

***Grant Final Report***

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**Showing Health Information Value in a Community Network**

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# Abstract

**Purpose:** To evaluate the impact of using health information technology (HIT) to facilitate appropriate care utilization, coordination and quality in a community setting using a population health management model.

**Scope:** 20,108 Medicaid beneficiaries living in Durham County North Carolina were randomly assigned by family unit to receive HIT-augmented care or usual care.

**Methods:** Sentinel health events were detected using a standards-based clinical decision support tool that conducted routine surveillance on a centralized regional health information exchange database. Notifications were sent to patients' assigned care managers through weekly emails, to patients' assigned clinical homes via quarterly feedback reports, and to patients directly through weekly postal letters. The impact of the three notification methods on emergency care utilization, hospitalizations and care quality was compared to usual care and to each other using regression model techniques.

**Results:** The combined interventions compared to controls showed no effect on the primary study outcome of overall emergency care utilization. However, email notifications to care managers significantly decreased the number of low severity emergency department visits and showed a trend towards reduced hospitalization costs. In contrast, letters to patients had no verifiable impact on costs and had no impact on utilization. Feedback reports had no impact on utilization or costs.

**Key Words:** clinical decision support, population health management, computers in healthcare, Medicaid, healthcare utilization, healthcare costs, healthcare quality.

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# Final Report

## Purpose

The use of Health Information Technology (HIT) has been identified as a promising strategy for improving the quality of health care. However, little is known of the specific benefits of using HIT to share information in a community setting using a population health management care model. The purpose of this project was to increase knowledge and understanding regarding the value of HIT at clinical, organizational and financial levels within a community partnership focusing on care management of a vulnerable population; to determine its value to various stakeholders; and to demonstrate a generalizable approach to HIT in a community setting that can be replicated at other sites.

## Objectives of Study

This project has been conducted over four years in accordance with three specific aims (Table 1) that explicitly reflect the project objectives (Table 2).

**Table 1. Original project specific aims**

#	Specific Aim
1	Evaluate the clinical, organizational and financial value of HIT in a community network from a societal perspective.
2	Evaluate the value of HIT in a community network from the perspective of specific stakeholder groups. These groups include patients, providers, hospitals, payers, and purchasers.
3	Disseminate the design of our community-based health information network, the techniques of our intervention approaches and the results of our evaluation to interested stakeholders.

**Table 2. Project objectives to achieve specific aims**

#	Objective
1	<b>Clinical Outcomes.</b> Determine the ability of HIT in a community network to improve clinical outcomes. (Aim 1)
2	<b>Service Delivery/Care Quality.</b> Determine the ability of HIT in a community network to improve compliance with care standards, enhance identification of health risks, and lower barriers to accessing care. (Aim 2)
3	<b>Coordination/Communication/Collaboration.</b> Determine the ability of HIT in a community network to improve coordination of care. (Aim 1)
4	<b>Cost Reduction/Revenue Enhancement.</b> Clarify the financial impact of a community-wide effort to promote clinical data exchange, in terms of cost reduction and revenue enhancement. (Aims 1 and 2)
5	<b>Stakeholder Satisfaction.</b> Determine the ability of HIT in a community network to improve patient satisfaction and achieve provider support. (Aim 2)
6	<b>Dissemination.</b> Disseminate the approaches used in this project as well as the results of the value analyses, so as to facilitate broader adoption of initiatives to use HIT to share information across a community. (Aim 3)

# Scope

## Background

Conventional models of clinic-based healthcare delivery have failed to provide consistent, high-quality care across entire populations.<sup>1</sup> Such models promote crisis-oriented care and serve only individuals who seek assistance by going to a clinic site. New population-oriented care models are emerging that seek to provide care for patients not presenting to an outpatient site.<sup>2</sup> Information technology has been identified as a critical element for supporting such new models and for reducing errors and improving quality.<sup>3</sup> Information technology, and in particular health information exchanges (HIEs), have the capacity to enhance the management of the health of populations by promoting the sharing of health information across independent healthcare organizations. The information available through HIEs can be used by clinical decision support (CDS) systems to identify sentinel health events and patient-specific care needs, and then to promote proactive interventions.

Relatively little has been published regarding the role of health information technology in population health management.<sup>4</sup> Previous studies have shown that population-based care management programs focusing on potentially high risk patients can reduce costs and improve outcomes.<sup>5-7</sup> These studies did not rely on health information technology to facilitate the identification of patients in need of care management and showed only modest improvements. In 2005, Javitt *et al.* reported that alerts to physicians that identify errors and promote best practices reduced hospitalizations and costs.<sup>8</sup> These alerts were generated through a claims-based surveillance system for commercially insured patients. Involvement of nurses in the alerting process through interactions with patients and physicians increased the identification and resolution of concerning clinical issues.<sup>9</sup> These studies, however, focused solely on patients and data from within a single private health insurance program.

In this study, we describe and evaluate an information-based, population-oriented care model that draws upon information from a regional HIE to provide proactive care management to Medicaid beneficiaries using a standards-based approach to clinical decision support. We provide results regarding the frequency of sentinel health events detected within this population and the impact of distributing notifications about these events through three distinct modalities.

## Context

This project focuses on the care delivered to a population of Medicaid beneficiaries in Durham County, North Carolina through a partnership of academic, private and government service providers. The current project enrolled Medicaid patients residing in this single county; as described below, however, the care network initially developed for this population has now been expanded to include 5 additional North Carolina counties.

