AHRQ Grant Final Progress Report

Title of Project:

Electronic Prescribing and Decision Support to Improve Rural Primary Care Quality

Principal Investigator

James T. Veline, MBA - Senior VP/CIO, Avera Health

Team Members

Tad B. Jacobs, DO - Chief Medical Information Officer, Avera Health
Chris Sonnenschein, PharmD, PMP
Executive Director of IT Clinical Support, Avera Health
Sandra Crisp, RN – Director of Clinical Quality Initiatives, Avera Health
Carol J. DeSchepper, RN, MSN, MHA, FACHE
Director of Parish Nursing/IRB Chair, Avera Health
Kristine M. Becker – Director of Clinic EMR Systems and Processes, Avera Health
Jon Hagen, MA – Clinical EMR Process Improvement Specialist, Avera Health
Nancy Hartung – Standards Compliance Coordinator, Avera Health
Matt Kock, MBA, PMP – IT Project Manager, Avera Health
Stuart M. Speedie, Ph.D., FACMI
Director of Graduate Studies, Health Informatics Graduate Program, University of Minnesota
Professor of Laboratory Medicine and Pathology, School of Medicine, University of Minnesota
Fellow, Institute for Health Informatics, University of Minnesota
Terrence Adam, M.D., Ph.D.
Assistant Professor, University of Minnesota College of Pharmacy
Pharmaceutical Care and Health Systems, Health Informatics

Organization: Avera Health

Inclusive Dates of Project: 09/01/2007 – 08/31/2011

AHRQ Project Officer: Heather A. Johnson-Skrivanek

Grant Award Number: R18 HS17149

Acknowledgment of Agency Support: This project was supported by grant number5R18HS017149 from the Agency for Healthcare Research and Quality.

Structured Abstract

Purpose: The purpose of Avera Health's *Improving Quality Through the Use of E-prescribing With Electronic Decision Support* Project was to examine whether, in rural ambulatory care settings, the use of an electronic prescribing system with clinical decision support related to medication management increases patient prescription adherence, improves health outcomes in hypertensive patients and improves the medication management process.

Scope: The project extensively implemented electronic prescribing in nine rural ambulatory care (clinic) settings within the Avera Health System service area; particularly Eastern South Dakota, Southwest Minnesota and Northwest Iowa. The research focused on blood pressure management of hypertensive patients 18 years of age or older.

Methods: The study model was a staged implementation, first gathering baseline measures, then tracking clinics using e-prescribing as a standalone tool before moving to an integrated electronic medical record (EMR) with e-prescribing. To examine whether patient prescription adherence improved, medical claims data and the e-prescribing patient-fill histories were used. Improved outcomes were measured in blood pressure readings, and changes in treatment for patients with blood pressure over 140/90. Additionally, provider interview and patient surveys were completed to assess the perception of electronic prescribing.

Results: There did not appear to be a significant effect on hypertension control with the implementation of electronic prescribing based on the crude population analysis. Provider perceptions were more positive when compared to the baseline pre-implementation for both the stand-alone electronic prescribing and the electronic medical record implementations. There did appear to be an increase in the patient adherence, as reflected in the medication possession ratios and an upward trend in the prescribing of generic anti-hypertensive medications, however, there were a number of limitations in the data.

Key Words: rural**,** ambulatory care, primary care, e-prescribing, standalone, electronic medical record, hypertension, blood pressure, outcome, medication adherence

Purpose

The goal of this project was to test the following hypothesis: Use of an electronic prescribing system with clinical decision support related to medication management increases patient prescription adherence, improves health outcomes in rural hypertensive patients, and improves the medication management process.

The proposed study attempted to address the following research questions in order to assess the impact of these technologies on patient outcomes, clinical processes, providers and costs.

Research question 1: Does implementing an e-prescribing system in an ambulatory care environment lead to improvement in patient health outcomes?

Research question 2: Does implementing compliance and adherence messaging at the point of care in a standalone e-prescribing system lead to improvements in adherence-related behaviors?

Research question 3: Does the use of an e-prescribing system linked to an ambulatory care electronic medical record improve patient health outcomes and medication related behaviors more than electronic prescribing alone?

Research question 4: Does the implementation of either a stand-alone e-prescribing system or an e-prescribing system linked to an ambulatory electronic medical record affect the attitudes of health care providers.

Research question 5: Does the implementation of either a stand-alone e-prescribing system or an e-prescribing system linked to an ambulatory electronic medical record reduce the costs of providing care?

Scope

Background

This project focused on two vital areas of health care quality related to management of the potentially fatal chronic disease of hypertension; medication safety and patient compliance with medication programs that improve patient outcomes.

Over the last several years, the Institute of Medicine has published dozens of reports challenging the health care system in America to create a higher level of safety for consumers of health care. The first call to action was in 1999 with the report *To Err is Human: Building A Safer Health System.* This was followed in 2001 with *Crossing the Quality Chasm.* The report, which came out in 2006, challenged health care providers to focus on preventing medication errors, one study in the report citing that there are an estimated 380,000 preventable adverse drugs events (ADEs) in hospital each year. Another estimated 450,000 and these both may be underestimates of the actual number of ADEs that occur[1].

The report goes on to recommend that by the year 2010, all prescribers and pharmacies should be using e-prescription technology, in an effort to decrease ADEs. “They will also need to put effective internal monitoring programs in place which will allow them to determine the incidence rates of ADEs more accurately and thus provide a way of measuring their progress toward improved patient safety”[2]

Another Institute of Medicine report, *Quality Through Collaboration: The Future of Rural Health* identifies a five-pronged approach to address the quality challenges of rural communities. Because of the challenges faced in rural communities (including limited technological infrastructure and limited capital resources, to name only two), one of the five specifically recommends “*investing in an information and communications technology(ITC) infrastructure, which has enormous potential to enhance health and health care over the coming decade”.*[3]This provides impetus for Avera Health, and other rural health systems, to examine how they can access health information technology to improve patient outcomes.

