Technical Assistance for Health IT and Health Information Exchange in Medicaid and CHIP

A Guide to Calculating the Costs and Value of E-Prescribing

Prepared for:
Agency for Healthcare Research and Quality
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The information in this report is intended to help clinicians, employers, policymakers, and others make informed decisions about the provision of health care services. This report is intended as a reference and not as a substitute for clinical judgment.

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Chapter 1. Introduction

Electronic prescribing (e-prescribing) has the potential to generate value in many areas—such as preventing adverse drug events (ADEs) because of drug allergies or drug-drug interactions—and to generate cost savings in the prescribing, transmission, and filling process, including avoiding duplicate prescriptions. These potential benefits are likely an important reason for the interest and activity regarding e-prescribing on the part of State Medicaid and Children's Health Insurance Program (CHIP) agencies.[1] At the same time, e-prescribing will result in several types of costs, including a range of initial investment and operating costs.

Evaluating and comparing the costs and value involved in e-prescribing can provide a number of benefits. First, estimating the value generated by e-prescribing quantifies these benefits and helps to define those results most desired from e-prescribing. While the lengthy list of potential benefits is the same everywhere, as a joint State/Federal program Medicaid has been adapted to each individual State's population and provider characteristics, philosophies, and economic realities. As a result, each State may emphasize different areas where value may be generated. The specific focus of a State Medicaid/CHIP agency in analyzing value (and costs) will depend on the objectives for the e-prescribing initiative, the characteristics of the Medicaid/CHIP program and how it is administered, and the characteristics of enrollees and providers.

Second, attempting to measure the value of e-prescribing in specific areas can help inform choices among a large number of competing approaches to e-prescribing, especially in the area of the clinical decision support and payer-oriented analyses that a specific e-prescribing system entails.

Third, after an e-prescribing system has been implemented, calculating and comparing value and costs can inform what changes, if any, may be beneficial. For example, if e-prescribing is introduced stepwise across providers or initially as a pilot test, mid-course corrections can be very productive. And any system will need to be maintained and updated—and with the current rate of technological change possibly replaced—at regular intervals. So opportunities to obtain greater value from spending on e-prescribing will always be present or imminent.

This guide provides the following:

- A detailed discussion of the stages in e-prescribing where costs and value may enter the picture, including to which participants (e.g., the State agency, enrollees, providers, and so on) in e-prescribing these costs or value will accrue;
- A summary presentation of what is known about the costs and value of e-prescribing, largely as reported in refereed journal articles;
- A presentation of the techniques that may be used to compare costs to value; and
- A discussion of some key topics in using these techniques.

The types of evaluation discussed in this guide focus on costs and value. The value considered here may be measured in dollars, but it may also consist of quantitative measures to which dollar values have not been attached. Other types of evaluations focus on other areas, such as understanding the processes that either facilitate or inhibit the effective use of e-prescribing, or on satisfaction with an e-prescribing system. While valuable, these types of evaluations are not covered in this guide.

It is hoped that this guide will provide:

- A better understanding of the range of potential costs and value, and the methods that can be used to analyze them, regardless of whether an evaluation is being conducted within an agency, by another part of government, or through the use of outside contracting.
- The ability to obtain a clearer picture of what value is expected to be generated by the specific e-prescribing system that is being implemented.
- A better understanding of the data collection and retention requirements for a high-quality evaluation.

Chapter 2. The Elements of Cost and Value for E-Prescribing

The U.S. Department of Health and Human Services defines e-prescribing for Part D of the Medicare program as follows:

> "*E-prescribing* means the transmission using electronic media, of prescription or prescription-related information between a prescriber, dispenser, pharmacy benefit manager, or health plan, either directly or through an intermediary, including an e-prescribing network. E-prescribing includes, but is not limited to, two-way transmissions between the point of care and the dispenser."[2]

While this definition describes the fundamental elements of e-prescribing, it omits description of the many dimensions along which specific e-prescribing efforts may differ. These include the degree to which the following are incorporated:

- Program eligibility determinations for individuals;
- Data for a program's formulary;
- Data for each individual on other prescribed drugs; and
- Clinical decision support systems (CDSS).

Not only are there many possible variations for the specific form of e-prescribing, there are also many variations for the nature of Medicaid program involvement. Will the e-prescribing process be administered through a vendor, not directly administered by the State agency? Will the Medicaid/Children's Health Insurance Program (CHIP) program directly subsidize the introduction and/or maintenance of e-prescribing for health care providers, pharmacies, or other health care delivery participants?

The step-by-step presentation in this chapter of the places where cost and value may occur discusses the many possible enrichments of e-prescribing that may be incorporated.

Participants in E-Prescribing and Perspectives on Costs and Value

E-prescribing involves interactions among a number of participants in the health care delivery system:

- The Medicaid/CHIP program.
- Enrollees.
- Prescribing providers.
- Pharmacies.
- Pharmacy benefits managers (PBMs) and/or managed care organizations contracted by the Medicaid/CHIP agency to assist in program administration and implementation.

Each of these participants and the interactions among them may involve costs and/or generate value. This makes understanding the costs and value of e-prescribing a complicated task with many dimensions.

Costs and value can be viewed from the perspectives of any and all of these participants. One approach is simply to view costs and benefits from the budgetary perspective of Medicaid/CHIP agencies. In this case, the measurements would be strictly in terms of program spending changes.

A second approach is to incorporate costs and benefits for both Medicaid/CHIP agencies and Medicaid/CHIP enrollees. In this case, the costs and value would also incorporate additional benefits to consumers beyond those changes in costs that are directly reflected in Medicaid spending. For example, avoiding potentially harmful drug interactions can result in both reduced program costs for emergency room (ER) visits and inpatient care and in direct benefits to enrollees (reduced time lost from school or work; and less pain and suffering from ADEs). Attaching a dollar value to all of these benefits is probably not feasible.

Costs and value to prescribing providers and pharmacies may not be of direct primary importance to the Medicaid/CHIP program. However, they represent incentives and disincentives that these participants face in participating in e-prescribing, and an understanding of these may therefore be useful to the agency in determining what efforts to consider to counter the disincentives.

The Medicaid/CHIP agency may contract with PBMs and managed care organizations to assist in program administration and implementation. To somewhat simplify this discussion, this guide combines PBMs and managed care organizations with the Medicaid/CHIP program in describing to whom costs and value accrue. Given that some programs use separate PBMs and some do not, and care to some enrollees is administered through managed care organizations and care to others is not, incorporating all of these possibilities would greatly complicate the discussion. In the short run, costs and value may possibly accrue to these entities that are not shared with the Medicaid/CHIP program. However, over the longer run it is assumed that the program will eventually capture these costs and value in the future.

Finally, one can evaluate costs and value from an overall *societal* perspective, basically summing up the costs and value across all categories of participants. However, from a variety of perspectives, including policy and political ones, it will likely be important to take into account the detail on the specific distribution of costs and value among participants.

Which perspective on costs and value an agency chooses will be determined in part by the program objectives in instituting e-prescribing.

Stages of E-Prescribing Implementation

It is helpful to divide e-prescribing into three components:

- Investment/setup
- Operations
- Maintenance

In the investment stage software and hardware are purchased and installed, training is provided, and the installation is refined in light of any problems encountered. Generally speaking, large costs are incurred in this early stage, but little value is generated. Most of the value is generated in the ongoing operations component, while operating costs are also incurred.

The maintenance portion involves corrections, updates, refinements, and accommodations to meet new program initiatives or to meet new technologies with which the e-prescribing system needs to interface. This component involves both costs and increased value.

In the next sections we describe the wide variety of costs and value that may be generated for each stage and for each category of program participant.

The Investment/Setup Component

As noted, this component consists of costs, with little or no value directly accruing at this stage. The cost components are as follows for the Medicaid/CHIP program and associated PBM/managed care agents, prescribing providers, and pharmacies:

- Hardware and software costs of the e-prescribing system (possibly including design or design modification costs to integrate with existing systems).
- The costs of training staff for the new system (both the time/expense of those conducting the training and the time cost of agency/staff who are being trained and who could otherwise have been carrying out other functions).
- The costs of installing and initial troubleshooting of the new system (both the time/expense of the installers and the time cost of agency/staff who are involved in this process and who could otherwise have been carrying out other functions).
- The costs of making the e-prescribing system secure, in particular its connections with other systems.

For enrollees there are no costs for this component.

In practice, the troubleshooting phase will likely extend beyond the rest of the initial investment phase, as will the learning-by-doing of relevant staff.

Costs and Value from E-Prescribing Operations

Ongoing operation of the e-prescribing system generates the value from this technology, while also resulting in operating costs. This value can be generated at any of the points along the path that starts with prescribing and ends with followup and monitoring activities. To better understand where costs and value occur and to whom they accrue, we divide the operation of an e-prescribing system into five sequential components:

- Prescribing by the provider.
- Transmission via e-prescribing to a pharmacy.
- Pharmacy transmission to/from PBM (administrative transaction).
- Patient pickup/delivery of the prescription (in an inpatient setting, this is replaced by administration of the prescription).
- Followup/monitoring activities.

Table 1 proceeds through these five components, briefly describing the potential costs and value that may be generated for each type of participant.

