risk fields.

VIII. Ambulatory CPOE System Costs

Determining the total value of ACPOE requires identifying the system costs, which include the initial acquisition costs of purchasing and installing a system, plus opportunity costs—the foregone revenues during and immediately following system implementation—and the annual operation and maintenance costs. Figure 11 details annual costs for the first five years of ACPOE use across different-sized provider groups. Year one includes acquisition and opportunity costs, on top of annual costs.

As with evidence on ACPOE value, CITL collected cost data from academic and general literatures, the expert panelists, and vendors. CITL assumed a buy-only option, since the majority of outpatient providers lack the capital, IT systems development staff, and clinical informatics expertise to develop their

Figure 11: ACPOE System Costs per Provider, Self Financing

	Intermediate Rx	Intermediate Rx-Dx	Advanced Rx-Dx
1 Provider			
Year 1 costs	$13,130	$32,170	$377,600
Year 2-5 costs (per annum)	$4,266	$6,625	$31,950
Total 5 year costs	$30,194	$58,670	$505,400
5 Providers			
Year 1 costs	$7,599	$19,220	$87,350
Year 2-5 costs (per annum)	$2,732	$4,105	$8,652
Total 5 year costs	$18,527	$35,640	$121,958
10 Providers			
Year 1 costs	$6,907	$17,600	$51,070
Year 2-5 costs (per annum)	$2,540	$3,790	$5,739
Total 5 year costs	$17,067	$32,760	$74,026
25 Providers			
Year 1 costs	$6,492	$16,630	$29,300
Year 2-5 costs (per annum)	$2,425	$3,601	$3,991
Total 5 year costs	$16,192	$31,034	$45,264
50 Providers			
Year 1 costs	$6,354	$16,310	$22,040
Year 2-5 costs (per annum)	$2,387	$3,538	$3,409
Total 5 year costs	$15,902	$30,462	$35,676

own applications. To enable detailed cost-benefit analyses and produce a scaleable cost model, CITL estimated all system costs *per provider*. Finally, these cost estimates assume that providers use their own capital to finance ACPOE acquisition and do not include any financing costs.

Costs increase rapidly with system sophistication. First-year costs for advanced systems are substantial: $29,300 per provider for a practice with 25 providers. However, advanced ACPOE estimates include license fees and partial infrastructure and maintenance costs for ambulatory EMRs. Vendors often bundle EMR and ACPOE pricing because advanced ACPOE requires EMR system components, such as clinical data repositories.