Thirdly, the research focused on patients with hypertension (high blood pressure), a major risk factor for heart disease and stroke, end-stage renal disease, and peripheral vascular disease. Unquestionably, it is a major contributor to adult disability, if left uncontrolled. The Center for Disease Control (CDC), in a study

conducted between 1999 and 2002 identified that approximately one in four adults in the United States has hypertension. Secondly, even though effective therapy has been available for more than 50 years, most persons with hypertension do not have their blood pressure under control. According to the CDC study, it is estimated that only 18% of people with hypertension who are aware of their condition, have their blood pressure under control.

The introduction of electronic prescribing systems has the potential to greatly improve the accuracy and efficiency of pharmaceutical treatments. Patient non-adherence to pharmaceutical treatment is an area of concern. For many chronic conditions, poor patient compliance with prescribed medications can adversely affect the treatment outcome. It is estimated that the compliance rate for patients receiving long-term treatment for chronic asymptomatic conditions, such as hypertension, can be as low as 50%. Failure to obtain a medication is especially problematic in patients with asymptomatic conditions, such as hypertension. Electronic prescribing systems can alert the ordering provider of prescription fill status for patient follow-up contact and education. In addition, the use of electronic prescribing systems can help physicians avoid prescribing errors, adhere to treatment guidelines and monitor patient's response to treatment. They also offer physician decision support to prevent drug to drug and drug to disease interactions.

Health IT Systems Evaluated

The research focused on the following Health IT systems:

- DrFirstRcopia electronic prescription management system as a stand-alone product
- DrFirstRcopia integrated within the Meditech/LSS Medical and Practice Management (MPM) Suite; the electronic health record system being implemented by Avera Health in the ambulatory setting.

Settings of Care

This project focused on 58 providers practicing in ambulatory care (clinic) settings within the Avera Health System service area. The clinics in the study included: Avera St. Benedict Certified Rural Health Clinics in Parkston, Tripp, and Lake Andes; Avera Medical Group Dell Rapids; Avera Medical Group Flandreau; and Avera Medical Group Miller, in South Dakota; Avera Medical Group Spencer; and Hegg Medical Clinic Avera, in Iowa; and Avera Medical Group Windom in Minnesota. Clinic demographics can be found in Table 1. During the project, each of the primary care clinics implemented the DrFirst, Inc. Rcopia electronic prescribing tool. Additionally, all of the clinics with the exception of the clinics in Spencer and Rock Valley, Iowa also implemented the integrated LSS Medical and Practice Management Suite with e-prescribing.

Table 1

AHRQ e-Prescribing Grant Clinics

Clinic Name:	Location:	Community Population:	Number of Providers:
Avera St. Benedict Certified Rural Health Clinic	Parkston, SD	1,508	7
Avera St. Benedict Certified Rural Health Clinic	Tripp, SD	647	1
Avera St. Benedict Certified Rural Health Clinic	Lake Andes, SD	879	1
Avera Medical Group Dell Rapids	Dell Rapids, SD	3,633	10
Avera Medical Group Flandreau	Flandreau, SD	2,341	7
Avera Medical Group Miller	Miller, SD	1,489	5
Avera Medical Group Spencer	Spencer, IA	16,667	16
Hegg Medical Clinic Avera	Rock Valley, IA	3,354	7
Avera Medical Group Windom	Windom, MN	4,646	4

Avera Medical Group Flandreau

In addition to the clinics, rural retail pharmacies in Dell Rapids (SD), Flandreau (SD), Miller (SD), Parkston (SD), Rock Valley (IA), Spencer (IA), and Windom (MN) are also participated in the project.

Population

The study included 9845 rural hypertensive patients receiving treatment in the nine project primary care clinics. Patients were required to meet 5 criteria to be enrolled in the study. Each patient was 18 years of age or older. Each patient was cared for by a provider in one of the grant clinics. Each patient had a confirmed hypertension diagnosis. Each patient was prescribed an antihypertensive medication as part of treatment. Each patient had medication claims history available through Surescripts.

Methods

Intervention

This study was based on the observation of a "natural" process of disseminating and implementing a set of HIT innovations to rural clinics in the Avera Health system. As such, the experiment can be characterized as a quasi-experimental design with opportunistic, non-random assignment of clinics to the experimental conditions. Furthermore those experimental conditions evolved over time as new technologies were introduced and upgraded. The study design attempted to take advantage of the opportunity to study the impact of these technologies on a selected group of patients (hypertensives) as well as the clinics themselves while taking into account the relative lack of control that is experienced in such real-world situations.

The project consisted of four phases: baseline with no e-prescription capabilities, implementation of Rcopia stand alone e-prescribing, implementation of compliance and adherence messaging available at the point of care, and migration to the integrated LSS MPM. See Table 2 for the implementation timeline.