Table 1. Potential costs and value for e-prescription operations

	Medicaid/CHIP program[a]	**Enrollees**	**Prescribing providers**	**Pharmacies**
Prescribing by provider	• Costs: Ongoing subsidies/ performance payments to providers for using e-prescribing, if applicable. Ongoing contractual payments to an e-prescribing vendor, if applicable, in excess of what agency costs would be otherwise. • Value: Decreased program costs because of doctor shopping, duplicate prescriptions, potential fraud/abuse by doctors, with attendant program cost savings. Also, decreased program costs because of improved provider information on less expensive formulary choices. Decreased costs of ADEs because of drug-drug interactions and drug allergies. Decreased costs for program administration of individual claims.	• Costs: None. • Value: Where drug-drug interaction and allergy ADEs are avoided, increased well-being (less pain and suffering; separate from reduced health care system costs).	• Costs: Possible increase in time interacting with e-prescribing system. • Value: Improved access to formulary information, patient medication history, and decision support systems. Decreased recordkeeping costs (transcribing).	• No costs or value at this step.

Table 1. Potential costs and value for e-prescription operations (continued)

	Medicaid/CHIP program[a]	Enrollees	Prescribing providers	Pharmacies
Transmission via e-prescribing to pharmacy	• Costs: Ongoing operating transmission costs, usually charged by the e-prescribing service provider. • Value: Cost savings from decreased treatment costs for ADEs resulting from garbled prescription transmission.	• Costs: None. • Value: Where drug-drug interaction and allergy ADEs because of garbled prescription transmission are avoided, increased well-being (less pain and suffering; separate from reduced health care system costs). Small savings in time used to deliver to pharmacy, or consumer processing time to send to mail-order pharmacy. Potentially, lower chance of misplacing prescription.	• Costs: E-prescribing transmission costs to the provider, usually charged by the e-prescribing service provider. • Value: Reduced costs of interactions with pharmacy/PBM to resolve confusion. Decreased costs of alternative transmission methods.	• Costs: Net change (reduction?) in costs of processing of incoming prescription, after incorporating e-prescribing transmission costs to the pharmacy, usually charged by the e-prescribing service provider. • Value: Reduced costs of interactions with provider to resolve confusion.
Pharmacy transmission to/from PBM (administrative transaction)	• Costs: Potentially faster outflow of funds as payment. • Value: None.	• No costs or value at this step.	• No costs or value at this step.	• Costs: None additional from e-prescribing (pharmacy is usually connected to PBM). • Value: Potentially improved cashflow from faster payment and electronic funds transfers.

Table 1. Potential costs and value for e-prescription operations (continued)

	Medicaid/CHIP program[a]	Enrollees	Prescribing providers	Pharmacies
Patient pickup/delivery of prescription[b]	• Potentially, increased Medicaid prescription costs if more prescriptions are filled, and decreased Medicaid program costs for nonprescription treatment that results from not taking medication.	• If e-prescribing increases the likelihood that a prescription is actually obtained, increased value due to improved health status and decreased sick days from taking appropriate medications. There would also be a possible increase in costs if there is a patient copay for prescriptions.	• No costs or value.	• Potentially, costs related to restocking of prescriptions that are never picked up.
Followup/ monitoring	• Costs: Increased Medicaid prescription costs, if more prescriptions are filled. • Value: Decreased Medicaid program costs for nonprescription treatment that results from not taking medication, if more prescriptions are filled and used appropriately.	• Costs: Copay costs. • Value: Improved health status, decreased sick days.	• Costs: Increased time in patient followup. • Improved quality of care.	• Costs: Increased costs for feedback to physician. • Value: Increased net prescription revenues if monitoring results in increased prescriptions.

Note: ADE = adverse drug events, CHIP = Children's Health Insurance Program, PBM = pharmacy benefits manager

a. Includes costs to PBMs and/or managed care organizations acting on behalf of the agency to assist in administering the program.

b. Because this remains a physical, nonelectronic activity, the net effects of e-prescribing are minimal here. In an inpatient setting, this is replaced by administration of the prescription.

Maintaining the E-Prescribing System

Maintaining the value of the system is a key component of e-prescribing. This can involve corrections, updates (new clinical findings, new drugs, changes to formularies, and so on), refinements, accommodations to meet new program initiatives, and adjustments to meet new technologies with which the e-prescribing system needs to interface. Although issues of security and privacy are relevant throughout all phases and areas of operations, rather than discuss these throughout the guide, they are listed here. Electronic portals are the key areas where privacy and security are most threatened. Yet as technologies evolve, it is likely that new portals to access the e-prescribing system, both intended and unintended, will be developed, with a concurrent need to both adapt and secure the system for these developments. System maintenance involves both costs and increased value.

Chapter 3. What Does the Literature on the Costs and Value of E-Prescribing Tell Us?

The preceding section provided detail on the many places where costs may be incurred or value generated. This section of the guide provides data on these costs and value, derived from content in the Health IT (information technology) Knowledge Library located on the Agency for Healthcare Research and Quality's (AHRQ) National Resource Center for Health IT Web site[3] and from a PubMed search. The Knowledge Library[4] contains both evidence-based and theoretical content gathered by health IT experts. Appendix A presents the details of the multistage approach that was used to identify the studies whose results are presented in this section. In addition to data derived from studies specifically of e-prescribing, this section presents data from studies of computerized provider order entry (CPOE), a broader technology that can include e-prescribing, *if* results specific to prescribing are reported.

The studies that resulted from this approach are summarized in Tables 2 through 7. The studies are listed in categories that were discussed above:

- Insurers.
- Managed care organizations.
- Prescribing providers.
- Pharmacies.

The providers category was further broken out by type of care setting:

- Outpatient clinics.
- Hospitals.
- Long-term care facilities.

Most of the results reported in Tables 2 through 7 are positive, showing either decreased costs or increased value from e-prescribing, and many are supported by tests of statistical significance. They span a range of practice settings and organizations, and collectively provide some information for most of the areas of cost and value described in Table 1, thereby demonstrating a realization of some of the promise of e-prescribing. However, several qualifications need to be noted. No studies were found that met the selection criteria and reported results for a Medicaid or Children's Health Insurance Program (CHIP). And there are results from only one or two studies for private insurers, managed care organizations, or pharmacies. Most of the results are for providers, and most of these are for inpatient hospital care.

A number of the results for providers are for patient-related outcome measures. However, several of these outcomes are process-oriented or intermediate measures (e.g., number of medication orders completed, number of rule-associated lab test orders initiated), as opposed to outcomes such as ADEs. Finally, there are no studies specifically from the perspective of patients.

As discussed later in this guide, estimates of costs and value from external sources are of particular importance in prospective analyses. When estimates are utilized from the sources presented above and elsewhere, one must use caution when incorporating these results into estimates of costs and value for a State's Medicaid/CHIP. It is not clear how well results from

one type of provider can be carried over to other types of providers. In addition, almost all of the findings are for a small number of providers in a specific State. Again, it is not clear how well these results would translate to other situations. Finally, there may be differences in the nature of the care needed between the patients involved in these studies compared to any specific State's Medicaid/CHIP population.

Table 2. Insurers: Findings on cost and value for e-prescribing

Citation	E-prescribing program tested	Measure(s) of cost/value analyzed	Summary of findings	Sample description	Method/type of analysis	Statistical significance testing
Fischer et al., 2008[5]	• E-prescribing with CDSS.	• Cost savings were estimated using average medication costs by formulary tier (generic versus brand name).	• Physicians using e-prescribing prescribed 1.4% more tier 1 (generic), 0.3% fewer tier 2 (brand name), and 1.0% fewer tier 3 (brand name) meds than physicians who did not use e-prescribing. • Projected cost savings of $0.70 per patient per month, using assumptions about prescription volume per patient and average copayment by formulary tier. • Equivalent to $845,000 annual savings in prescription drug spending per 100,000 insured patients who fill prescriptions.	• E-prescribing system was provided to high-volume prescribers by two large Massachusetts insurers. • The prescribers were mostly in community health clinics across Massachusetts.	• Pre-post with concurrent controls, using 18 months of administrative data. • Unit of analysis was individual prescription. • Intervention group: all prescriptions written using e-prescribing. • Control group: all prescriptions not written with e-prescribing. • Calculated the percentage of prescriptions written in each of three formulary tiers for 6 months before and up to 12 months after the start of e-prescribing.	• No. Used multivariate longitudinal models to estimate effects of e-prescribing when controlling for some baseline differences between intervention and control prescribers and patients.

Note: CDSS = clinical decision support system.

Table 3. Managed care organizations: Findings on cost and value for e-prescribing

Citation	E-prescribing program tested	Measure(s) of cost/value analyzed	Summary of findings	Sample description	Method/type of analysis	Statistical significance testing
McMullin et al., 2005[6]	• E-prescribing with CDSS.	• 12-month savings on new prescriptions. • Impact of CDSS on all pharmacy claims and per member per month expenditures. • Prescribing behaviors within eight high-cost therapeutic categories that were frequently targeted by the electronic messages to prescribers.	• Clinicians using the e-prescribing system had lower prescription costs than controls throughout the 12-month followup period. • Proportion of prescriptions for high-cost drugs was lower among the intervention group compared with the controls. • No statistically significant difference in per member per month expenditures	• Nineteen physicians using the e-prescribing system were matched with 19 control clinicians from the same medical group who were not yet using the system. • Examined new prescriptions and their refills via database queries on pharmacy claims.	• Identified all new prescription claims for the two groups of clinicians throughout the 12-month followup period. • Assessed all pharmacy claims during the same 12-month period to provide more complete savings estimates and to examine between-group differences in per member per month expenditures.	• Yes. Mixed ANOVA model for continuous variables and generalized mixed linear model for dichotomous variables.
Ross et al., 2005[7]	• E-prescribing with CDSS.	• Formulary compliance. • Generic drug utilization.	• E-prescribers and traditional prescribers had high levels of formulary compliance (83% for both groups). • No difference in generic drug utilization rates between e-prescribers and traditional prescribers.	• Reviewed 110,975 paid pharmacy claims from a large managed care organization, over a 12-month period in 2001–2002.	• Retrospective review of pharmacy claims data from 2 groups of doctors: 95 using e-prescribing and 95 traditional prescribers matched to the other group by zip code and medical specialty.	• Yes. Chi-square tests to compare groups.