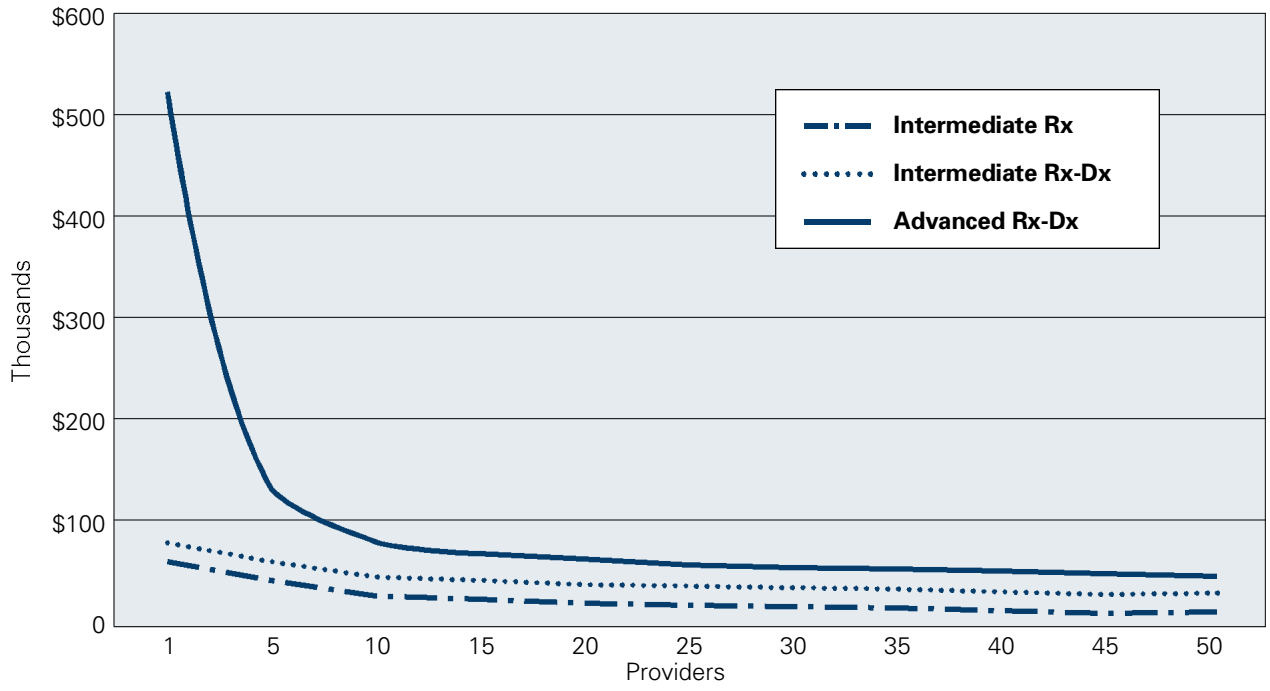
Impact of Practice Size

Provider size is the prime determinant of costs for most ACPOE systems. Figure 12 illustrates the impact of provider size on system costs for one to 50 providers over five years.

Economies of scale radically improve for these systems as the number of providers increases. For instance, for Advanced Rx-Dx, going from five to 50 providers decreases total five-year costs by roughly 70 percent per provider. Advanced system costs are highly sensitive to practice size because these systems feature the most expensive shared components of all ACPOE systems, such as infrastructure, system interfaces, and knowledge bases. Since vendor estimates for these shared components assume a large practice setting, extrapolating to solo providers results in high costs.

Because of their lower functionality, intermediate systems enjoy far less dramatic economies of scale with increasing numbers of providers. Five providers purchasing an Intermediate-Rx system, for instance, pay about 15 percent more per provider over five years than a 50-provider practice adopting the same system.

Figure 12: Five-Year ACPOE Costs per Provider



IX. Conclusion

Should providers implement CPOE in ambulatory settings? CITL's model of ACPOE costs and benefits shows that both California and the United States as a whole are likely to reap significant clinical and financial benefits from widespread adoption of this technology.

Providers and patients, the central stakeholders in care, both stand to gain. Most importantly, patients are the beneficiaries of reduced errors, better care management, improved efficiencies, and, ultimately, lower care costs. Providers stand to gain both financially and from improved workflow. Relatively few have adopted ACPOE, and even fewer actively measure the value these systems provide. Evidence suggests that, with experience, providers will come to appreciate ACPOE and see it as an essential component of practice. One way ACPOE adoption will spread is through medical training; clinicians will carry it into the community after they have used it in large hospital clinic training settings.

Some of ACPOE's important benefits are present even in intermediate systems. Simply writing orders that are *complete*—a feature of all ACPOE systems—generates benefits at multiple points. Complete orders save time by reducing pharmacy, laboratory, and radiology callbacks, and improve providers' cash flow by reducing the number of claims rejected by insurers.

The magnitude of error prevention makes a compelling clinical case for advanced systems: Widespread use of advanced ACPOE could avert nearly 250,000 in California, or almost nine per outpatient provider annually, and more than two million at the national level. CITL's expert panelists estimated that intermediate systems avoid better than half of those errors. In addition, only advanced ACPOE systems allow for the integration of clinical guidelines and other sophisticated decision support features with ordering capabilities—functionality that can contribute to higher quality care.

CITL projected net financial returns for the United States, California, and individual providers. This was accomplished by assuming a rapid, five-year ACPOE system adoption schedule—during which 20 percent of providers install intermediate and advanced systems each year—and projecting the net financial benefit after system costs.