Table 2 AHRQ e-Prescribing Clinics

Clinic	2007	2008				2009				2010				2011			
	Q1-4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Avera St. Benedict CRHC - Parkston																	
Avera St. Benedict CRHC - Lake Andes																	
Avera St. Benedict CRHC- Tripp																	
Avera Flandreau Medical Clinic																	
Avera Dell Rapids Medical Clinic																	
Avera United Medical Clinic - Windom																	
Avera Hand County Medical Clinic																	
Hegg Medical Clinic Avera																	
Avera Spencer Family Care																	

Legend	
Phase 1 Baseline	
Phase 2 Rcopia Standalone	
Phase 3 Compliance & Adherence Messages	
Phase 4 LSS MPM	

Measures and data collection

Proportion of Patients with Controlled Blood Pressure: The proportion of patients meeting or exceeding the criteria for control. Blood pressure readings were manually collected from enrolled patients' paper charts up until the date each clinic migrated to the integrated LSS Medical and Practice Management EMR. Once the clinic was live with LSS, blood pressure readings were extracted from the EMR through reporting. The project team attempted to extract three blood pressure readings during each phase of the study. Coders were instructed not to record more than one reading from the same patient visit. Given the large number of patients for whom blood pressure data was available, the primary study metric which was assessed was the overall blood pressure levels for patients in each phase of the study.

Patient Satisfaction with Care: The satisfaction level of patients with their care as measured by the Adult Primary Care Questionnaire of the CAHPS Clinician and Group Survey. The survey was administered to all patients enrolled in the study. Each patient received the three surveys. The first survey was administered prior to the introduction of Rcopia standalone e-prescribing. The second survey was administered after the implementation of Rcopia but just before the transition to LSS in each of the clinics. The final survey was administered at the end of the grant after the clinic was live with LSS.

First Medication Fills: This is defined as the proportion of new prescriptions for antihypertensive drug therapy that are actually obtained by the patient after the prescription is written by the physician. Unfortunately, the project team discovered that there was no standard measurement or compliance notification available to providers at the point of care. The Medicare Prescription Drug, Improvement, and Modernization Act of 2003 (MMA) laid the ground work for the development of standards to facilitate interoperability across e-prescribing transactions. One of the initial standards tested in 2006 was the

transaction standard, RxFill. RxFill is a transaction whereby dispensing pharmacies capture when prescriptions are picked up by patients. The RxFill transaction would then be transmitted through Surescripts to e-prescribing applications and made available to providers. After piloting in 2006, CMS found that RxFill was not mature enough to require e-prescribing stakeholders to support. To address this issue the project team worked with DrFirst to create a program whereby DrFirst matched prescriptions written electronically with Pharmacy Benefits Manager (PBM) medication claims available through Surescripts. For the purpose of this measure, a prescription written electronically with a matching pharmacy claim within 28 days of the prescription written/transmission date suggests the prescription was filled by the patient. DrFirst then uploaded the calculated metric into the e-prescribing tool to be available to the provider at the point of care.

Medication Possession Ratio (MPR): MPR was intended to track adherence to a medication regimen over time. This measure was challenged with the same concerns as First Fill. The program created by DrFirst also addressed this metric through matching prescriptions written electronically with medication claims available through Surescripts. This metric was defined as the ratio of the number of days of prescribed/dispensed therapy to the number of days between the first and last fill of the medication. DrFirst also uploaded this metric into the e-prescribing tool to be available to the provider at the point of care.

Proportion of Hypertensive Patients with Uncontrolled Blood Pressure Receiving Educational Interventions: This was obtained from chart reviews conducted by the project staff to search for evidence of an educational intervention in the charts of patients lacking blood pressure control. When found, the nature and date of the intervention was noted. Additionally, DrFirst created an enhancement that allowed providers to easily document education interventions in the Rcopia e-prescribing tool.

Provider Satisfaction: "Satisfaction" is a multi-factored concept that is difficult to meaningfully capture in regards to the introduction and use of an IT system such as Rcopia or an EMR. The concept of satisfaction in situations such as those being investigated in this study, often relates to the discrepancies between expectations and perceptions. In order to gain an understanding of the provider's satisfaction with their practice, a qualitative analysis was performed based upon interviews. The study was conducted by project staff and assessed the perceptions by clinic providers about their practice and their experiences with the use of the electronic prescribing systems. Each provider participated in three interviews for each phase of the study. The first interview was conducted prior to the introduction of Rcopia standalone e-prescribing. The second interview was conducted after the implementation of Rcopia but just before the transition to LSS in each of the clinics. The final interview was conducted at the end of the grant after the clinic was live with LSS.

Proportion of Days of Generic Drug Therapy: Generic drugs are often significantly less expensive than brand name drugs with a significant number of generic drug entities available for treatment of hypertension in contrast to treatments for some other major chronic diseases. As such, their use lowers the costs of care for hypertensive patients with generally equivalent effectiveness. Thus their use was desirable in controlling the costs of health care in the context of this study. The Rcopia system, with its access to both formularies and its ability to suggest generic substitution at the time of the prescription ordering, should increase the use of generic drugs including those for hypertension and will serve as the data source for this measure. Accordingly we calculated the proportion of antihypertensive medication prescriptions that specify a generic entity for each clinic as a means of measuring their use of generic drugs.

Adjusted Annual Clinic Operating Dollars/Patient Encounter: This measure intended to reflect the efficiency of a practice in terms of lowering the overall costs of a clinical encounter by the introduction of Rcopia or the combination of Rcopia and the EMR. Some studies have indicated that there should be cost savings associated with EMR use, though there has been little empirical evidence of those savings yet. It is recognized that there are differences in operating costs due to differences in geographic location, practice structure and simple historical factors. To take this into account, the measure was calculated as a deviation from a baseline measurement obtained from the clinic business records prior to the introduction of the technology and adjusted for inflation each year.

Results
Associated with each of the research questions are a set of one or more specific hypotheses investigated.

Research question 1: Does the implementation of an e-prescribing system in an ambulatory care environment lead to improvements in patient health outcomes?