Note: CDSS = clinical decision support system.

Table 4. Clinics and ambulatory care: Findings on cost and value for e-prescribing

Citation	E-prescribing program tested	Measure(s) of cost/value analyzed	Summary of findings	Sample description	Method/type of analysis	Statistical significance testing
Berner et al., 2006[8]	• PDA-based CDSS.	• Safety of prescriptions for nonsteroidal anti-inflammatory drugs.	• Physicians who used the PDA provided safer prescriptions as judged by clinicians who were blinded to condition.	• University-based resident clinic. • 68 clinicians participated.	• RCT comparing two groups of physicians at baseline and at followup. • Physicians were blind to the type of drug being examined.	• Yes. ANCOVA to compare change in prescribing across groups, controlling for baseline differences between groups.
Hollingworth et al., 2007[9]	• Basic e-prescribing system that used the Multum drug lexicon. • No clinical decision support component.	• Time spent by staff prescribing.	• E-prescribing was time neutral (compared with paper-based prescribing) for prescribers and staff.	• Three ambulatory care sites, each using a different prescribing method: paper-based prescribing, desktop, or laptop e-prescribing. • 27 prescribers. • 42 staff.	• Cross-sectional comparison of three sites. • Used time-motion methods to observe staff tasks continuously for 4 hours. • Data were collected by six recorders, sequentially at the three sites.	• Yes. Used t-tests to calculate the mean difference in minutes per hour that prescribers and staff spent on prescribing tasks in paper-based versus e-prescribing clinics.

Table 4. Clinics and ambulatory care: Findings on cost and value for e-prescribing (continued)

Citation	E-prescribing program tested	Measure(s) of cost/value analyzed	Summary of findings	Sample description	Method/type of analysis	Statistical significance testing
Steele et al., 2005[10]	• Physicians entered prescriptions into a computer and were alerted to specific drug-lab test result combinations.	• Number of medication orders not completed. • Number of rule-associated laboratory test orders initiated after alert display. • ADEs.	• Increase in percentage of time the provider did not complete the medication order when an alert for a combination of drug and abnormal laboratory result was displayed. • Providers increased ordering of the rule-associated laboratory test when an alert was displayed. • No statistically significant difference between pre- and post-intervention probable ADEs.	• One outpatient primary care clinic in Colorado. • Review of patient records.	• Pre-post, random sample of patient charts before and after system implementation. • Pre-assessment period lasted 17 weeks. Intervention and post-assessment lasted 21 weeks.	• Yes. Compared percent of orders changed by physicians in response to alert at pre- versus post-intervention.

Note: ADE = adverse drug event; CDSS = clinical decision support system; PDA = personal digital assistant.

Table 5. Hospitals: Findings on cost and value for e-prescribing

Citation	E-prescribing program tested	Measure(s) of cost/value analyzed	Summary of findings	Sample description	Method/type of analysis	Statistical significance testing
Bates et al., 1998[11]	• E-prescribing with CDSS.	• Rate of medication errors. • Rates of preventable ADEs.	• 55% relative risk reduction in medication errors (statistically significant). • 17% relative reduction in ADEs (not statistically significant).	• Large tertiary care hospital.	• Pre-post: Two time points.	• Yes. Paired t-tests used to compare pre versus post.
Bates et al., 1999[12]	• E-prescribing with CDSS.	• Rate of medication errors (not including missed dose errors). • Rate of serious medication errors that were interrupted before the prescription was filled.	• 86% relative reduction in noninterrupted serious medication error rates. • 82% relative reduction in medication errors (not including missed dose errors) (both statistically significant).	• Three units of an inpatient academic hospital. • Participants were all patients admitted to a study floor during the study period. More than 50,000 patient records over the 4 time periods.	• Time series analysis with four time periods. • CPOE was implemented in stages across the study time periods. The system became more sophisticated at each stage.	• Yes. Chi-square test for trends.

Table 5. Hospitals: Findings on cost and value for e-prescribing (continued)

Citation	E-prescribing program tested	Measure(s) of cost/value analyzed	Summary of findings	Sample description	Method/type of analysis	Statistical significance testing
Chertow et al., 2001[13]	• E-prescribing with CDSS to adjust drug dose and frequency.	• Rate of inappropriate drug dose and frequency. • Length of stay. • Hospital and pharmacy costs. • Changes in renal function.	• 13% decrease in inappropriate dose and 24% decrease in inappropriate frequency (both statistically significant). • Length of stay statistically significantly shorter for intervention versus control group. • Comparisons on other outcomes were not significantly different.	• 7,490 adult inpatients with renal insufficiency at a large academic hospital.	• RCT with a crossover design. • Four consecutive 2-month intervals consisting of control (usual e-prescribing) alternating with intervention (e-prescribing + CDSS). • Compared outcomes among hospitalizations during the intervention versus control periods.	• Yes. T-tests, chi-squares, and multivariate regression to compare groups.
Cordero et al., 2004[14]	• E-prescribing with CDSS.	• Medication error rates. • Time from initiation to completion of pharmacy orders.	• Statistically significant reductions in medication turnaround times. • Medication errors decreased from pre to post (no significance testing reported).	• Nursing units in an academic health system. • 111 very low birthweight infants in these units.	• Pre-post. • Retrospective records for two groups: • Infants born in the 6-month period before e-prescribing was implemented. • Infants born in the 6-month period after e-prescribing was implemented.	• Yes. T-tests and chi-squares for comparison of groups.

Table 5. Hospitals: Findings on cost and value for e-prescribing (continued)

Citation	E-prescribing program tested	Measure(s) of cost/value analyzed	Summary of findings	Sample description	Method/type of analysis	Statistical significance testing
Cunningham et al., 2008[15]	• Electronic Physician Order Management (ePOM). Included a CDSS component.	• Compliance with hospital's medication ordering protocol. • Efficiency—time to first dose of antibiotics.	• Medication orders placed using CPOE were more compliant than paper-based orders. • First doses of antibiotics were delivered faster when ordered with CPOE.	• Two hospitals in southwestern Virginia (CPOE versus control). • Reviewed 1,071 patient records at CPOE hospital and 979 records at control hospital.	CPOE compared to control site at three time points: 1. Prior to CPOE implementation. 2. Just after initial CPOE. implementation. 3. After full CPOE implementation.	• Yes. Used a series of ANOVAs and t-tests to test for differences in compliance and efficiency across conditions and time.
Kaushal et al., 2006[16]	• E-prescribing with CDSS, as part of CPOE.	• System costs, including hardware, software, network, leadership, and training. • Benefits: reduction in ADEs, decreased use of drugs, physician and nurse time utilization.	• Over 10 years, the overall CPOE system saved the hospital $28.5 million. • Cumulative net savings were $16.7 million. • Net operating budget savings of $9.5 million.	• Inpatients at a large academic hospital.	• Used a range of data from operating budgets, key informants, internal documents, published literature.	• No.

Table 5. Hospitals: Findings on cost and value for e-prescribing (continued)

Citation	E-prescribing program tested	Measure(s) of cost/value analyzed	Summary of findings	Sample description	Method/type of analysis	Statistical significance testing
Mekhjian et al., 2002[17]	• Physician order entry system.	• Time from initiation to completion of order. • Timeliness of countersignature of verbal order. • Volume of nursing transcription errors. • Length of stay. • Total cost.	Statistically significant reductions from pre to post in several measures, including: • Medication turnaround times. • Improvement in countersignature of verbal orders. • All physician and nursing transcription errors eliminated.	• Inpatient nursing units in an academic health system.	• Pre-post. • Compared records from before e-prescribing implementation versus after e-prescribing implementation. • Each time period lasted 1 month.	• Yes. T-tests to compare groups.
Potts et al., 2004[18]	• E-prescribing with CDSS.	• Potential ADEs. • Medication prescribing errors. • Rule violations (errors that were not compliant with standard hospital policies such as abbreviations).	• 41% decrease in medication errors categorized as potential ADEs. • 99% decrease in medication prescribing errors. • 98% reduction in rule violations.	• 514 pediatric patients admitted to a 20-bed ICU in a children's hospital.	• Pre-post implementation of e-prescribing. • Review of all orders during the study period, identification and classification of errors as potential adverse events, medication prescribing errors, and rule violations.	• Yes. Chi-square and Fisher's exact test to compare rates at pre- versus post intervention.