**Population-based Care Management.** In 1997, the North Carolina Department of Medical Assistance instituted a demonstration project to provide care management for Medicaid beneficiaries in Durham County, North Carolina. This program expanded in 2004 to include four adjacent counties and became the Northern Piedmont Community Care Network (NPCCN).

Care management services in Durham County are provided through a community-based care management team that is led by a program manager and includes nurses, social workers, community health workers, nutritionists, and health educators. Approximately 500 individuals are under active care management at any time. Care management services offered through the Network include home assessments, in-home health education and dietary instruction, assistance keeping scheduled clinic appointments, and support for obtaining and taking medications. Furthermore, these providers routinely interact with other network partners including physicians, nurse practitioners, nurses, and pharmacists.

**Development of a Regional HIE.** In an effort to support community-based care management, a regional Health Information Exchange (HIE) network was developed. The COACH system (Community-Oriented Approach to Coordinated Healthcare) was initiated in 2000 as a care management documentation tool.<sup>10</sup> Over the ensuing eight years, the system has been enhanced to facilitate communication between team members collaborating in the care of patients in the Network. Basic demographic and eligibility data for Network enrollees are uploaded to the system from the North Carolina Office of Rural Health and Community Care on a monthly basis, and data transfer protocols are in place to import clinical and billing data from partner sites. The imported data include encounter and pharmacy claims data from the State Medicaid Office, as well as billing data from nine clinics and all five hospitals in the service region. The four types of data collected by the system include: 1) administrative data (demographics and identifiers, services used, provider associations, audit trails); 2) care management data (care management encounters, health risk and environment assessment, socio-economic data, special needs, and care management plans); 3) clinical data (encounters, problems/procedures, missed appointments, medications, allergies, laboratory results, disease-specific care plans); and 4) data on communications (messages and alerts, referrals, notices of new information). Through data imported from partner organizations, COACH currently contains records on 109,834 unique patients (41,541 active); 4,391,044 healthcare encounters; 79,476 care management encounters (e.g. home visits); 63,285 missed appointments; 4,573,767 billing diagnoses; 4,781,099 billing procedures; 257,266 laboratory results; and 1,613,865 pharmacy claims.

**Clinical Decision Support.** To detect sentinel health events from data within the COACH HIE network, we refined our decision support tool known as SEBASTIAN (System for Evidence-Based Advice through Simultaneous Transaction with an Intelligent Agent across a Network) to support sophisticated population health management activities.<sup>11</sup> SEBASTIAN is a general decision support tool based on an international draft standard (the Health Level 7 Decision Support Service Draft Standard for Trial Use).<sup>12</sup> SEBASTIAN uses Web service technology to receive patient data from a client application. It then processes these data according to an application independent, pre-programmed set of rules (e.g., clinical algorithms and guidelines) and returns back patient-specific recommendations to the client application.

## Settings

The specific partners participating in the Medicaid care management network in Durham County, North Carolina are summarized in Table 3.

**Table 3. Clinical practices and community partner organizations participating the study**

Organization Type	Project Partners
Clinical Sites	Duke Family Medicine Center, Duke Children's Primary Care, Lincoln Community Health Center*, Central Family Practice**, Duke Outpatient Clinic, Durham Pediatrics, Duke OB/GYN, Regional Pediatrics Associates
Government Agencies	Durham County Health Department, Durham Department of Social Services (DSS)
Hospitals	Duke University Hospital, Durham Regional Hospital
Urgent Care Facilities	Duke Urgent Care - North, Lincoln Urgent Care, Duke Urgent Care - South
Community Organizations	Durham Community Health Network

\* Federal Qualified Health Center

\*\* Practice closed during the study and patients were referred to the Lincoln Community Health Center.

## Participants

Study participants in this project include Medicaid beneficiaries residing in Durham County, North Carolina who are continuously enrolled in the NPCCN during the intervention period and their care providers. We elected to study only continuously enrolled patients because we wanted to have the complete dataset of all of the care provided to the individuals included in the analysis. Detailed demographic data for subjects enrolled in Phase I are summarized in Table 4 by study arm along with p-values to identify differences between groups.

**Table 4. Baseline characteristics of subjects randomized for Phase 1 of the intervention**

	Information Intervention Strategy: Email Notices to Care Managers (N=3322) Count (%)	Information Intervention Strategy: Feedback Reports Sent to Clinics (N=3351) Count (%)	Information Intervention Strategy: Reminder Letters Sent to Patients (N=3387†) Count (%)	No Intervention: Controls (N=10048) Count (%)	P-value (3 df)#
Family size, median, (25th, 75th), Min, Max	2, (1,3), 1,9	2, (1,3), 1, 11	2, (1,3), 1, 12	2, (1,3), 1, 14	0.62*
Age <2 years	441 (13.3)	461 (13.8)	484 (14.3)	1475 (14.7)	0.19
Age 3-6 years	746 (22.5)	745 (22.2)	754 (22.3)	2336 (23.3)	0.47
Age 7-15 years	1134 (34.1)	1182 (35.3)	1177 (34.8)	3385 (33.7)	0.34
Age 16-30 years	487 (14.7)	426 (12.7)	444 (13.1)	1320 (13.1)	0.084
Age >30 years	514 (15.5)	537 (16.0)	525 (15.5)	1532 (15.2)	0.76
Black race	2256 (67.9)	2278 (68.0)	2221 (65.6)	6713 (66.8)	0.11
Male gender	1480 (44.6)	1453 (43.4)	1408 (41.6)	4489 (44.7)	0.012
History of diabetes	72 (2.2)	92 (2.8)	88 (2.6)	287 (2.9)	0.19
History of asthma	319 (9.6)	352 (10.5)	307 (9.1)	937 (9.3)	0.17
Asthmatic with age>18	82 (2.5)	91 (2.7)	81 (2.4)	252 (2.5)	0.85