Hypothesis HR1-1: The proportion of patients meeting or exceeding the criteria for control will be higher after the implementation period of the stand alone e-prescribing system in clinics as compared to the proportion before implementation in the same clinics.

Data was collected on blood pressure values with data collected in four discrete phases with the first phase being before the implementation of the stand-alone electronic prescribing system, the second phase representing the stand alone electronic prescription system and the third phase including electronic prescribing with compliance and adherence messaging and the last phase being the incorporation of the electronic health record with electronic prescribing (Phase 4). There did not appear to be a substantial effect of electronic prescribing on the outcome of measured hypertension. Data was collected using paper and electronic chart review to obtain the results of evaluation. The results were not adjusted for patient comorbidities for any disease states which may have alternative blood pressure targets as there was insufficient data on patient conditions present as potential comorbidities. No assessment was made to look at the types of medication therapy to see if there were any medication specific effects.

Table 3

Aggregate Blood Pressure Results		
Study Phase	**Systolic**	**Diastolic**
Phase 1	134.1	75.8
Phase 2	135.4	75.4
Phase 3	135.0	75.1
Phase 4	133.7	73.9

In assessing the patients at the sites who had participated in all four phases of the study for the control of hypertension, the control level of 140 systolic and 90 diastolic was assessed. Those patients who met both the systolic and diastolic targets were designated to be in overall blood pressure control. In addition the control of systolic and diastolic blood pressure was assessed. 1021 patient chart were reviewed to assess blood pressure control before implementation (phase 1), after stand alone e-prescribing (phase 2), after compliance and adherence messaging (phase 3) and after EMR implementation (phase 4). The results are noted in Table 4: Proportion of Patient with Control of Hypertension below:

Table 4

Proportion of Patients with Control of Hypertension			
Study Phase	**Overall BP Controlled**	**Systolic Controlled**	**Diastolic Controlled**
Phase 1	0.658	0.670	0.927
Phase 2	0.641	0.652	0.919
Phase 3	0.632	0.640	0.928
Phase 4	0.679	0.683	0.934

The results did not indicate that the implementation of stand-alone electronic prescribing had an effect on the control of hypertension since the proportion of patients with control of blood pressure dropped slightly after implementation. However, after the EMR implementation occurred there was an upward trend in the proportion of patients with control of hypertension which was higher than during the stand-alone

electronic prescribing. In addition, the proportion of patients with control of hypertension after EMR implementation was higher than at the baseline (prior to e-prescribing).

Hypothesis HR1-2: The satisfaction level of patients with their care as measured by CAHPS will be higher after the implementation period of the stand-alone e-prescribing system in clinics as compared to the level before implementation in the same clinics.

Patients were invited to fill out surveys prior to electronic prescribing implementation, after stand-alone electronic prescribing was in place and after the electronic medical record with integrated electronic prescribing was implemented. The baseline patient set was identified from the patients who were seen in the Avera clinic system and who were identified as having hypertension from medical claims data. Of the patients who responded to the original survey, additional surveys for the second and third round surveys were sent out. Patients were given the opportunity to respond to a series of questions with Likert scale responses to assess their impressions in the domains of hypertension, medical care for blood pressure, confidence in their medications and electronic prescription preferences. The results were collected and aggregated. The patients were initially selected based on the presence of hypertension as noted in the clinical claims data and confirmed in the survey. Patients who did not have a diagnosis of hypertension (self-reported) were given questionnaire options to exclude their responses from the survey results. For the second and third phases of the study, new patients diagnosed with hypertension along with existing patients were also included in the study.

The patients were surveyed on several key clinical domains that focused on hypertension, medication therapy and patient satisfaction with hypertension and overall clinical care. Specific question domains looked at the patient self-report results on their diagnosis of hypertension, the recognition of blood pressure as a serious health issue, the need to take medications to treat their hypertension, the satisfaction with hypertension care and the overall quality of care provide to the patients. The number surveys administered by clinic in each phase and the response rate is noted in Table 5. Phase 3 mailings did not go out to patients seen in Hegg Medical Clinic Avera and Avera Medical Group Spencer as neither clinic transitioned to the EMR during the grant period.

Table 5

Patient Survey Results by Clinical Site			
Clinical Site	**Phase 1**	**Phase 2**	**Phase 3**
Avera Medical Group Dell Rapids	1098	1213	1173
Avera Medical Group Flandreau	250	483	468
Avera St. Benedict Lake Andes	295	466	465
Avera Medical Group Miller	705	236	236
Avera St. Benedict Parkston	495	719	715
Hegg Medical Clinic Avera	206	60	
Avera Medical Group Spencer	3568	951	
Total Surveys Sent	6617	4128	3057
Total Responses	3121	1594	773
Percent Responses	0.4716639	0.3861434	0.252862

Table 6: Patient Survey Results

Survey Question	Phase 1	Phase 2	Phase 3
HTN is serious health issue (1 disagree 5 strong agree)	3.85	3.84	3.85
Satisfied with HTN Care (1 disagree to 5 strong agree)	4.23	4.20	4.24
HTN med treatment is good (1 extreme good 5 not at all)	1.55	1.68	1.70
HTN med benefit outweigh bad effects (1 certain-5 not certain)	1.75	1.85	1.85
Satisfaction with HTN meds (1 Ext dissatisfied-5 Ext satisfied)	3.98	4.41	4.39
Scale of 1-10 on overall care satisfaction (0=worst 10=best)	8.87	8.72	8.71

The patient survey results were similar across the three study phases. There was a slight downward trend in the level of satisfaction on hypertension treatment which decreased from the baseline after the implementation of the stand-alone electronic prescribing and after the implementation of electronic medical records. The patients also seemed slightly less certain on the benefits of medications as compared to the potential bad effects of the medications as well as the overall care satisfaction. The largest absolute magnitude of change in the results in the different study phases was noted with satisfaction with hypertensive medication. The study results seemed to indicate there was an increased level of satisfaction with hypertension medications after both the stand-alone electronic prescribing system and the electronic medical record implementations.