Table 5. Hospitals: Findings on cost and value for e-prescribing (continued)

Citation	E-prescribing program tested	Measure(s) of cost/value analyzed	Summary of findings	Sample description	Method/type of analysis	Statistical significance testing
Stone et al., 2009[19]	• E-prescribing with CPOE.	• Medication errors. • Order times. • Personnel requirements .	• Nonsignificant change in medication errors for surgical procedures. • Significant decline in mean total order time from 41.2 minutes per order before CPOE to 27 seconds per order using CPOE. • Four additional IT specialists were temporarily required to implement CPOE. After CPOE adoption, 11 of 56 (19.6%) ancillary personnel positions were eliminated due to order-entry efficiencies.	• Medication orders for surgical inpatients served by an academic multispecialty practice.	• Retrospective and prospective analyses of patient-safety measures pre- and post-CPOE introduction using data from an error self-reporting system.	• Yes, t-test for statistical significance.
Taylor et al., 2002[20]	• E-prescribing system.	• Process time for medication ordering. • Time from writing the medication order to the arrival of the medication.	• E-prescribing increased medication-ordering efficiency by 92% (efficiency defined as total processing time for ward clerks, nurses, and pharmacists).	• Academic hospital. • Inpatients in the family medicine unit consisting of 23 beds.	• Measurement of time spent on process activities during two 10-day periods, before and after e-prescribing, including time spent by physicians, nurses, clerks, and pharmacists in the hospital. Process times translated into dollar values using current pay rates.	• No.

Table 5. Hospitals: Findings on cost and value for e-prescribing (continued)

Citation	E-prescribing program tested	Measure(s) of cost/value analyzed	Summary of findings	Sample description	Method/type of analysis	Statistical significance testing
Teich et al., 2000[21]	• E-prescribing with CDSS.	• Change in use of recommended drug. • Change in standard deviation of drug dosage. • Proportion of doses that exceed the recommended maximum. • Change in use of approved frequency of all ondansetron orders. • Change in use of subcutaneous heparin sodium to prevent thrombosis in patients at bed rest.	• Statistically significant improvement in each of the five prescribing practices.	• Inpatients at a large academic hospital.	• Pre-post (1- and 2-year followups).	• Yes. Chi-square or t-test for each outcome.
Tierney et al., 1993[22]	• E-prescribing with CDSS (including guidance on cost of drugs).	• Costs and utilization of health care.	• 12.7% reduction in total costs per admission. • Decreases in hospital bed, medication, and diagnostic test costs. • Decrease in length of stay. • Increase in length of time spent ordering tests.	• Public hospital in Indianapolis. • 5,219 internal medicine inpatients and the 68 teams of practitioners who cared for them.	• RCT. • Physicians assigned to either intervention or control group. • Also performed a time-motion study where trained observers noted all activities for 24 randomly selected interns.	• Yes. Satterthwaite's approximate F test to compare intervention and control groups for each outcome.

Table 5. Hospitals: Findings on cost and value for e-prescribing (continued)

Citation	E-prescribing program tested	Measure(s) of cost/value analyzed	Summary of findings	Sample description	Method/type of analysis	Statistical significance testing
van Rosse et al., 2009[23]	• Meta-analysis of 12 studies of e-prescribing with CPOE.	• Medication prescription errors. • Potential and actual ADEs. • Mortality rate.	• For all studies combined, there was a significant reduction in medication prescription errors. • In pediatric and neonatal studies, potential and actual ADEs showed a nonsignificant decrease with the use of CPOE with significant heterogeneity among the studies. • In pediatric and neonatal studies, mortality rates were not significantly influenced by CPOE except for one study.	• Sample consisted of patients hospitalized in 4 adult ICUs, 4 pediatric ICUs, and 4 pediatric inpatient units. • Intervention compared CPOE with no CPOE. • Study utilized a randomized trial or observational cohort study design.	• Meta-analysis. • Studies were evaluated for whether: control and intervention groups were defined; possible sources of selection bias, or misclassification were identified and/or adjusted for; outcome measures were clearly defined; exact study period was defined; implementation process was described; and outcome data were provided. • Data were analyzed on an intent-to-treat basis.	• Relative risk estimates were calculated along with 95% confidence intervals (CI). • Pooled estimates across samples were calculated using a random-effects model.

Table 5. Hospitals: Findings on cost and value for e-prescribing (continued)

Citation	E-prescribing program tested	Measure(s) of cost/value analyzed	Summary of findings	Sample description	Method/type of analysis	Statistical significance testing
Yu et al., 2009[24]	• E-prescribing with CPOE.	• Hospital performance on 20 quality performance measures.	After controlling for confounders, CPOE hospitals • outperformed comparison hospitals on 5 of 11 measures related to ordering medications, • outperformed comparison hospitals on 1 of 9 nonmedication-related quality measures, and • underperformed comparison hospitals on 1 of 9 nonmedication-related quality measures.	• 3,364 U.S. hospitals in the Hospital Quality Alliance, which provided data for a number of quality performance measures and CPOE status. • 8% of hospitals had fully implemented CPOE systems. • CPOE hospitals were more frequently larger, not-for-profit, and teaching hospitals	• A cross-sectional study comparing hospitals having fully implemented CPOE systems with those not having a fully implemented system. • Performance measures were calculated at the hospital level.	• Performance on quality measures was assessed using univariate and multivariate methods.

Note: ADE = adverse drug event; CDSS = clinical decision support system; CPOE = computerized physician order entry; ICU = intensive care unit; RCT = randomized controlled trial.

Table 6. Long-Term Care Facilities: Findings on cost and value for e-prescribing

Citation	E-prescribing program tested	Measure(s) of cost/value analyzed	Summary of findings	Sample description	Method/type of analysis	Statistical significance testing
Field et al., 2009[25]	• E-prescribing with CDSS.	• Renal function medication error rates.	Physicians in the intervention units receiving alerts: • Submitted appropriate drug orders 62.8% of the time compared to 52.1% in the control units. • Ordered appropriate doses at a rate (75.4%) similar to the controls (79.9%). • Ordered drugs at or below the recommended maximum frequency 61.2% of the time, compared to 25.7% in the controls • Avoided prescribing a nonrecommended drug 40.6% of the time compared to 15.4% in the controls • Ordered missing serum creatinine testing 63.8% of the time compared to 34.8% in the controls.	• 833 long-term care residents in 22 units for Alzheimer's, behavioral/ mental health, complex medical condition, functional support, and stroke/ cognition in an academically affiliated long-term care facility.	• 12-month trial randomized by long-term care unit. • Unit of analysis was individual prescription.	• Yes. Intervention and control units were compared using x^2 for the categorical variables and unpaired t-test for age.

Note: CDSS = clinical decision support system.

Table 7. Pharmacies: Findings on cost and value for e-prescribing

Citation	E-prescribing program tested	Measure(s) of cost/value analyzed	Summary of findings	Sample description	Method/type of analysis	Statistical significance testing
Astrand et al., 2009[26]	• E-prescribing	• Clarification contacts with prescribers on all prescriptions transferred to the pharmacy within a 3-week time period.	• Clarification contacts were made for 2% of e-prescriptions vs. 1.2% of non-e–prescriptions. This represented a relative risk of 1.7.	• Three Swedish mail-order pharmacies that dispensed a large number of e-prescriptions.	• Compared percent of prescriptions with clarification contacts for e-prescriptions versus non-e–prescriptions.	• No. Calculated relative risk using crosstabs.

Note: ADE = adverse drug event; CDSS = clinical decision support system; CPOE = computerized physician order entry; PDA = personal digital assistant; RCT = randomized controlled trial.

Chapter 4. Cost Effectiveness Analysis and Other Types of Analysis

Regardless of the timeframe adopted for the evaluation of costs and value, there are several types of analyses in which costs and value can be combined to yield information about the desirability of an e-prescribing initiative, and some of these types have several variations. All of them may require time discounting, which is discussed in Chapter 5.

The most ambitious of these analyses require that dollar values be assigned to both the costs and the value generated. It is comparatively easy to quantify many of the direct costs of implementation of e-prescribing, and there are likely to also be some types of value produced to which dollar values can be attached. For example, if we can estimate hospitalizations avoided because of the avoidance of some adverse drug reactions (ADEs), we can attach a dollar value to those hospitalizations. However, it is more difficult to attach a dollar value to the pain and suffering that a Medicaid beneficiary will avoid by preventing an ADE.

A perennial difficulty in evaluating the benefits of many government initiatives is that it may be possible to *quantify* benefits in some way, but may be much more difficult to attach *dollar values* to these benefits. This monetization has been done in a variety of circumstances, including by government agencies in evaluating government programs either prospectively or retrospectively. As a result, from time to time Federal agencies have weighed in on some aspects of this process of attaching value to lives saved, life-years of improved health, and avoidance of events such as ADEs. However, the monetizing of such beneficial outcomes often requires that assumptions be made and is not without controversy. Therefore, this guide does not discuss the monetization of most types of value generated by e-prescribing. Instead this guide assumes that decisions that (in essence) take into account the dollar value of these beneficial outcomes will be made implicitly by representatives of government and voters. Nevertheless, other methods that require this monetization are briefly described in the following section.

This guide largely focuses on *cost-effectiveness* analysis to assist decisionmaking about e-prescribing. Cost-effectiveness analysis combines dollar measures of costs with quantified measures of value, but these are not measured in dollars.

Many cost-effectiveness analyses in health care have focused on just one or two outcomes, or sources of value, among many—for example, mortality, or direct health care costs. However, as the descriptions in Chapter 2 demonstrate, e-prescribing can potentially generate costs and value via many avenues. And for e-prescribing, the value generated is likely to include both benefits that can possibly be valued in dollars terms as well as benefits that are more difficult to express in dollar terms. Although measuring all costs and benefits is probably not feasible, it is advisable to incorporate measures for as many components of costs as is possible and for several elements of value. Choosing these elements of value is discussed in Chapter 5.