At the national level, advanced ACPOE systems produce significant net returns after the rollout period, saving $34 billion each year. However, installation and maintenance costs range from $20 to $30 billion each year during rollout, and the national breakeven point occurs in year five, after nationwide rollout is complete. In a separate analysis, CITL determined that use of public domain knowledge bases—a major component of advanced ACPOE system costs—could shorten the time to breakeven by more than 18 months.

Intermediate systems start producing positive returns in year one of a national rollout—that is, with only 20 percent of U.S. outpatient providers using these systems. Even though intermediate systems yield fewer savings in the long run—from $20 to $26 billion annually—their net returns exceed advanced system returns in the first six to eight years of use (Figure 13).

The picture is similar for the state of California. While the overall financial return patterns are similar to national projections, there are a few key differences. Because California providers have lower medication expenditures than the national average, an important source of ACPOE savings, advanced systems take 12 to 18 months longer to show positive returns in California. Therefore, as illustrated in Figure 14, intermediate systems are the best financial choice for the first decade of use in California. The analysis projects benefits

Figure 13: National Financial Returns

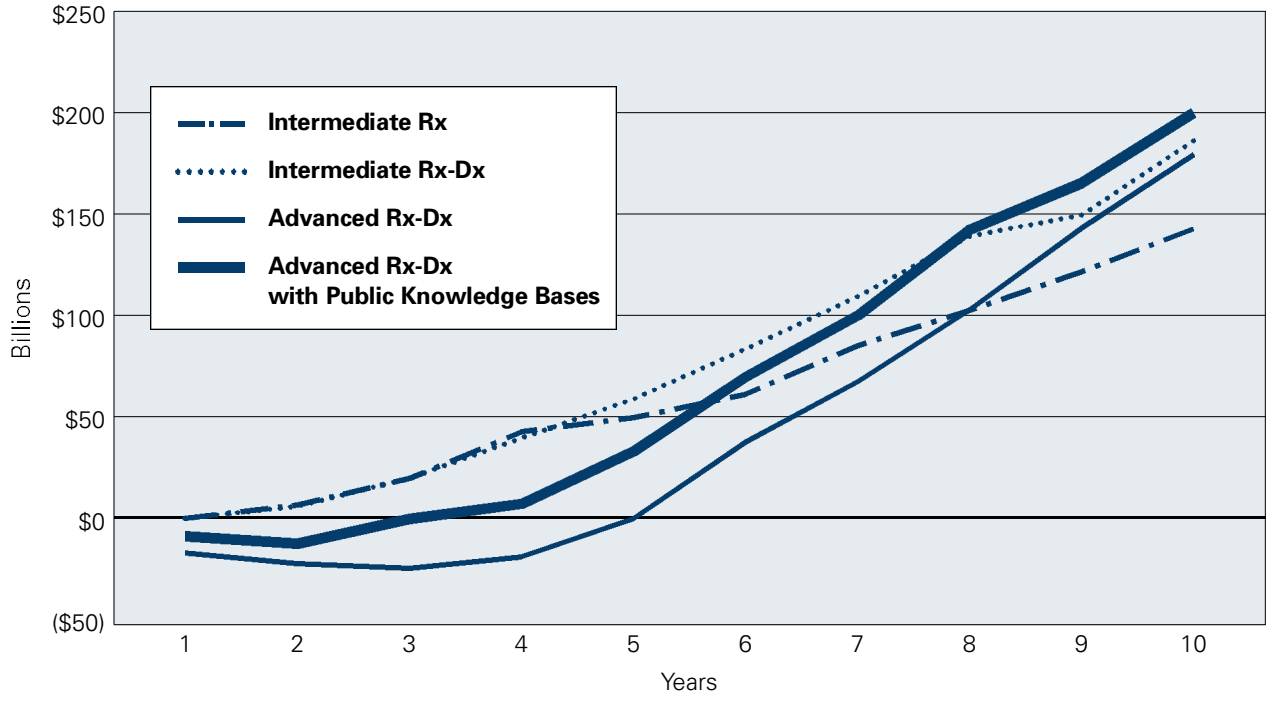
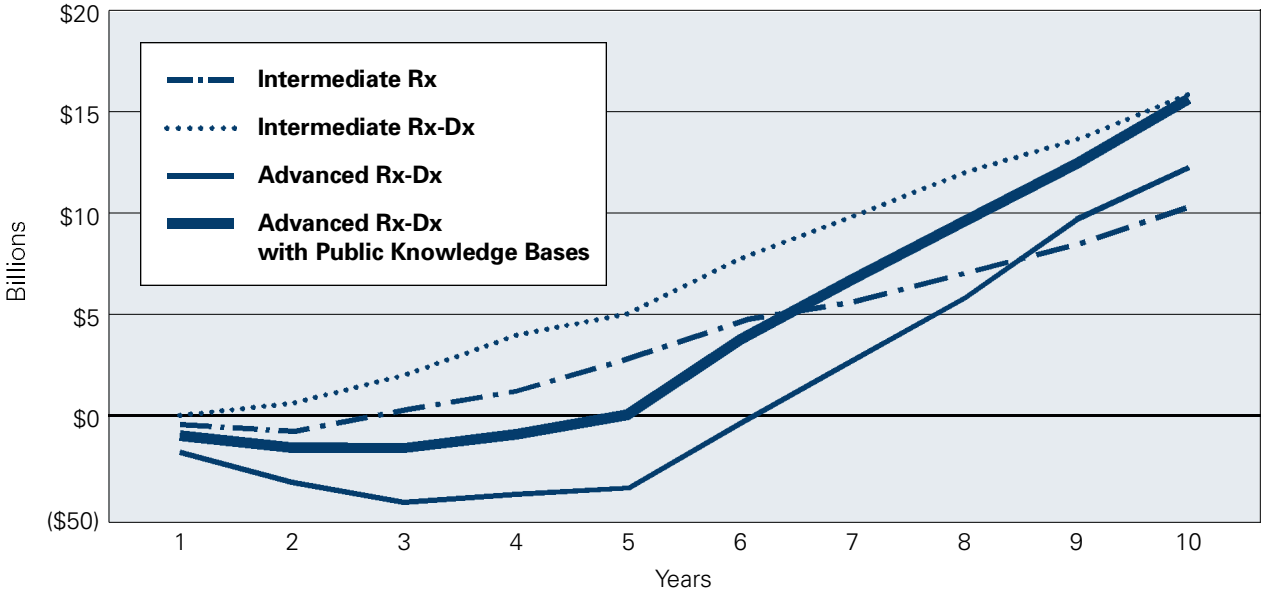