Research question 2: Does implementing compliance and adherence messaging at the point of care in a standalone e-prescribing system lead to improvements in adherence-related behaviors?

Hypothesis HR2-1*:* The proportion of patients having a new prescription filled will be higher after the implementation of compliance and adherence messaging in a standalone e-prescribing system as compared to the proportion before implementation of compliance and adherence messaging.

To assess medication utilization patterns, a proxy measure of patient medication usage was utilized to evaluate how frequently patients would fill their new medication prescriptions. The proxy measure utilized for the assessment of medication treatment initiation was the first fill of the new prescription. To identify a first fill for the parameters of this study, the prescription had to be filled within 28 days of when the prescription was written. The 28 day cutoff was used to address the type of medication which was the focus of this study, anti-hypertensives, since these medications tend to be used chronically. If a patient is using the antihypertensive medication appropriately, they will be obtaining a new medication prescription prior to running out of there previously utilized medication. This makes it difficult to assess short-term first fill data since there is likely to be a discrepancy between the timing of the prescription and the filling of the prescription. In addition, if a patient is started on a new prescription, they will sometimes get medication samples which may affect their need to get the first prescription filled. The samples may lead to delayed medication fills since they may be initially using the sample medications. The use of the 28 day cutoff should provide a broader measure of the first fill and address some of the inherent data limitations.

The data on first fill results is included in Table 7, noted below. There was a similar number of prescriptions in both the stand-alone system and after the implementation of added compliance and adherence messaging. The first fill rates in these first two implementations were substantially higher than during the EMR implementation. These results provide some insight on the prescription filling patterns of patients after new prescriptions are initiated. A slightly longer review period could be considered to further assess first fill patterns, however, given the availability of medication possession ratio data which informs long-term patient adherence patterns, further assessment of first fill data was not explored.

There was a smaller number of prescriptions completed in the electronic medical record phase with lower relative numbers of first fills. The results were limited by a significant number of prescriptions which did not match to the providers at the clinical sites which will require additional efforts to link to sites and the prescribing providers; however, this is unlikely to explain the large difference in the EMR phase first fill results.

Table 7

First Fill results			
Phase of Study	**Stand Alone eRx**	**eRx with Messaging**	**Electronic Med Record**
First Fill Completed	12034	11276	274
No First Fill Completed	10152	9038	3856
Percent First Fill Rx	54.2%	55.5%	6.6%
Total Prescriptions	22186	20314	4130

Hypothesis HR2-2: The adherence rate, as measured by the medication possession ratio (MPR), will be higher after the implementation of compliance and adherence messaging in a standalone e-prescribing system as compared to the proportion before implementation of compliance and adherence messaging.

The medication possession ratios were calculated to provide an estimate of patient compliance to antihypertensive medications. In assessing the medication possession ratios, the data on the prescriptions were linked to providers and to the clinical sites to generate a list of prescriptions which were generated after the implementation of electronic prescribing. For inclusion in the MPR calculations there needed to be at least three or more prescription fills to identify medication usage patterns. The starting and end dates for the prescriptions were bounded by the date of prescription entry in the system and had a defined end date for the prescription. The average MPR was calculated and trended upward from the beginning of the study to the end of the study as noted in Table 8.

Table 8 Medication Possession Ratio (MPR) Calculations

Study Phase	Stand Alone Data	Avg. MPR	ERX Comp and Adhere	Avg. MPR	EMR data	AVGMPR
# MPR Calculated	6712	75.07%	5374	78.68%	112	83.70%
No MPR Calculated	15474		14940		4018	
Total Prescriptions	22186		20314		4130	

There are a several factors which may have influenced the results of the study relative to compliance and adherence metrics, first fill and MPR. The cutoff used in the MPR calculation of at least 3 prescriptions for inclusion in the results limited the number of prescriptions which were analyzed for the MPR calculations. In addition, the enhancement program created by DrFirst to calculate and display compliance and adherence messages, first fill and MPR, relies on the availability and accuracy of the prescriptions written electronically through e-prescribing applications as well as PBM pharmacy claims. A prescription written electronically with a matching pharmacy claim was intended to suggest the

prescription was filled by the patient. Conversely, a prescription written electronically *without* a matching pharmacy claim was intended to suggest the prescription was *not* filled by the patient. Even with claims data available there were a number scenarios the project encountered with this model whereby false negatives were generated and compliance and adherence was potentially skewed downward.

- If a patient elects to pay cash for a prescription (i.e. low cost generic incentive programs) there is no pharmacy claim and will appear as though the patient did not fill the prescription.
- If a provider verbally directs a patient to take a medication in a manner that deviates from the instructions on the original prescription, it could possibly cause compliance to be reported incorrectly. For example, if the original electronic prescription calls for a medication to be taken as one tablet daily, but the provider verbally changes the instructions and directs the patient to split tablets and take one-half tablet daily, the compliance and adherence data will appear as though the patient is only 50% compliant. Other examples include a provider instructing the patient to take one tablet every other day or two tablets daily.
- A therapeutic substitution taking place outside of the e-prescribing application may cause compliance and adherence to be reported erroneously. For example, if the prescription is written electronically for Edarbi, but a therapeutic substitution for candesartan is authorized outside the e-prescribing application (i.e. conversation between pharmacist and provider), the application will not find a claim for Edarbi making it appears as though the patient is noncompliant.
- If a provider discontinues a medication but does not appropriately stop the medication in the e-prescribing application, compliance and adherence will erode overtime as the application will continue to look for pharmacy claims.
- Compliance and Adherence data may be erroneous as a patients' pharmacy benefits coverage changes (i.e. change in occupation, employer changes health plan). For example, if a patient's pharmacy benefits change from a PBM that shares data to a PBM that does not share data, claims will no longer be available causing compliance and adherence to inaccurately erode over time.
- Compliance and adherence may be calculated erroneously if prescription claims are not found at the time of the query due to a temporary loss of connectivity through Surescripts to the PBM's claims data.
- The potential for false negatives exist when a patient's PBM shares eligibility and formulary data through Surescripts, but not medication history needed to calculate first fill and MPR.