Other Types of Analysis That Require Value in Dollar Terms

The most ambitious analyses require that dollar values be assigned to both the costs and the value generated. When these measures of dollar costs and dollar benefits have been estimated, there are several methods that can be used to analyze the relationship between these benefits and costs. Each of these methods has advantages and drawbacks. Although attaching monetary

values to a portion of the value generated by e-prescribing is not the focus of this guide, these methods are briefly reviewed below.[*]

The method that the U.S. Office of Management and Budget (OMB) prefers is a calculation of *net present value*. In this calculation, all costs and benefits are brought to the present time, and the costs are subtracted from the benefits. However, the net present value of an e-prescribing initiative is not a perfect measure. In particular, it does not provide any sense of the value generated relative to the scale of the e-prescribing initiative. For example, one could have a relatively expensive e-prescribing system, with extensive clinical decision support that integrates a range of information from all sources, and that yields positive net benefits. Hypothetically, however, a more minimal e-prescribing system could yield roughly the same net present value by having lower costs but also lower benefits. In this hypothetical situation, given the opportunity costs of the funds for an e-prescribing initiative, it might not make sense to adopt the most complex, integrated, and far-reaching system (at least until the price of such a system decreases).

Another approach is to calculate a *cost-benefit ratio*, in which the benefits are divided by the costs. This measure does reflect the size of the investment. However, a cost-benefit ratio suffers from other limitations. In particular, it is sometimes somewhat arbitrary as to whether a reduction in some aspect of costs is counted as a benefit (to be included in the numerator) or a reduction in the costs of the e-prescribing implementation (to be subtracted from the denominator). Where this amount is counted will affect the numerical result for the cost-benefit ratio. An example is the potential savings in health care because of increased avoidance of ADEs. In a net present value, it does not matter how these cost reductions are recorded—the net present value will be the same. However, a cost-benefit ratio will change, depending on whether this cost reduction is counted as a benefit that goes in the numerator or a decrease in the level of costs that goes in the denominator.

Implementing e-prescribing may require a specific budget allocation or appropriation that will reflect the State's share of the costs of e-prescribing, but not the cost savings that may be generated (not even the cost savings to the State). In addition, in some instances the investment costs may be incurred by the agency (for example), while the cost savings accrue to other participants. To assist clarity in understanding these issues, this guide, therefore, considers all changes in costs beyond the direct net costs of e-prescribing implementation to either increase or diminish the value generated by the system.

Another approach that is often used in business applications is to calculate the *return on investment*. This approach takes the net present value of the system being considered, and divides this amount by the investment costs of the system. The resulting percentage represents the return on investment. This percentage, or rate, can then be compared with the rates of return for alternative investments, and with several different costs of capital, such as an interest rate for loans.

Yet another approach is to calculate an *internal rate of return* (IRR). The IRR results from a calculation that finds the discount rate that will equate the stream of costs to the stream of benefits. In other words, internal rate of return is the discount rate that will yield a net present value of zero: The higher the IRR, the more worthwhile the investment in an e-prescribing system. The IRR is most widely used in situations where those performing the analysis are comparing the value of a project with alternative uses of the same funds. For example, a company may want to make comparisons between the IRR and the rate at which the company

[*] Additional information on these techniques can be found in Campbell and Brown,[27] Nas,[28] and Zerbe and Bellas.[29]

can borrow funds, or invest them. A difficulty with the IRR method is that in situations where the stream of costs and benefits follows an unusual time pattern, more than one IRR may equate the stream of costs to the stream of benefits—that is, there may be two different IRRs.

Finally, another approach is to calculate the *payback period*, which measures the time required for the cash inflows to equal the original monetary outlay. A serious shortcoming of the payback period is that it provides no additional information about what types of benefits there might be beyond the payback period, which would potentially indicate greater benefit from the investment.

Chapter 5. Measuring Costs, Choosing Outcome Measures and the Time Frame for Evaluation

Given that e-prescribing can affect costs and value in many ways, narrowing the focus of an evaluation is necessary. One element, discussed in Chapter 2, is to decide which participants' costs and value will be included in the evaluation: only the Medicaid/Children's Health Insurance Program (CHIP) budget, or also some elements related to enrollees, prescribing providers, or pharmacies.

Beyond this decision, focusing on a subset of potential costs and value is necessary. The feasibility of estimating specific costs and value depends on the data sources required and the complexity of the analysis needed to transform the data into estimates of cost and value.

Much of the direct costs of e-prescribing to the State will be relatively easy for the State agency to estimate. These include the costs of the initial investment in e-prescribing, the training of staff, and the agency staff time taken up by this training. Also, many of these costs may be represented in specific contractual agreements with outside vendors or program payments to providers, and many others may be estimated by combining estimates of staff time used with payroll information. The ongoing operating and maintenance costs to the Medicaid/CHIP program of e-prescribing can be similarly estimated.[*]

The costs to be measured are the *net changes* in costs for any particular cost category. For example, if two full-time equivalent State employees are required to perform a specific set of functions for the new e-prescribing system, but the current manner that prescriptions are handled by the Medicaid/CHIP program also requires two full-time equivalent State employees (who will no longer have to perform the duties required for paper-based prescribing), then for an evaluation of cost and value the (net) cost to the State of employees performing these specific functions is zero. The same principle applies to value as well, but is less likely to be a troublesome issue.

However, there is no consensus on how exactly to treat *cost savings* in one area that result from increased costs in another area as a result of the adoption of new system. An example would be if a pharmacy reduces its costs of followup contacts with the prescribing provider as a result of the installation of e-prescribing for that provider, which required increased costs for that provider. One could subtract the cost savings for the pharmacy from the e-prescribing costs for the provider at the outset, generating measures of net costs related to e-prescribing. But this then obscures the actual processes that generate costs and value. In addition, while government budgeting may take into account net changes in government personnel costs, for example, in budgeting for e-prescribing (as described in the preceding paragraph), budgeting would probably not net out cost savings outside of the program budget. Therefore, cost savings not directly related to the same function for the same participant ought to be considered as components of the value generated.

Several factors can drive narrowing the set of costs and value to be analyzed. One approach is to consider what key policy objectives e-prescribing is expected to meet. These may include administrative cost savings for the program, better avoidance of duplicate prescriptions, further decreasing potentially avoidable ADEs, increasing/decreasing prescribing of specific types of medicines for children with specific conditions, and so on

Some e-prescribing systems may be better tailored to save operating and administrative costs or generate specific types of value among the range of activities involved in prescribing. The

[*] Some additional detail on estimating full personnel costs can be found in Hamblin and Shearer.[30]

characteristics and range of the clinical decision support system (CDSS) will affect the nature of the clinical situations that the e-prescribing will be able to detect and, thereby, the types of value that the e-prescribing is capable of generating.

This guide does not focus on the characteristics of specific competing e-prescribing systems and the CDSSs that they incorporate. However, policy priorities may affect the choice of system, because the system and its clinical decision support will in part determine what types of value and costs will result from the adoption of e-prescribing. For example, National Opinion Research Center,[31] in its report on e-prescribing pilot sites, discusses the (unexpected) role of "surrogate prescribers," the continuing use of a paper prescribing system, and physician concerns about the accuracy and usability of patient medication history and formulary functions.

Another potential approach is choosing measures to explore, among the many potential sources of costs and value, along two dimensions from the perspective of the agency. One dimension is the frequency with which a cost or value occurs; the other is the average magnitude of effect when it does occur. For example, ADEs that lead to emergency department and/or inpatient-hospital care have a low likelihood of occurring. However, when they occur they are quite expensive, both in terms of program costs and inconvenience and, potentially, pain and suffering of the beneficiary.

It may be helpful to set up a table with four cells, and review potential costs and value and determine in which of these four cells each potential measure falls, as follows:

	High Impact on Costs or Value	**Low Impact on Costs or Value**
High Probability	Category 1	Category 2
Low Probability	Category 3	Category 4

The most effort should be focused on quantifying elements of cost or value in Category 1. The cost-effectiveness evaluation can be made less complex by ignoring elements of Category 4. It is less clear-cut whether elements in Categories 2 and 3 should be included or excluded. One component of deciding about these elements is whether any of them represent explicit program objectives.

Another factor should be incorporated in deciding whether to focus on specific cost or value elements: ease of analysis. A State's Medicare or CHIP program will generate large amounts of administrative data that can be utilized in evaluating the value that is generated by e-prescribing, including outcome and process measures. These are the measures of costs and value with low collection costs. At a very aggregate level, for example, two basic measures are prescriptions per physician and prescriptions per enrollee. Statistical analysis may or may not be needed to extract results that can be associated with the introduction of e-prescribing when using measures at this level of aggregation. On the other hand, incorporating the entire relevant State population is possible, which will provide significant statistical power as well as a comprehensive evaluation.

Other measures may require abstraction from medical records, case-study observation of how e-prescribing is working in practice, or collecting data from pharmacies, PBMs, or providers. These measures will have (potentially significant) collection costs. One might be able to identify specific ADEs or medication errors that either occurred in the absence of e-prescribing or that were prevented using e-prescribing through chart review. Some examples of intermediate measures for which data might be collected are net change in time spent per patient or on time spent prescribing, or net change in system costs related to maintaining paper prescription records

(storage space, staffing costs, and so on). A clinical process measure might be the percentage of alerts or reminders that resulted in the indicated action. A pharmacy-related measure might be the number of pharmacist interventions/callbacks per medication order.