† Includes 3 patients for whom age data were not available

# p-values based on 3 degree-of-freedom Chi-square tests

\*p-value based on the Kruskal-Wallis test

Table 5 shows cumulative enrollment of subjects by gender and race/ethnicity across the entire 4-year study period (Phases 1 through 3).

**Table 5. Cumulative number of subjects enrolled by ethnicity and race across all phases**

Category		Females	Males	Unknown or not reported	Total
Ethnic	Hispanic or Latino	622	602	0	1,224
Ethnic	Not Hispanic or Latino	954	690	0	1,644
Ethnic	Unknown (Individuals not reporting ethnicity)	15,835	12,369	0	28,204
Ethnic	<b>Ethnic: Total All Subjects</b>	17,411	13,661	0	31,072
Racial	American Indian/ Alaska Native	16	12	0	28
Racial	Asian	91	71	0	162
Racial	Native Hawaiian or Other Pacific Islander	2	5	0	7
Racial	Black or African American	10,399	7,516	0	17,915
Racial	White	1,927	1,514	0	3,441
Racial	More than one race	0	0	0	0
Racial	Unknown or not reported	4,976	4,543	0	9,519
Racial	<b>Racial: Total of All Subjects</b>	17,411	13,661	0	31,072

## Incidence

**Detection of Sentinel Health Events.** The topics of the sentinel events monitored during this project are summarized in Table 6. These events are grouped as events of commission (i.e., reflecting an activity done by a patient) that were the target of Phase 1 of the study; events of omission (i.e., reflecting activities neglected by a patient such as preventive health services) that were the focus of Phase 2; and events self-reported by patients through questionnaires on health risk and barriers to care access completed by patients on free standing public kiosks. During the study period, less than 150 patient reported events were detected from all of the possible question responses from the four kiosks in Durham County. Because of the small number of events from any one question, these findings are not further analyzed in this report.

For the nine-month period from September 2006 through May 2007, 20,108 patients were continuously enrolled in Medicaid in Durham County. Out of this population, 4,880 sentinel health events were detected for 3,543 unique patients (17.6% of the total population). The range for the number of notices for individual patients was zero to 43. The frequency with which each sentinel health event was identified is summarized by study arm in Table 7.

**Table 6. Sentinel events, the population monitored for the event and the definition of the event**

<b>Event Type</b>	<b>Event Focus</b>	<b>Group</b>	<b>Event Definition</b>
Commission	3+ ED in 90 days	All	ED encounter in past month that constituted the 3rd or greater ED encounter in 90 days
Commission	Low-severity ED	All	Low-severity ED encounter in the past month. Low-severity ED encounters are deemed to have occurred if one of the following conditions hold: (1) patient had an evaluation and management CPT procedure code indicative of a low-severity ED visit, or (2) there are no encounter diagnoses deemed to be medium-to-high severity by NC Medicaid
Commission	ED visit by patient with asthma	Pts with Asthma	ED encounter in past month associated with any diagnosis by a patient with asthma
Commission	ED visit by patient with diabetes	Pts with Diabetes	ED encounter in past month associated with any diagnosis by a patient with diabetes
Commission	ED for fever	Aged 0 to 20	ED encounter in the past month with fever as the primary diagnosis
Commission	ED for pregnancy-related reason	Women	ED encounter in the past month with a pregnancy-related issue as the primary diagnosis
Commission	Hospitalization by patient with asthma	Pts with Asthma	Hospitalization in the past month associated with any diagnosis by a patient with asthma
Commission	Hospitalization by patient with diabetes	Pts with Diabetes	Hospitalization in the past month associated with any diagnosis by a patient with diabetes
Commission	2+ missed appointments in 60 days	All	Missed outpatient encounter in the past month that constituted the 2nd or greater missed encounter in 60 days
Commission	Childbirth, need for post-partum follow-up in 6-8 weeks	Women	Patients who gave birth to a live infant 6-8 weeks ago who have not had an outpatient encounter since the delivery
Omission	No mammogram in 2 years	Women, 52 to 69 y.o.	Woman age 52 to 69 years old who have no record of a mammogram in the past 2 years
Omission	No Pap smear in 3 years	Women, 21 to 64 y.o.	Woman age 21 to 64 years old who have no record of a Pap smear in the past 3 years
Omission	No Chlamydia screening in 1 year	Women, 16 to 26 y.o.	Woman age 16 to 26 years old who have no record of a Chlamydia test in the past 1 year
Omission	No post-partum visit after delivery in 21 to 56 days	Women	Women for whom a child delivery is recorded but no follow-up visit is detected within 3 to 8 weeks after delivery
Omission	No glycated hemoglobin test in 1 year	Patients w/ diabetes	Patient with diabetes for whom no glycated hemoglobin test is detected within the past 1 year
Omission	No LDL cholesterol test in 1 year	Patients w/ diabetes	Patient with diabetes for whom no LDL cholesterol test is detected within the past 1 year
Omission	No urine microalbumin test in 1 year	Patients w/ diabetes	Patient with diabetes for whom no urine microalbumin test is detected within the past 1 year
Omission	No eye exam in 1 year	Patients w/ diabetes	Patient with diabetes for whom no eye examination is detected within the past 1 year
Omission	No well child visit in 6 months	Children age 0 to 36 months	Patient up to 3 years of age who does not have record of a well child visit in a 6-month period
Omission	No well child visit in 1 year	Children age 3 to 6 years	Patient between 3 and 6 years of age who does not have record of a well child visit in a 12-month period
Patient-Reported	Patient reported possible need for prenatal care in a woman		Kiosk users who entered a Medicaid ID number for him/herself or as a guardian for a child and responded to specific questions about modifiable health risks or barriers to accessing care. Definitions of the item is self explanatory
Patient-Reported	Patient reported possible depression in teenager		Kiosk users who entered a Medicaid ID number for him/herself or as a guardian for a child and responded to specific questions about modifiable health risks or barriers to accessing care. Definitions of the item is self explanatory