Hypothesis HR2-3: The proportion of uncontrolled patients who have received an appropriate educational intervention will be higher after the implementation period of the e-prescribing system in clinics as compared to the proportion before implementation in the same clinics.

For the patients who received educational interventions in the study for hypertension the types of interventions were identified and the events were recorded. A total of 149 educational interventions were recorded for patients with hypertension. Of those who received educational interventions, the patients who had pre-interventional blood pressure and post-interventional blood pressure data were identified. A total of 26 patients were identified with blood pressure pre- and post-intervention. The average blood pressure pre-intervention was a systolic of 131.5 and diastolic of 75.5. Post-intervention the average blood pressure was 132.2 systolic and 74.5 diastolic. There did not appear to be a significant effect on blood pressure control, however, there was limited data both in terms of educational interventions as well as the number or blood pressure readings pre- and post-intervention. There was an insufficient number of educational intervention events across the phases of implementation to assess the effect of the electronic prescribing systems on educational intervention activity.

Research question 3: Does the use of an e-prescribing system linked to an ambulatory care electronic medical record improve patient health outcomes and medication-related behaviors more than e-prescribing alone.

Hypothesis HR3-1: The proportion of patients having their new prescription filled will be higher in clinics with an e-prescribing system including compliance and adherence messaging linked to an electronic medical record as compared to the proportion in standalone e-prescribing clinics with compliance and adherence messaging.

See the results noted in Hypothesis HR2-1 above. There did not appear to be data to support an increased level of prescription first fills with the use of electronic medical records. The relatively smaller number of prescriptions in the EMR implementation phase does raise the question is a larger sample in the EMR phase would be more consistent with the stand-alone electronic prescribing results. In addition, since the results of the first fill evaluation are dependent on medication claims the most recent data, which includes the EMR phase, is more prone to under-reporting as there may be a lag in claims processing and data availability. Additional follow-up could better clarify if the results are consistently below the stand-alone electronic prescribing

Hypothesis HR3-2: The adherence rate for medications as measured by medication possession ratio (MPR) will be higher in clinics with an e-prescribing system including compliance and adherence messaging linked to an electronic medical record as compared to the proportion in standalone e-prescribing clinics with compliance and adherence messaging.

See results noted in Hypothesis HR2-2 above. There did appear to be data to support increased levels of patient compliance as reflected in the patient medication possession ratios. The relatively smaller number of prescriptions in the EMR implementation phase raises the possibility that the upward trend in the MPR may be due to chance. In addition, since the MPR results are dependent on medication claims, the most recent data, which includes the EMR phase, is more prone to under-reporting as there may be a lag in claims processing and data availability. Additional follow-up could better clarify if the results are consistently higher than the MPR results during the stand-alone electronic prescribing phase of the study.

Research question 4: Does the implementation of either a stand-alone e-prescribing system or an e-prescribing system linked to an ambulatory electronic medical record affect the attitudes of health care providers.

Hypothesis HR4-1 (Qualitative): The attitudes of providers, as measured by the proportions of positive and negative statements concerning their work environment (*obtained by interview*), will be related to the technology deployed in the clinic in which they work where the environment is classified as baseline, Rcopia or Rcopia - EMR.

The perceptions of the clinical providers was assessed from provider interviews completed onsite and transcribed. The prescribers were asked a series of pre-formulated interview questions to address their expectations and perceptions of the electronic prescribing process before implementation, after stand-alone electronic prescribing implementation and after EMR implementation. Each prescriber was asked the same set of questions. The transcriptions were assessed and the prescriber's comments were categorized into positive, negative or neutral responses. Positive and negative perception ratios were assessed in each of the phases to provide a measure of provider satisfaction with e-prescribing implementation as noted in Table 9 and Table 10 below:

Table 9: Provider Interview Qualitative Responses

Study Phase	Positive Responses per Provider	Negative Responses per Provider	Neutral Responses per Provider
Pre-Implementation	3.9	1.9	3.1
Post-Stand Alone	10.9	4.2	2.7
Post-EMR Implementation	9.9	5.0	2.8

Table 10: Prescribing Provider Perception Ratios			
Study Phase	**Positive Perception Ratio**	**Negative Perception Ratio**	**Total Comments**
Pre-Implementation	0.4	0.2	329
Post-Stand Alone	0.6	0.2	695
Post-EMR Implementation	0.6	0.3	352

As noted in Table 9, the numbers of positive and negative responses both increased with the two system implementation phases. There seemed to be slightly fewer positive and slightly more negative responses in the EMR phase as compared to after the implementation of the stand-alone phase. When including the number of overall responses as noted in Table 10, in the positive perception ratios, the positive perception rates were higher after electronic prescribing implementation as compared to prior to implementation. The negative perception ratio was unchanged for stand-alone implementation, but slightly higher after EMR implementation. The slightly higher negative perceptions with EMR implementation may be due to the interviews occurring shortly after EMR implementation which may have captured more of the implementation related issues which were just recently or were at the time yet unresolved. The relatively smaller system change associated with stand-alone e-prescribing may also have caused fewer potential issues and associated provider perceptions.