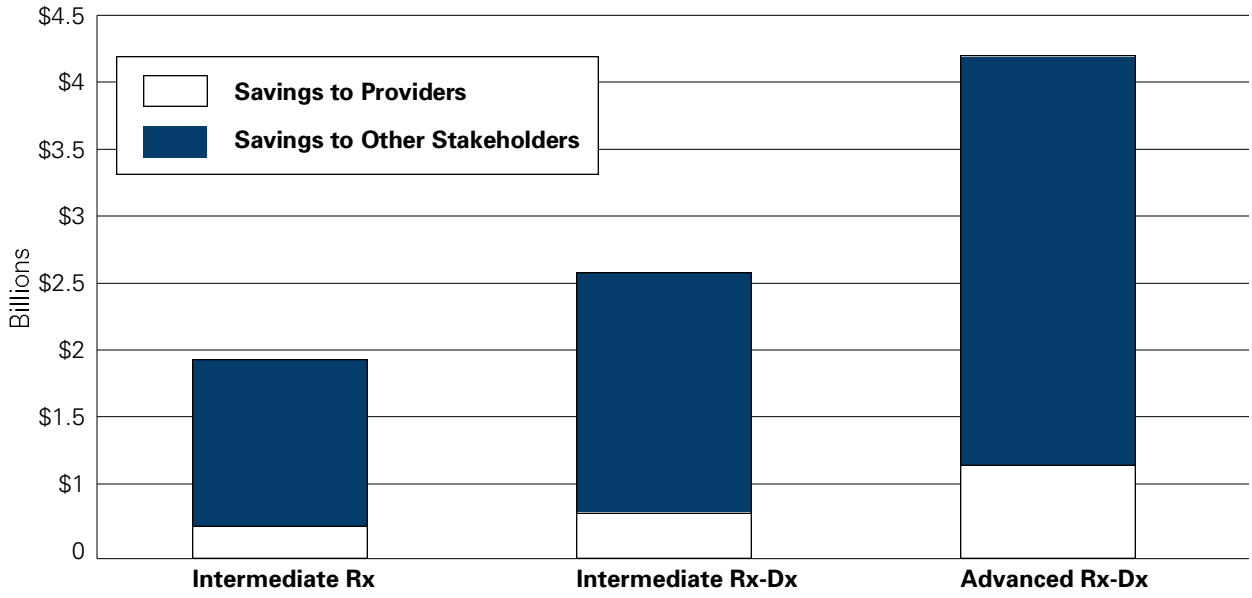
Figure 14: California Financial Returns



only through year 10, but the slope of the lines suggests advanced systems with public knowledge bases produce the highest value in the long term, past year 10.

Of course, the providers investing in these systems must consider their personal costs and financial returns. Most of the financial benefits do not accrue to providers, but to other health care stakeholders like payers and purchasers. Providers only pocket savings under capitated contracts: 14.4 percent of health care spending in California (Figure 15), and 11.6 percent of all care nationally. Costs escalate rapidly with functionality, and more sophisticated systems are affordable only in large practice settings. Therefore, the appropriate system for a particular

Figure 15: California Annual ACPOE Savings for Providers and Other Health Care Stakeholders



practice is heavily dependent on the proportion of revenues from capitated contracts, and on the size of the practice.

For the solo practitioner at 14.4 percent capitation, intermediate systems are the only ones whose benefits outweigh costs by the end of year five (Figure 16). For a practice with five clinicians, intermediate systems are the best choice. Advanced systems make sense from a cost-benefit perspective only if the practice has 10 or more clinicians. Of course, the picture changes with increasing capitation as more of the benefits accrue to the practice; advanced systems may make sense for smaller groups if they are heavily capitated.

According to the AMA, nearly two-thirds of U.S. physicians practice in groups of three or fewer,[28] where the financial case is least compelling. This significant proportion of practitioners may view advanced systems as financially infeasible. However, many solo providers and small practices are affiliated with larger practice plans, or are members of professional associations that sometimes function as purchasing cooperatives and may make systems more affordable.

Society clearly benefits from widespread adoption of sophisticated ACPOE systems. Yet, in the current payment environment, providers bear the full cost of ACPOE and reap only a fraction of its financial rewards, raising the questions of who should pay and who should benefit. The complexity of U.S. payer arrangements makes it difficult to confidently distribute financial benefits among the various stakeholders, which include pharmacies, managed care plans, and employers, to name a few. Should payers offer incentives for ACPOE systems, as some insurers have done for inpatient CPOE? Should other stakeholders share the costs? Should public funds be used to set up an infrastructure that would reduce implementation costs for individual sites, particularly for smaller providers for whom the financial returns are less compelling? Policy issues are beyond the scope of this assessment. Future public debate about these and related questions will help resolve some of these questions.

Figure 16: Five-Year Net Return per Provider at 14.4 Percent Capitation

	Intermediate Rx	Intermediate Rx-Dx	Advanced Rx-Dx
1 Provider	$25,240	$24,040	($362,800)
5 Providers	$36,910	$47,060	$21,600
10 Providers	$38,370	$49,940	$69,650
25 Providers	$39,240	$51,670	$98,480
50 Providers	$39,530	$52,240	$108,100

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