**Table 6. Sentinel events, the population monitored for the event and the definition of the event (continued)**

<b>Event Type</b>	<b>Event Focus</b>	<b>Group</b>	<b>Event Definition</b>
Patient-Reported	Patient reported family struggles with abuse in the home		Kiosk users who entered a Medicaid ID number for him/herself or as a guardian for a child and responded to specific questions about modifiable health risks or barriers to accessing care. Definitions of the item is self explanatory
Patient-Reported	Patient reported need for Pap smear in a woman		Kiosk users who entered a Medicaid ID number for him/herself or as a guardian for a child and responded to specific questions about modifiable health risks or barriers to accessing care. Definitions of the item is self explanatory
Patient-Reported	Patient reported need for mammogram in a woman		Kiosk users who entered a Medicaid ID number for him/herself or as a guardian for a child and responded to specific questions about modifiable health risks or barriers to accessing care. Definitions of the item is self explanatory
Patient-Reported	Patient reported need for well child visit for a child		Kiosk users who entered a Medicaid ID number for him/herself or as a guardian for a child and responded to specific questions about modifiable health risks or barriers to accessing care. Definitions of the item is self explanatory
Patient-Reported	Patient reported new onset pregnancy in a woman		Kiosk users who entered a Medicaid ID number for him/herself or as a guardian for a child and responded to specific questions about modifiable health risks or barriers to accessing care. Definitions of the item is self explanatory
Patient-Reported	Patient reported missing >10 days of school/year in a child		Kiosk users who entered a Medicaid ID number for him/herself or as a guardian for a child and responded to specific questions about modifiable health risks or barriers to accessing care. Definitions of the item is self explanatory
Patient-Reported	Patient reported no blood test for lead in past year in a child		Kiosk users who entered a Medicaid ID number for him/herself or as a guardian for a child and responded to specific questions about modifiable health risks or barriers to accessing care. Definitions of the item is self explanatory
Patient-Reported	Patient reported high risk of TB exposure		Kiosk users who entered a Medicaid ID number for him/herself or as a guardian for a child and responded to specific questions about modifiable health risks or barriers to accessing care. Definitions of the item is self explanatory
Patient-Reported	Patient reported concern about weight		Kiosk users who entered a Medicaid ID number for him/herself or as a guardian for a child and responded to specific questions about modifiable health risks or barriers to accessing care. Definitions of the item is self explanatory
Patient-Reported	Patient reported difficulty accessing PCP		Kiosk users who entered a Medicaid ID number for him/herself or as a guardian for a child and responded to specific questions about modifiable health risks or barriers to accessing care. Definitions of the item is self explanatory
Patient-Reported	Patient reported poor compliance with medications		Kiosk users who entered a Medicaid ID number for him/herself or as a guardian for a child and responded to specific questions about modifiable health risks or barriers to accessing care. Definitions of the item is self explanatory
Patient-Reported	Patient reported need for assistance to get care services		Kiosk users who entered a Medicaid ID number for him/herself or as a guardian for a child and responded to specific questions about modifiable health risks or barriers to accessing care. Definitions of the item is self explanatory
Patient-Reported	Patient reported need for assistance to get medical equipment		Kiosk users who entered a Medicaid ID number for him/herself or as a guardian for a child and responded to specific questions about modifiable health risks or barriers to accessing care. Definitions of the item is self explanatory
Patient-Reported	Patient reported need for assistance to get medications		Kiosk users who entered a Medicaid ID number for him/herself or as a guardian for a child and responded to specific questions about modifiable health risks or barriers to accessing care. Definitions of the item is self explanatory