Research question 5: Does the implementation of either a stand-alone e-prescribing system or an e-prescribing system linked to an ambulatory electronic medical record reduce the costs of providing care?

Hypothesis HR5-1: The proportion of days of generic drug therapy will be higher after the implementation period of the stand alone e-prescribing system in clinics as compared to the proportion before implementation in the same clinics.

Generic medication prescribing was assessed in 3 of the phases of the study with the first phase represented by the results after the implementation of stand-alone electronic prescribing, the second phase representing the time after the implementation of compliance and adherence messaging and the third phase representing the prescription results associated with prescribing through the electronic medical record. The numbers of prescriptions are fairly similar for the first two phases with fewer prescriptions completed during the electronic medical record phase of the study with some sites without electronic medical records in place at the time of study data acquisition.

The aggregate results for electronic medical record prescribing are summarized in Table 11 (Medication Source Prescribing Patterns). Medications were placed into three categories. They include generic, multi-source brand, and single-source brand. A multi-source brand drug has a generic equivalent that a dispensing pharmacist may substitute. A single-source brand does not have a generic equivalent. Using the phase one data (stand-alone electronic prescribing) as the baseline the percentage of generic medication went up in the second phase when the compliance and adherence messaging was implemented. In the third phase, the generic medication prescribing was lower but the use of multi-source medications increased.

Table 11

Medication Source Prescribing Patterns								
Phase One			**Phase 2**			**Phase 3**		
Med Type	**Rxcount**	**Percent**	**Med Type**	**Rxcount**	**Percent**	**Med Type**	**RxCount**	**Percent**
generic	14604	63.60%	generic	14791	70.24%	generic	2694	63.96%
multisource	6829	29.74%	multisource	5005	23.77%	multisource	1269	30.13%
Single	1531	6.67%	Single	1262	5.99%	Single	249	5.91%
Total Rx	22964			21058			4212	

Given the likelihood pharmacies dispense a generic medication when receiving a prescription for a multi-source brand; it is useful to view the results of potential generic medication use as summarized in Table 12: Generic Medication use. The potentially generic medications include both the generic medications as well as the medications which are multi-source for which there is the potential for generic substitution. Using the combined results, there was a small, but consistent pattern across the three study phases which showed reduced use of brand name medications and increased use of multisource or generic medications. There certainly could be confounding due to changes in medication availability during the time period of the study with additional multisource medications added to the options for prescribers which may have influenced the results.

Table 12

Generic Medication Use								
Phase One			**Phase 2**			**Phase 3**		
Med Type	**Rxcount**	**Percent**	**Med Type**	**Rxcount**	**Percent**	**Med Type**	**RxCount**	**Percent**
Potential Generic	21433	93.33%	Potential Generic	19796	94.01%	Potential Generic	3963	94.09%
Brand Name	1531	6.67%	Brand Name	1262	5.99%	Brand Name	249	5.91%

Hypothesis HR5-2: The annual clinic operating dollars/patient encounter, when adjusted for the baseline values obtained before any system implementation, will be equivalent to or higher than the equivalent value after either a stand-alone e-prescribing system or an e-prescribing system linked to an ambulatory electronic medical record is implemented.

The operating expenses for each clinical site were identified and assessed to look for the effects of the introduction of electronic prescribing on the operating expenses at the clinical sites for the overall costs of operations. Overall costs were assessed since the intervention of electronic prescribing potentially affects all patients receiving care at the clinical sites. The results were obtained for 6 sites as there was insufficient data at the other sites for operating expense evaluation. The clinical operating expense results are included in Table 13. To provide comparable values over time, the table also has inflation adjusted cost data which are normalized to 2007 cost data using US Bureau of Labor Statistics data on medical inflation using regional inflation data.

The costs trended downward for the first 3 phases, with an increase in cost for phase four during the implementation of electronic medical records at most of the clinical sites. The operating expenses were obtained from the clinical operating general ledgers. The data which was included in the operating

expenses included salaries, benefits, supplies, purchased services (laboratory, radiology, laundry, etc), insurance, repairs/maintenance, utilities, depreciation and all other expenses (rent, advertising, minor equipment, travel, etc). The cost data was aggregated for each of the clinics which had adequate data for the assessment and included in Table 13.

Of the six sites included in the operating expense assessment, four of the sites had completed the transition to electronic records by the time of the cost assessment. Four of the sites were located in South Dakota (Sites 1, 2, 3, 5). Two sites were in other states including site four which was located in Minnesota and site 6 which was in Iowa. There may be regulatory and labor structure differences at site 4 and 6 which may affect the results of the study, though the limited number of clinics in the study will make it difficult to control for regulatory and labor differences. Having a potential downtrend in costs with the implementation of stand-alone e-prescribing is interesting since the process assessment prior to implementation and changes in the clinical workflow may have resulted in a lower cost structures for care delivery. There may also have been affects on clinical productivity as well since the volume of visits increased after implementation.