If additional data collection is considered, the costs of such an activity will likely limit the number of observations available for the evaluation. Cusack and Poon[32] discuss these tradeoffs and a range of metrics for provider settings. They also discuss the issue of statistical power, which will be determined by the size of the data collection effort. However, even when a study design provides ample statistical power, the costs of record abstraction (or similar data collection), and the fact that data collected from a small number of sites may not be representative of the Medicaid/CHIP program overall, indicate that incorporating such additional types of data collection represents an ambitious evaluation strategy.

Finally, the evaluation should make careful distinctions between process or intermediate outcome measures and final outcome measures. Final outcome measures are the ultimate objectives of the e-prescribing. Examples are decreased ADEs, increased compliance with prescribed drug regimens, and from the agency perspective, decreased program spending. Process measures are not ends in and of themselves (e.g., decreased pharmacy callbacks to providers).

The Time Frame for Evaluation

An evaluation of costs and value can be performed in three basic timeframes:

1. **Prospective evaluation—**before a decision is made to implement a specific e-prescribing system.
2. **Early implementation evaluation—**during the initial adoption period, whether this involves a (partial) pilot implementation, or the initial stages of a full-State rollout.
3. **Retrospective evaluation—**after the e-prescribing system has been operational for several years.

An evaluation in each of these timeframes can yield useful information. This guide presents brief detail for each in the next three sections.

Chapter 6. Prospective Evaluation

Often the greatest interest in wanting to know the costs and value of e-prescribing comes *before* the decisions are made on whether to implement this type of health IT, and which e-prescribing system to implement. While this justification is compelling, understanding the costs and value is difficult because little or no data will be available yet on the effects of implementing an e-prescribing system for that State's specific Medicaid or Children's Health Insurance Program (CHIP). Therefore, prospective evaluation at this pre-adoption juncture is much more dependent than an early implementation or retrospective evaluation on making assumptions about what is expected to happen when a specific e-prescribing application is introduced in a specific program in a specific State.

Many of the broader analyses of the cost-effectiveness and benefits of e-prescribing that have appeared in recent years, especially the most optimistic ones, are in essence prospective analyses. Because the results of these analyses are determined by a combination of assumptions and data derived from other places, settings, and/or times, they involve greater uncertainty and need to be conducted carefully. In particular, it is necessary to guard against the introduction of biases. These biases may be in several directions—for example, a prospective evaluation may insufficiently explore the ways in which actual implementation may fall short of the desired or claimed ideal, provide an incomplete accounting of all relevant costs that will be incurred, or omit unforeseen areas where value may be generated.

This guide is not intended to cover the entire process of selecting a particular e-prescribing system and/or how to implement it from a contractual or provider adoption perspective. However, following the steps below will assist in understanding the costs and value of any e-prescribing system under consideration.

A prospective evaluation of the costs and value of an e-prescribing implementation can be broken into the following seven steps.

1. **Decide which perspectives you will consider in evaluating costs and value** (for example, the Medicaid/CHIP program, enrollees, prescribing providers, and so on, as discussed in Chapter 2).

2. **Estimate the costs of the e-prescribing implementation.** It will likely help to divide these costs into investment/setup, operations, and maintenance components. Chapters 2, 3, and 5 provide additional detail on costs.

Some cost data are reported in the research and results described in Chapter 3. However, those studies reported results for specific types of providers treating specific populations in specific locales. Consequently, adopting these results needs to take into account and adjust for these differences. Prospective cost estimates can also be provided by vendors of specific systems, but may reflect a range of motivations, and may omit costs that would not be incurred by the vendor. Cost estimates may also be available from your or other agencies for similar technology adoptions. However, the technology evaluated may also have significant differences from the one under consideration. Here again, adopting these results needs to take into account and adjust for these differences.

3. **Decide which value elements are most important.** The discussion in Chapter 5 can help guide these choices.

4. **Create estimates of value for these components.** This is the most difficult step in this process. Data can be obtained from the research and results described in Chapter 3. However, those studies reported results for specific types of providers treating specific populations in specific locales. Consequently, adopting these results must take into account and adjust for these differences.

Analyses may also be available from your or other agencies that provide information on expected effects on value. However, the technology evaluated may be significantly different from the one under consideration. Consequently, adopting the results reported for these other adoption processes must take into account and adjust for these differences.

These potential sources of information may not provide sufficient information for the selected value areas. If that is the case, then it may be necessary to explore the use of data even more removed from the specific e-prescribing system being evaluated.

The following example demonstrates the need to estimate potential value from data that do not directly result from an actual e-prescribing adoption. It is likely that some type of e-prescribing system may decrease inpatient hospital stays resulting from ADEs. Because inpatient hospital stays are expensive, decreasing such stays may be considered an important value outcome, even if such adverse events are rare. However, as demonstrated in Chapter 3 there is little in the way of rigorous evidence that provides quantifiable data on how large this effect of any specific e-prescribing system is. However, research does exist on the magnitude of emergency department visits and hospitalizations due to ADEs, which could be used to provide an estimate of the extent of these expensive events for State Medicaid/CHIP programs. What would then be needed is some assumption about what percentage of this care resulting from ADEs would be prevented as the result of implementing a specific e-prescribing system. The percentage would clearly be less than 100 percent, for several reasons—for example: drug allergies and reactions are not known until they occur for the first time, resulting in unavoidable ADEs; the specific e-prescribing system may not incorporate an exhaustive and up-to-date set of clinical decision support data; and even if present, the prescriber may not respond to the clinical decision support system (CDSS) prompts. The assumption made about what percentage of ADEs would have been prevented will possibly have little empirical support, which makes the performance of sensitivity analysis (Step 6 below) all the more important.

5. **If your timeframe for costs and value extends 3 or more years into the future, use discounting in the calculations (see Chapter 9).** Because the investment and implementation costs of e-prescribing are heavy in the initial phase and the value generated will occur over a number of years following implementation, discounting will likely be necessary for a quality evaluation.

6. **Conduct sensitivity analyses (see Chapter 9).** It is particularly important in a prospective evaluation to incorporate sensitivity analysis, as it is more likely in this type of evaluation to be necessary to make assumptions that may have little empirical support. In the example described in Step 4, one sensitivity analysis would involve taking the estimate of the number of hospitalizations due to ADEs that would be prevented due to e-prescribing implementation and raise and lower it by different percentages. These higher and lower percentages are then used to generate additional estimates of the number of hospitalizations due to ADEs that would be prevented due to e-prescribing. If the resulting estimates of prevented hospitalizations are significantly different from the baseline estimate, then it is important to: (1) present these additional results; and (2) investigate further how much confidence there is in the baseline assumptions.

7. **Combine the cost and value estimates into an evaluation document.** Some value may be expressed in dollars (avoided hospitalizations and emergency room visits), while others will not have dollar values attached. In presenting an evaluation of costs and value, it is important to give appropriate weight to the nonmonetized value elements. Policy input and political considerations will be needed to interpret this combination of monetized and nonmonetized value, a process outside the scope of this guide.

Chapter 7. Early Implementation Evaluation

An early implementation evaluation can be performed during the initial adoption period when the evaluation may affect whether a demonstration project is taken statewide, or during the early period of a full-State adoption. This type of evaluation can contribute to discussions of whether the implementation should be modified based on the early results. One limitation of an early implementation evaluation is that while the large investment costs of e-prescribing will be easily observed, only the early years in the stream of value that may be generated will be observed. Another is that providers and others may require time to become efficient in the use of the e-prescribing system, and fully incorporate its value-generating features into their practices.[†] If these adjustments to e-prescribing take sufficiently long, the full measure of this stream of value may be underestimated.

An early implementation evaluation of the costs and value of an e-prescribing system implementation can be broken into the following eight steps.

1. **Plan the data needs for the evaluation.** Your State Medicaid/CHIP program will have access to a range of program administrative data, as well as cost and administrative data generated by vendors (if applicable). However, where an outside vendor is used, data may also be created (as part of their operations) that are not routinely transmitted to your agency. Some of these data may relate to costs and value. One example might be the number of physician callbacks that are required to safely fill prescription orders. It will be valuable to consider incorporating access to such data in planning documents or contractual agreements. If the evaluation includes any chart review or enrollee surveys, then these need to be planned early in the process. Even if the evaluation is only utilizing administrative data, it will be worthwhile to ensure convenient access to baseline data when the evaluation is performed.

2. **Decide which perspectives you will consider in evaluating costs and value** (for example, the Medicaid/CHIP program, enrollees, prescribing providers, and so on, as discussed in Chapter 2).

3. **Estimate the costs of the e-prescribing implementation.** Dividing these costs into investment/setup, operations, and maintenance components will be helpful. Chapters 2, 3, and 5 provide additional detail on costs. A good portion of the investment/setup and operations portions of costs will be known. However, even some of these, such as agency costs that are devoted to the implementation and monitoring of the e-prescribing system, may need to be estimated.

4. **Decide which value elements are most important.** The discussion in Chapter 5 can help guide these choices.

5. **Create estimates of value for these components.** An early implementation evaluation is valuable in two ways. First, actual data are available for the implementation of that specific system in that particular program. Second, those providers or other health system components that are not yet using the system can serve as comparison groups. However, it is important to control for possible differences between the group for which e-prescribing has been introduced and the group that is still operating under the previous system, if these two groups are being compared. See the parts of Chapter 9 on "Comparing Like with Like" and "Differences in Differences."

[†] Many adjustment issues are described in National Opinion Research Center.[31]

6. **If your timeframe for costs and value extends 3 or more years into the future, use discounting in the calculations (see Chapter 9).** This step applies if you are making assumptions about future value and costs, beyond the early implementation data, to provide a more complete evaluation. Because the investment and implementation costs of e-prescribing are heavy in the initial phase and the value generated will occur over a number of years following implementation, discounting will likely be necessary for a quality evaluation.