**Table 7. Notifications generated during the 9-month Phase I period from September 2006 through May 2007**

Focus of Detected Sentinel Event	# of Events	Emailed (N=3322) Count (%)	Reports (N=3351) Count (%)	Letters (N=3387) Count (%)	Withheld N=10048) Count (%)	P-Value
3+ ED in 90 days	224	71 (2.1)	54 (1.6)	78 (2.3)	211 (2.1)	0.21
Low-severity ED	2,099	324 (9.8)	343 (10.2)	367 (10.9)	1,065 (10.6)	0.45
ED visit by patient with asthma	438	126 (3.8)	140 (4.2)	133 (3.9)	390 (3.9)	0.86
ED visit by patient with diabetes	284	49 (1.5)	45 (1.3)	51 (1.5)	139 (1.4)	0.92
ED for fever	425	50 (1.5)	63 (1.9)	73 (2.2)	239 (2.4)	0.016
ED for pregnancy-related reason	46	8 (0.2)	4 (0.1)	7 (0.2)	27 (0.3)	0.47
Hospitalization by patient with asthma	41	8 (0.2)	8 (0.2)	6 (0.2)	19 (0.2)	0.81
Hospitalization by patient with diabetes	66	12 (0.4)	14 (0.4)	10 (0.3)	30 (0.3)	0.73
2+ missed appointments in 60 days	1,257	183 (5.5)	209 (6.3)	230 (6.8)	635 (6.3)	0.18
Total Events Detected	4,880	831	880	955	2214	
Unique Patients with Events	3,543	545 (16.4)	588 (17.6)	621 (18.3)	1,789 (17.8)	0.19

## Prevalence

In a sub-analysis over the 6 months from September 2006 through February 2007, we compared the relative percent of the population across race and age strata to the relative percentage of individuals in these substrata who received at least one notice during the 6-month period (Table 8). We discovered that events were disproportionately more frequent among individuals aged 19 to 64. Patients between ages 19 and 64 were much more likely to be in the subset of patients receiving notices. The results of the logistic regression models support these findings (Table 9). For all endpoints, patients aged 19-64 were much more likely to have sentinel health events. For the model predicting 2 or more missed appointments, those patients aged 19-64 were between 2 and 5 times more likely to have sentinel health events. For the same endpoint, Hispanics were approximately 40% less likely to have sentinel health events.

**Table 8. Characteristics of NPCCN population**

Characteristic	Total Sample (%)	Sample with alerts (%)
Age in years (range): 0-5	35.8	36.9
Age in years (range): 6-12	25.1	15.2
Age in years (range): 13-18	16.6	12.2
Age in years (range): 19-64	20.7	34.0
Age in years (range): 65+	1.8	1.7
Female Gender	54.7	59.4
Race: White	10.8	8.6
Race: Black	66.0	71.4
Race: Hispanic	13.8	10.6
Race: Am. Indian	0.1	0.0
Race: Asian	0.2	0.1
Race: Unknown	10.8	9.3

**Table 9. Logistic regression results**

Patient Factors	Any Alert	Low Severity ED	3+ED visits in 90 days	Missing 2+ appts in 60 days
Age 0-5	0.59*	0.81*	0.19*	0.45*
Age 6-12	0.30*	0.35*	0.08*	0.22*
Age 13-18	0.36*	0.39*	0.21*	0.30*
Age 65+	0.48*	0.32*	0.26*	0.15*
Black	1.12	1.15	1.09	1.04
Hispanic	0.81	0.94	0.65	0.59*
Female	1.07	1.10	1.18	1.09

Numbers shown are the odds ratios for notification; \*P<0.01; age reference group: 19-64 year old patients

## Methods

### Study Design

This study was a randomized controlled trial evaluating three interventions against each other and against a usual care control. Medicaid beneficiaries who were continuously enrolled in the NC Community Care Program in Durham County, North Carolina for at least one year were randomly assigned by family unit to one of six groups (Table 10). Groups 1 through 3 were exposed to information interventions of progressively increasing intensity introduced through three sequential phases. Groups 4 through 6 were maintained with usual care. The study was registered with ClinicalTrials.gov as NCT00365885 as of August 16, 2006.

**Table 10. Study design and duration of the four study phases**

Study Group	Study Cycle: Run-in Dates: 8-2005 to 8-2006 Duration: 13 Months	Study Cycle: Phase 1 Dates: 9-2006 to 5-2007 Duration: 9 Months	Study Cycle: Phase 2 Dates: 6-2007 to 12-2007 Duration: 7 Months	Study Cycle: Phase 3 Dates: 1-2008 to 6-2008 Duration: 6 Months	Study Cycle: Phase 4 Dates: 7-2008 & ongoing Duration: 5+ Months
Intervention: 1		Commission Email Notices	Commission + Omission Email Notices	Email Notices Feedback Reports Patient Reminders	Email Notices
Intervention: 2		Commission Feedback Reports	Commission + Omission Feedback Reports	Feedback Reports Patient Reminders Email Notices	Email Notices
Intervention: 3		Commission Patient Reminder Letters	Commission + Omission Patient Reminder Letters	Patient Reminders Email Notices Feedback	Email Notices
Control: 1					Email Notices
Control: 2					Email Notices
Control: 3					Email Notices

## Data Sources/Collection

Data for the primary and secondary outcomes were obtained from claims data from the NC Department of Health and Human Services. Analyses were delayed by at least 6 months after the completion of each study phase to ensure that the claims dataset was complete and stable. As a consequence of these lag times, preliminary analyses have not been performed for all phases, but the completed and verified analyses from Phase 1 provide the primary content for this report. After further validation and sub-analyses, the results from the subsequent phases will be submitted for peer reviewed publication.