Table 13: Operating Expenses by Clinic (Crude and Inflation Adjusted)

Clinical Site	Unadjusted Phase 1	Inflation Adjusted Phase 1	Unadjusted Phase2	Inflation Adjusted Phase2	Unadjusted Phase 3	Inflation Adjusted Phase 3	Unadjusted Phase4	Inflation Adjusted Phase4
Site1	$162	157.9228	147	$138	$126	$112	$ 157	$ 136
Site2	131	127.8839	138	130	119	108	143	125
Site3	146	143.5650	139	131	122	111	150	131
Site4	165	161.5565	177	167	190	170	191	166
Site5	127	124.0203	130	122	131	116		
Site6	122	119.4061	129	121	137	121		
Overall Average	**$ 142**	**$ 139**	**$ 143**	**$ 135**	**$ 137**	**$ 123**	**$ 160**	**$ 139**

All Inflation Adjusted Values Reflect 2007 prices

In review of the clinical encounter visits by site as noted in Table 14: Clinical Encounter Volumes by Site, the encounter data varied some with the different phases of implementation. The results reflect the average of the monthly encounter data for each site while each site was in the respective phase of implementation. In site one which had the largest drop in operating expenses per encounter, there was an increase in encounter numbers prior to the implementation of the electronic medical record. Similar results were noted at site two with lower costs per encounter and increased encounters with implementation of stand-alone electronic prescribing. At the other sites (3 through 6) the effects of electronic prescribing varied on encounter production, but in three of the four sites encounter numbers dropped after electronic medical record implementation. There are some limits on the data in phase 3 (compliance and adherence messing) and phase four (electronic medical record implementation) since the time periods were not directly comparable to other phases due to potential provider variation in full-time equivalent provides as well as the potential for seasonal variation which was not accounted for in the analysis. Since the cost/encounter data did monetize the labor and productivity costs, those results likely provide a better measure of the effects of the implementation on operating expense at the clinical sites.

Table 14

Clinical Encounter Volumes by Sites				
Location	**Phase1 Encounters**	**Phase2 Encounters**	**Phase 3 Encounters**	**Phase 4 Encounters**
Site1	765	847	857	739
Site2	947	982	996	897
Site3	1477	1348	1362	1249
Site4	1033	985	906	931
Site5	5732	5546	5822	
Site6	1505	1519	1491	

Conclusion

The results of the study provide important insight on some of the challenges and opportunities for electronic prescribing to affect patient care. The overall results, as measured in the control of patient blood pressure did not appear to show a substantial effect of electronic prescribing on blood pressure. However, since the patients at baseline were meeting the blood pressure target of 140/90, it is not surprising the aggregate data was similar before and after implementation, since as a population, there was not a clear need to increase the intensity of anti-hypertensive treatment.

The patient‘s use of medications as reflected in medication compliance via the MPR data provided some evidence that electronic prescribing may positively enhance medication compliance. However, the drop in the first fill results with EMR implementation did not have a clear cause and needs additional assessment to understand the unexpected data trend. Patients did also have more questions about their antihypertensive medication therapy but did seem to be more satisfied with their medication therapy after implementation.

The provider perception of the implementation efforts was more positive than negative in both phases of the implementation to provide some evidence that providers were generally satisfied with the effects of electronic prescribing. Further assessment of the results may be helpful in identifying which aspects of electronic prescribing were seen in both positive and negative ways to better inform future implementation efforts.

The effects of electronic prescribing on operating expenses showed a reduction in operating expenses at the majority of sites after electronic prescribing implementation when adjusted for inflation. The site encounter volumes varied by site and had many other factors outside of electronic prescribing that may have affected the operating expense results. Having the potential for a reduction in operating costs with electronic prescribing is an interesting finding that would be expected with such system automation and provide more questions on the broader effects of HIT implementation on health care operation costs.

The results of the study may not be generalizable outside of similar rural ambulatory clinic sites using a staged multiple year implementation process. The project does provide some insight on the potential effects on electronic prescribing on patient adherence, which may be a positive effect. Further exploration on the implementation of information systems which provide point of care feedback to providers (and patients) on patient adherence may be helpful to maintain or improve medication adherence. Similarly, the availability of this information may be helpful for patient education on medication effects and medication safety issues.

List of publications and products

1. BrooksP., Sonnenschein C. (2010). E-Prescribing: Where Health Information and Patient Care Intersect. *JHIM, 24(2).* 53-59.
2. Sonnenschein C.(June 8, 2008). *e-Prescribing 101: An introduction to electronic prescribing*. Presentation at South Dakota Pharmacist Association Annual Convention, Spearfish, SD.
3. Sonnenschein C.(June 7, 2009). *e-Prescribing 201: A 2009 Update.* Presentation at South Dakota Pharmacist Association Annual Convention, Watertown, SD.
4. Sonnenschein C. (June 26, 2008). *Electronic Prescribing to Improve Rural Primary Care Quality and Utility of Related Standards.* Minnesota e-Health Summit, Brooklyn Park, MN
5. Lagermeier, M., Adam, T. Sonnenschein, C. (June 16, 2011).MN eHealth Summit, "Electronic Prescribing in the Avera Health System: Lessons Learned" Brooklyn Park, MN.
6. Lagermeier, M. Adam, T., Sonnenschein,, C. Speedie, S. "An Electronic Prescribing Implementation Evaluation of Prescribing Provider Perceptions"(In Submission).

References

1. Institute of Medicine of the National Academies. Preventing Medication Errors: Quality Chasm Series, Report Brief. 2006. Available online at http://www.iom.edu/~/media/Files/Report%20Files/2006/Preventing-Medication-Errors-Quality-Chasm-Series/medicationerrorsnew.pdf. Accessed September 15, 2011.
2. Ibid.
3. Institute of Medicine of the National Academies. Quality through Collaboration: The Future of Rural Health. 2004. Available online at http://www.iom.edu/Reports/2004/Quality-Through-Collaboration-The-Future-of-Rural-Health.aspx. Accessed September 15, 2011