7. **Conduct sensitivity analyses (see Chapter 9).** It is important to incorporate sensitivity analysis in an early implementation evaluation. Of particular importance is estimating what the year-after-year costs and effects on value will be after the e-prescribing system has passed beyond early implementation issues. For example, if the early data show that the generation of value is increasing over time as providers and enrollees adapt to the new system, one sensitivity analysis might focus on analyzing different assumptions about whether the value generation will remain at the last observed level, or continue to increase for at least some additional time.

8. **Combine the cost and value estimates into an evaluation document.** Some of the value may be expressed in dollars (avoided hospitalizations and emergency room visits), while others will not have dollar values attached. In presenting an evaluation of costs and value, it is important to give appropriate weight to the nonmonetized value elements. Policy input and political considerations will be needed to interpret this combination of monetized and nonmonetized value, a process that is outside the scope of this guide.

Chapter 8. Retrospective Evaluation

An evaluation that is performed after the e-prescribing system has been operational for several years is most likely to provide an accurate representation of the costs and value associated with the system (assuming that appropriate data have been collected and retained). The evaluation can avail itself of a number of years of data post-introduction, and can, therefore, better reveal the costs and value that actually result over the life of the e-prescribing system. In particular, a retrospective evaluation is more likely to fully span the adjustment process to a new e-prescribing system. If a retrospective evaluation finds a discrepancy between what was expected (in a prospective evaluation, for example) and what the e-prescribing system has actually yielded, this finding can help direct a search for improvements in the e-prescribing system. A retrospective evaluation can also help make future evaluations more accurate through the knowledge of hindsight.

A retrospective implementation evaluation of the costs and value of an e-prescribing system implementation can be broken into the following eight steps.

1. **Plan the data needs for the evaluation.** Your State Medicaid/CHIP program will have access to a range of program administrative data, as well as cost and administrative data generated by vendors (if applicable). However, where an outside vendor is being used, data may also be created as part of their operations that are not routinely transmitted to your agency. Some of these data may relate to costs and value. One example might be the number of physician callbacks that are required to safely fill prescription orders. It will be valuable to consider incorporating access to such data in planning documents or contractual agreements. If the evaluation includes any chart review or enrollee surveys, then these need to be planned early in the process. Even if the evaluation is only utilizing administrative data, it will be worthwhile to ensure convenient access to baseline data by the time the retrospective evaluation is performed.
2. **Decide which perspectives you will consider in evaluating costs and value** (for example, the Medicaid/CHIP program, enrollees, prescribing providers, and so on, as discussed in Chapter 2).
3. **Estimate the costs of the e-prescribing implementation.** Dividing these costs into investment/setup, operations, and maintenance components will be helpful. Chapters 2, 3, and 5 provide additional detail on costs. Most of the investment/setup and operations portions of costs will be known. However, even some of these, such as agency costs that are devoted to the implementation and monitoring of the e-prescribing system may need to be estimated.
4. **Decide which value elements are most important.** The discussion in Chapter 5 can help guide these choices.
5. **Create estimates of value for these components.** One advantage of a retrospective evaluation is that actual data are available for the implementation and maintenance of that specific system in that particular program. If the entire Medicaid/CHIP program is using the e-prescribing system, then it will take some effort and analysis to estimate the net additions to value resulting from adopting the system. In using a comparison group to get at this, it is important to control for possible differences between the comparison group and enrollees in the Medicaid/CHIP program. See the parts of Chapter 9 on "Comparing Like with Like" and "Differences in Differences."
6. **If your timeframe for costs and value extends 3 or more years into the future, use discounting in the calculations (see Chapter 9).** In a retrospective evaluation, discounting should likely be employed, as the timeframe will be long enough to justify it.

7. **Conduct sensitivity analyses (see Chapter 9).** Because of the data available in a retrospective evaluation, sensitivity analyses are not as strongly needed. However, they may be worthwhile, in particular, in analyzing the effects of differences between the control group and the intervention group program.

8. **Combine the cost and value estimates into an evaluation document.** Some of the value may be expressed in dollars (avoided hospitalizations and emergency room visits), while others will not have dollar values attached. In presenting an evaluation of costs and value, it is important to give appropriate weight to the nonmonetized value elements. Policy input and political considerations will be needed to interpret this combination of monetized and nonmonetized value, a process that is outside the scope of this guide.

Chapter 9. Analytical Issues in Estimating Costs and Value

There are a number of technical issues to consider in conducting a high-quality evaluation of the costs and value generated by an e-prescribing program. This chapter provides brief discussions of some of the more important issues. The objective of the following sections is to familiarize the reader with the basic substance of these issues and indicate additional resources if more detail is desired. Regardless of whether an evaluation is conducted within an agency, by another part of government, or by outside contractors, the information in these sections can help ensure that important methodological questions are asked and appropriate analytical techniques are used.

The Stream of Benefits Over Time, Discounting, and Return on Investment

Investing in some form of e-prescribing system will usually involve some significant upfront investment. This is then followed by the costs needed to operate and maintain the system over the ensuing years, and the generation of a stream of value and cost savings in other areas over time. If one simply compares the startup costs of the e-prescribing investment with the value generated during a single subsequent year, this comparison will almost certainly underestimate the cost-effectiveness of the initiative. To evaluate e-prescribing, a full accounting is needed that takes into account the entire time frame over which costs and value occur. Regardless of the type of evaluation being conducted, it is necessary to bring this stream of future value and costs back to the present by calculating a "present value." This is accomplished through the use of a discount rate, which reflects a time preference for the present over the increasingly remote future as we consider years further out. When both costs and value are discounted from each time period back to the present and summed, this is called the net present value, as discussed earlier in Chapter 4 of this guide.[‡]

The higher the discount rate, the lower the present value of future costs and benefits. Some policy analysts have commented that although the private sector discounts the future in calculating the returns on business investments, a government effort should possibly not use a similar approach. That is, government investments should take a longer view, whether that involves considering benefits for future generations or future benefits for current generations. While this is an element of government decisionmaking, it is still important to incorporate a "positive rate of time preference" by discounting future benefits and costs. Consider two e-prescribing technologies that cost the same amount in terms of initial investment and maintenance costs. They also generate the same levels of value each year, for the same number of years, but one starts generating these benefits more quickly than the other. Without discounting, the two technologies would be considered equivalent in terms of cost-benefit and cost-effectiveness calculations. However, when discounting is used to bring all benefits and costs to the present year, the system that delivers more benefits sooner will show a higher level of benefits, a useful characteristic of discounting.

[‡] Texts such as Drummond et al.[33] and Muennig[34] provide and discuss the formula for calculating present value. The Wikipedia also provides a description of net present value[35] and discounting from a private business perspective.

Costs are at least conceptually easier than generated value to estimate for the time period used in the evaluation process. After discounting the stream of costs back to the present, one can add up these costs. The result is the present value of total costs.

If the stream of value from e-prescribing is also available in dollar terms, then the same approach using the same discount rate can be used to discount these dollar benefits to the present. This would apply to the cost savings that are generated by e-prescribing. However, as was discussed above, much of the value generated by e-prescribing will be measured in a form not easily monetized in dollar terms. Nevertheless, if this value can be quantified, it should still be discounted to a present value.

Which discount rate should be used? One question is whether a discount rate should include the expected rate of inflation (a nominal discount rate) or whether it should ignore inflation (a real rate). The answer to this question is that the type of discount rate should reflect how the costs and value are being measured. If the costs of e-prescribing and the cost savings it generates are measured in current dollar terms at each point in time, then a nominal discount rate should be used. Much of the value generated by e-prescribing will be measured in real terms; that is, hospitalizations avoided, queries between providers and pharmacies that were avoided, and so on In these instances a real discount rate should be used; that is, a rate that eliminates the effect of expected inflation. A real discount rate is usually created by subtracting expected inflation from a nominal interest rate.

While there is agreement on where to use a nominal versus a real discount rate, there is not unanimous agreement on precisely which discount rates to use. Nevertheless, the U.S. Office of Management and Budget (OMB) has for several decades provided discount rates for Federal programs and projects that extend 3 or more years into the future. OMB has stated that the Federal government should use discount rates that are based on the "Treasury borrowing rate on marketable securities of comparable maturity to the period of analysis."[36] This set of real and nominal discount rates is computed and presented annually in Appendix C of OMB's Circular No. A-94.[37] Real Treasury rates are obtained by removing expected inflation over the period of analysis from nominal Treasury interest rates. Tables 8 and 9 provide the rates for 2010 (that were presented in December 2009).[38]

Table 8. Nominal interest rates on treasury notes and bonds of specified maturities (in percent) to be used for discounting nominal flows

3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
2.3	3.1	3.5	3.9	4.4	4.5

Table 9. Real interest rates on treasury notes and bonds of specified maturities (in percent) to be used for discounting constant-dollar flows (as is often required in cost-effectiveness analysis)

3-Year	5-Year	7-Year	10-Year	20-Year	30-Year
0.9	1.6	1.9	2.2	2.7	2.7

E-technologies continue to evolve at a rapid rate. Therefore, while it is appropriate to consider the discounted costs and value generated over a number of years, it is also appropriate to limit the number of years included in the evaluation to the expected time interval by the end of which a system may be considered obsolete.