One example of the importance of our data validation efforts was the discovery of missing claims data for the months of October 2007 and December 2007 through March 2008. When we were validating our preliminary analyses for Phase 2 and 3, we discovered some unexplainable sporadic cost decreases. Upon digging deeper into the data, we discovered a significant drop in the number of claims during the aforementioned months. We were later able to show our State colleagues that these months on average were missing 150,000 claims each (approximately one third of the usual volume of monthly claims for our program) in the master Medicaid dataset. After several iterations over 3 to 4 months, we have been able to fill in the missing claims and move forward with confidence that our dataset is complete, albeit with a delay in the analysis of the project results.

Patient satisfaction and quality of life were assessed using the CAHPS and the EuroQoL survey instruments, respectively. Provider opinions were assessed using validated survey instruments for assessing usability.

The population health management system records, at the level of the individual patient, every sentinel health event that is detected from a patient's data in the COACH HIE. The number of sentinel health events for the nine-month period from September 2006 to May 2007 was extracted from the event recording database along with patient characteristics including date of birth, gender, race/ethnicity, number of family members in Medicaid, and clinic assignment.

This study was approved by the Duke University School of Medicine Institutional Review Board.

## Interventions

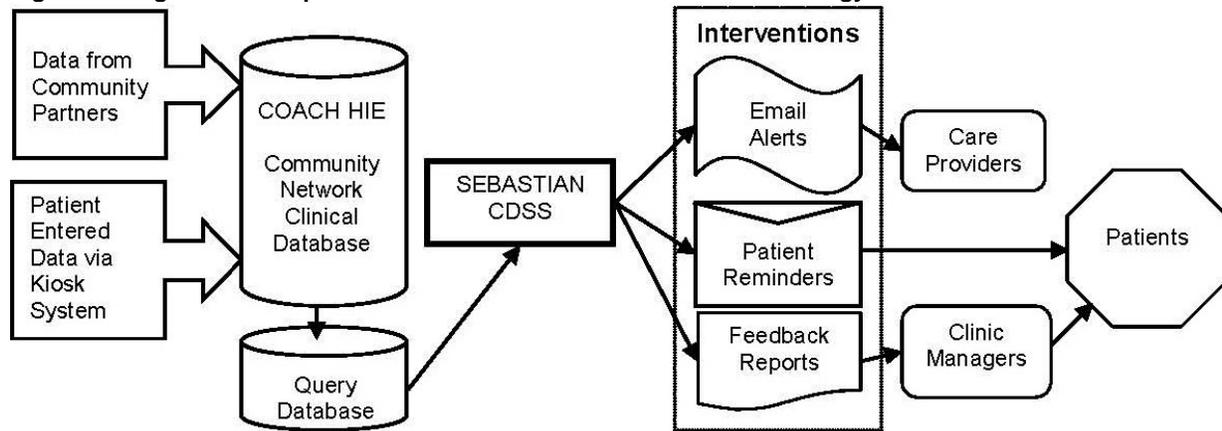
**Identification of Sentinel Health Events.** We worked with the medical directors and administrators for the primary care clinics participating in the network and with members of the care management team to define and prioritize sentinel health events that would benefit from care management. Sentinel events were defined as resource utilization by patients (i.e., events of commission) that were considered excessive (e.g., three ED visits in 90 days) or potentially avoidable (e.g., ED visit for asthma) and that could potentially be modified by the involvement of care managers and other providers. Prioritization was empirically derived so that issues of greatest importance to the care management team such as ED and hospital resource use received the greatest weight. We used standards for preventive health services and diabetes from the Healthcare Effectiveness Data and Information Set (HEDIS) for Medicaid for 2005 to define “events” related to care quality (i.e., events of omission).

**Integration of Standards-Based CDS in Population Health Management.** We created over 150 rules in the SEBASTIAN knowledge base to detect sentinel events using the Java

programming language. The accuracy of these rules for correctly identifying both events of commission and omission as well as sentinel patient self-reported information was validated using chart audits. Rules were iteratively modified until a minimum of 90% accuracy was achieved.

**Implementation of Population Health Management.** SEBASTIAN is currently being used to support population health management in the COACH HIE network (Figure 1). The COACH population health management module uses rule-based knowledge modules to detect such care issues as inappropriate resource utilization and patient-reported barriers to accessing care services. The sentinel events identified by SEBASTIAN are prioritized and then distributed as email notices to care managers (Figure 2), as feedback reports to clinic managers (Figure 3), and as care reminder letters to patients or their guardians in cases involving minors (Figure 4).

**Figure 1. Diagrammatic representation of the health information technology intervention**



**Figure 2. Sample email notice to care manager**

**COACH Alerts for Ms. Carolyn Williams**  
 Document ID: 5658  
 10/18/08 (Sat)

Reminder: Many of the following recommendations are derived from Medicaid claims data and may have errors because of incomplete or delayed data. If you have any questions or concerns, please contact Chet Orton (Software Engineer; chet.orton@duke.edu; 919-688-4376) or Teresa Ebel (Project Coordinator; teresa.ebel@duke.edu; 919-681-7011).

Patients requiring attention (highest priority patients listed first):

1. [REDACTED] Daisy (COACH link). 62 yr. old African-American female, DOB [REDACTED] 46.  
 Medicaid: [REDACTED] Duke MRN: [REDACTED] PCC: Lincoln Priority: 17.0  
 [REDACTED] Ave, Durham, NC 27 [REDACTED] Home #: 919-[REDACTED]

Hospitalizations that may require follow-up:  
 Hospitalization in past month: Location: Durham Regional Hospital (listed as ' in COACH) . Date: 10/01/08. Primary diagnosis: ICD9 578.0 (Hematemesis). # hospitalizations in past 12 mo: 1.

Diabetes care needs:  
 Hemoglobin A1c test may be due: Test recommended every 6 months for patients with diabetes. No test on record from past 2 years.  
 Flu vaccine may be due: Flu vaccine recommended every flu season (Sept.-Feb.) for patients with diabetes, provided patient is not allergic to eggs. Last known flu vaccine done on 10/30/07.  
 Ophthalmologic exam may be due: Exam recommended every 12 months for patients with diabetes. Last known exam done 12 to 23 months ago on 01/31/07.  
 Urine microalbumin test may be due: Test recommended every 12 months for patients with diabetes, unless patient has nephropathy or is prescribed an ACE inhibitor or an Angiotensin II Receptor Blocker (ARB). No test on record from past 2 years.

Preventive care needs:  
 Mammogram may be due: Test recommended every 2 years for women aged 40+. No test on record from past 2 years.  
 Pap test may be due: Test recommended every 3 years for women aged 18 to 64, unless patient has had a hysterectomy. No test on record from past 3 years.

2. [REDACTED] Mary (COACH link). 75 yr. old female, DOB [REDACTED] 33.  
 Medicaid: [REDACTED] Duke MRN: [REDACTED] PCC: Lincoln Priority: 15.0  
 [REDACTED] Durham, NC 27 [REDACTED] Home #: 919-[REDACTED]

Hospitalizations that may require follow-up:  
 Hospitalization in past month: Location: Durham Regional Hospital (listed as ' in COACH) . Date: 10/07/08. Primary diagnosis: ICD9 562.11 (Colon Diverticulitis). # hospitalizations in past 12 mo: 1.

Diabetes care needs:  
 Hemoglobin A1c test may be due: Test recommended every 6 months for patients with diabetes. No test on record from past 2 years.  
 Flu vaccine may be due: Flu vaccine recommended every flu season (Sept.-Feb.) for patients with diabetes, provided patient is not allergic to eggs. Last known flu vaccine done on 10/30/07.  
 Ophthalmologic exam may be due: Exam recommended every 12 months for patients with diabetes. Last known exam done 12 to 23 months ago on 04/05/07.

**Figure 3. Sample section from clinic feedback report**

**COACH Feedback Report for Duke Family Medicine**  
 Document ID: 4080  
 04/11/08 (Fri)

Reminder: Many of the following recommendations are derived from Medicaid claims data and may have errors because of incomplete or delayed data. If you have any questions or concerns, please contact Chet Orton (Software Engineer; chet.orton@duke.edu; 919-688-4376) or Teresa Ebel (Project Coordinator; teresa.ebel@duke.edu; 919-681-7011).

Patients requiring attention (highest priority patients listed first):

1. [REDACTED] Erica (COACH link). 23 yr. old African-American female, DOB [REDACTED] 84.  
 Medicaid: [REDACTED] Duke MRN: [REDACTED] PCC: Duke Fam Med Priority: 21.0  
 [REDACTED] Durham, NC 27 [REDACTED] Home #: 919-[REDACTED]

Asthma care needs:  
 6+ short acting asthma meds dispensed last year: # short acting asthma meds dispensed last year: 32. # maintenance asthma meds dispensed last year: 0.

Diabetes care needs:  
 Hemoglobin A1c test may be due: Test recommended every 6 months for patients with diabetes. Last known test done 6 to 11 months ago on 06/20/07.  
 LDL cholesterol test may be due: Test recommended every 12 months for patients with diabetes. Last known test done 12 to 23 months ago on 03/07/07.  
 Total cholesterol test may be due: Test recommended every 12 months for patients with diabetes. Last known test done 12 to 23 months ago on 03/07/07.  
 Ophthalmologic exam may be due: Exam every 12 months for patients with diabetes. No exam on record from past 2 years.  
 Urine microalbumin test may be due: Test recommended every 12 months for patients with diabetes, unless patient has nephropathy or is prescribed an ACE inhibitor or an Angiotensin II Receptor Blocker (ARB). No test on record from past 2 years.

2. [REDACTED] Priscilla (COACH link). 56 yr. old African-American female, DOB [REDACTED] 51.  
 Medicaid: [REDACTED] Duke MRN: [REDACTED] PCC: Duke Fam Med Priority: 16.0  
 [REDACTED] St, Durham, NC 27 [REDACTED] Home #: 919-[REDACTED]

ED visits that may require follow-up:  
 3+ ED visits in 90 days, most recent in past 3 months: Location: Duke Hospital ED (listed as 'Emergency Room-duke' in COACH). Date: 02/10/08. Primary diagnosis: ICD9 788.63 (Urgency Of Urination). # ED visits in past 6 mo: 7.  
 Low-severity ED visit in past 3 months: Location: Duke Hospital ED (listed as 'Emergency Room-duke' in COACH). Date: 02/10/08. Primary diagnosis: ICD9 788.63 (Urgency Of Urination). Reason deemed to be low-severity: lack of encounter diagnosis indicative of a true emergency. # low-severity ED visits in past 6 mo: 7.