Comparing Like with Like

Delineating what differences exist between an environment (the nature of the providers, patients, and so on) where e-prescribing occurs and an environment where traditional prescribing occurs is a key element in estimating the effects of e-prescribing. Taking these differences into account is necessary to estimate the effect of e-prescribing based on the different outcomes in these two situations. Whether the costs and value of e-prescribing are estimated by comparing the same participants before and after the introduction of e-prescribing, or by comparing different participants over the same time period, it is important to avoid comparing apples with oranges. The same considerations will apply if costs and value for a specific Medicaid/CHIP plan are estimated by incorporating estimates published elsewhere, as may be the case in a prospective evaluation.

A number of difficulties can arise in attempting to compare like with like. If e-prescribing is introduced as a pilot, or if outside estimates of effects are being used, then many characteristics may vary between providers with and without e-prescribing. These differences may include

- Type of provider.
- Size of provider.
- Specialty of provider.
- Location of provider (urban/rural, and so on).
- Participation in managed care.
- Category of Medicaid/CHIP eligibility for enrollees treated.
- Age and other characteristics of Medicaid/CHIP enrollees treated.

For example, a pilot introduction may involve providers with large Medicaid practices. These may differ in many ways from the other providers in the State. As a result, comparing the experience of those in the pilot with those not in the pilot may be comparing groups whose differences depend on many factors other than the use of e-prescribing.

Another simple but potential source of difference relates to what is being measured. For both groups, one needs to compare all prescriptions prescribed through all means for each provider (or alternatively, only those prescriptions that are eligible for e-prescribing). In the cases of Class-II narcotics and certain other drugs that the physician may not be able to e-prescribe, this means combining e-prescriptions with all nonelectronic prescriptions for the physicians in the pilot to obtain appropriate totals to compare with physicians who do not use e-prescribing at all.

Managed care is an important element of Medicaid and CHIP, with the proportion varying among States. In some States more urban areas may be administered by managed care organizations, while more rural areas may not. Whatever effects that result from managed care may create differences between providers involved with managed care and those who are not. Managed care payment systems initially did not require submission of data from managed care organizations that would match the level of detail available in fee-for-service procedure billing. Although this situation has been improving, the use of different types and levels of managed care among States may affect the degree to which any given investment in e-prescribing yields value in each State, and to whom any cost savings may accrue. These differences may affect the appropriateness of extrapolating the effects of e-prescribing in one area/State to another.

Some differences can be managed by choices made in staging the implementation of e-prescribing. Attempts to control for these differences can also be accomplished either

descriptively or through multivariate estimation. One way to control for these differences is through statistical estimation such as multivariate regression. Bias in estimates of the effects of e-prescribing may also be reduced using propensity scoring methods.[§]

The relationships between provider characteristics and the number of prescriptions they write, for example, with e-prescribing and without it will not be exact: it will be subject to some random noise or error.

Regression estimation makes specific assumptions about the noise or error in estimating the effects on outcomes of e-prescribing and the characteristics of providers and patients, estimating values for these relationships that minimize the amount of the relationship that is attributed to noise. Because statistical analysis such as regression makes such assumptions about statistical error, the estimation process may need to be adjustments in order to fulfill these assumptions. For example, not only do larger practices tend to write more prescriptions in total, the number of prescriptions from large practice to large practice may vary over a wider absolute range than is the case for smaller practices (for example, this variation may be proportional to the size of the practice). To obtain the best estimate of the effect of e-prescribing, this characteristic (called heteroscedasticity) would need to be taken into account in the estimation process. Standard software packages can make such adjustments.[**]

Difference in Differences

When e-prescribing is introduced, one can compare the costs and value before implementation with the costs and value after implementation. This type of pre-post comparison can yield useful information, but is subject to the caveat that the difference between what is observed pre versus post could have resulted from a number of changes that may have occurred over that time period, not just the introduction of e-prescribing. One way to attempt to control for these other factors is to find a comparable group for which e-prescribing is *not* introduced over the same period. One can calculate the change from the pre to the post period for this comparison group, and then subtract this from the change over the pre-post period for the group that was involved in the introduction of e-prescribing. The expectation is that the resulting difference in differences is more likely to represent solely the effects of the introduction of e-prescribing, because other factors that may have caused changes would have also affected costs and value for the comparison group and will, therefore, have been subtracted out.

Even if e-prescribing were introduced throughout the entire program, some potentially useful comparison groups might be available. For example, other insurers in the State may have administrative data that are obtainable, and the behavior observed in these data over the pre-post period might be used to generate a difference in differences. However, differences between the Medicaid e-prescribing enrollees and the comparison group might affect their experience over the time period. The improvement in the estimates of the effects of e-prescribing using a difference-in-differences approach will be only as good as the degree to which the comparison group is similar to, and is affected by the same extraneous forces as, those Medicaid/CHIP enrollees for whom e-prescribing was introduced. So if a pilot e-prescribing project is directed at large Medicaid providers, then comparisons with all other Medicaid providers may not be ideal, to the degree that different forces affected these different types of providers over the study period.

[§] Love[39] and D'Agostino[40] provide discussions of propensity scoring and its potential to reduce bias in estimates.
[**] Kennedy[41] provides intuition-oriented word descriptions and more technical discussions of a range of econometric techniques.

Sensitivity Analysis

Prospective analyses of the costs and value of e-prescribing require making a number of assumptions. For example, an estimate may be available from the literature for how many visits to emergency departments resulting from ADEs were avoided using e-prescribing compared with traditional prescribing. However, this estimate may have been derived for a specific type of provider, possibly based on a small sample of them, treating a specific patient population in a specific area. The estimate chosen for a cost-effectiveness analysis will incorporate a best judgment about what adjustments, if any, need to be made to the estimate reported in the literature for this type of value created by e-prescribing.

It is worthwhile to analyze how much the resulting cost-effectiveness results depend on the specific values selected for parameters. This can be done by conducting a sensitivity analysis, which involves taking the specific values that were chosen for parameters, and generating cost-effectiveness estimates using higher and lower values than these "best" parameter estimates that were used to produce the cost-effectiveness results.[††]

As this guide has described, there are many potential costs and sources of value, with associated parameters, for e-prescribing. Therefore, analyzing the cost-effectiveness results with respect to changes in all of these parameters would require a very large quantity of information. Instead, it is more sensible to focus on those aspects of the costs and value of e-prescribing that appear to have the largest magnitude impacts on the cost-effectiveness results. Which aspects these are will depend in part on program objectives and the characteristics of the e-prescribing being considered. In addition to the parameters that represent the effects of the e-prescribing system, the discount rate is another parameter that can be subjected to sensitivity analysis.

There is no consensus on how the specific alternative values to be used in a sensitivity analysis should be chosen. One approach is to use values that are higher and lower than the best estimate but nevertheless still appear fairly plausible. Another approach is to choose more extreme values that will allow one to place upper and lower bounds on the cost-effectiveness estimate with a high degree of confidence.

In a sensitivity analysis, each crucial assumption/parameter can be varied by itself, to understand its impact. However, it is also useful to see how the cost-effectiveness estimate will change if several of the parameters considered most important are changed simultaneously. Changing several estimates simultaneously makes particular sense if one believes that parameter values are correlated; that is, if one is lower than the primary estimate, another is also likely to be lower.

In addition to being important in prospective analyses, sensitivity analysis can be useful in an early implementation evaluation as one way to improve understanding of the effects of differences in parameters between the portion of the program using e-prescribing and the remaining portions where e-prescribing has not yet been introduced. For example, the providers and enrollees involved in the early implementation may write/receive fewer (or more) prescriptions than those that will adopt e-prescribing later in implementation process. Hypothetically, writing fewer prescriptions may make providers less likely to fully utilize some aspects of the e-prescribing system that generate value. Sensitivity analysis can even play a role in a retrospective evaluation. While actual data are available from which to estimate cost-effectiveness in a retrospective evaluation, the agency may be facing changes in its program or

[††] Texts such as Drummond et al.[33] and Muennig[34] provide discussions of sensitivity analysis.

the State environment that will affect costs or the ability to generate value in the future. A sensitivity analysis can provide information on how the cost-effectiveness estimated in the retrospective analysis would change in the future.

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Appendix A: Detailed Description of Search Process and Full Citations for Literature in Chapter 3

To identify studies on e-prescribing, we used a multistage approach. First, AHRQ's Health IT Knowledge Library located on AHRQ's National Resource Center for Health IT Web site[‡‡] contains more than 300 sources under the topic of e-prescribing. These sources were skimmed to identify research studies that measured the impact of e-prescribing in any cost or value domain. Second, we performed a PubMed search using the term "e-prescribing." All resulting abstracts were reviewed to identify research studies focusing on the impact of e-prescribing. Third, all research studies identified by these two methods were then cross-referenced to gather any research studies cited by these sources which were not picked up by the AHRQ Knowledge Library or PubMed searches. Finally, the Endnote® library created for the broader literature review that is part of this contract was searched for any research studies not previously identified.

This search process yielded a set of documents including peer-reviewed journal articles, government-sponsored monographs, and Microsoft® PowerPoint slideshows from scientific conference presentations. Based on more thorough reading of these 37 documents, we included studies in the current review if e-prescribing outcomes were clearly delineated and quantified. In addition to data derived from studies specifically of e-prescribing, this section also presents data from studies of computerized provider order entry (CPOE), a broader technology that can include e-prescribing, *if* results specific to prescribing are reported.

Below are the citations for the literature cited in Chapter 3 of this guide.

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