3. [REDACTED] Ta [REDACTED] (COACH link). 8 mo. old African-American female, DOB [REDACTED] 07.  
 Medicaid: [REDACTED] Duke MRN: [REDACTED] PCC: Duke Fam Med Priority: 14.25  
 [REDACTED] Dr, Durham, NC 27 [REDACTED] Home #: 919-[REDACTED]

ED visits that may require follow-up:  
 3+ ED visits in 90 days, most recent in past 3 months: Location: Duke Hospital ED (listed as 'Emergency Room-duke' in COACH). Date: 03/06/08. Primary diagnosis: ICD9 780.6 (Fever). # ED visits in past 6 mo: 3.

Figure 4. Sample patient reminder letter tailored to the patient's assigned medical home

<b>Durham Community Health Network</b>	 <b>Lincoln Community Health Center, Inc.</b>
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*Lincoln Community Health Center • Duke University Medical Center • Durham Pediatrics • Regional Pediatric Associates  
Central Family Practice • Durham County Health Department • Durham Department of Social Services*

July 12, 2008

Dear Ms. M [REDACTED],

As members of your health care team, we want to give you the best care possible! We are sending you this letter because we want to improve the quality of health care we offer. Our records suggest that you may need the following health care services:

**Diabetes services that may be due:**

- Hemoglobin A1c (blood sugar) Test: You should have this test every 6 months. It shows whether your blood sugar was under control during the past few months.
- LDL Cholesterol Test: You should have this test every 12 months to help prevent heart disease. Talk with your doctor about your goals for good (HDL) and bad (LDL) cholesterol.
- Dilated Eye Exam: You should see an eye doctor at least once every 12 months. Diabetes increases your risk for eye diseases. But, the risk of vision loss can be reduced if problems are found early.
- Urine Protein Test: You should have this test at least once every 12 months. This test helps your doctor know how well your kidneys are working.

**Preventive care services that may be due:**

- Mammogram: Women over 40 years old you should have a mammogram every 1 to 2 years. This helps to find breast cancer early – when it is easier to treat.
- Pap Test: Most women should have a Pap test at least once every 3 years. This test finds cell changes that can lead to cervical cancer. Early treatment can prevent cervical cancers from developing.

If you have not received the service(s) listed, please schedule a visit with our office. Call us at (919) 958-4000 to make an appointment. When you call, tell the front desk about this letter. Also, please bring this letter with you. If you have already received the service(s) listed above we want to make sure that our records are updated. Please call 866-459-5341 if you have concerns about the accuracy of the information in this letter.

We look forward to seeing you soon!

Sincerely,  
*Your Care Team*

Lincoln Community Health Center  
A Member of the Durham Community Health Network

Lincoln Community Health Center, Inc. • 1301 Fayetteville St. • Durham, NC 27717  
(919) 956-4000 • www.lincolnchc.org • A JCAHO Accredited Facility

The primary study measures are summarized in Table 11.

**Table 11. Study measures**

<b>Measurement Focus</b>	<b>Measures</b>
Clinical Outcomes: ED Encounters Hospitalizations	ED encounters per 1000 pt years Hospitalizations per 1000 pt years Primary care encounters per 1000 pt years HgbA1c levels
Care Quality: Preventive Services Chronic Disease Management for Asthma & Diabetes	HEDIS scores for mammograms, Pap smears, Chlamydia screening HEDIS scores for asthma staging, recording action plans, prescribing inhaled corticosteroids HEDIS scores for performing glycated hemoglobin, microalbumin, lipid panel, dilated eye exam HEDIS scores for well child visits AHRQ PQI for asthma AHRQ PQI for uncontrolled diabetes, short- & long-term complications
Care Coordination: Missed Appointments F/U Appointments	Missed appointments per 1000 patient years Rate of postpartum f/u after child birth per 1000 patient years
Costs/Revenues: ED costs Hospitalization Costs	Costs of HIT interventions including personnel/hardware/software costs Co-pay costs Professional fees Technical fees Pharmaceutical reimbursement ED costs Hospitalization costs
Satisfaction: Patient Satisfaction Patient Quality of Life Provider Opinions	Patient satisfaction survey EuroQoL Provider opinion surveys

## Limitations

The findings of this study need to be interpreted in the context of the setting in which it was performed. The successful arm of the interventions involved care managers who received and acted upon notices about sentinel health events. The availability and responses of these care managers were likely pivotal to the intervention's success. Our approach can be used in other settings provided that recipients can be identified who will respond to the notices. Furthermore, this study focused exclusively on patients enrolled in Medicaid. Accordingly, the study findings may not necessarily be generalizable to other populations. A third limitation is that our system has functioned primarily by using billing/claims data as opposed to clinical data from an electronic health record system. This approach represents a minimalist view of what could be possible in terms of population health management if a more comprehensive clinical dataset were available. As the breadth of clinical data available in HIEs increases, the value of proactive population health management is also likely to increase. Finally, this study has no correction factor (e.g. Bonferoni) applied to the level of significance for the analysis in spite of the multiple comparisons that were made.

# Results

## Principal Findings

**Aim 1.** The primary finding from this investigation is that e-mail notices sent to care managers weekly regarding sentinel health events can lower emergency department utilization for low severity issues. These notifications are well received by care managers and are reported to enhance productivity. In contrast, feedback reports sent quarterly to clinic managers did not impact ED utilization or hospitalizations nor did letters sent to patients. None of the interventions appeared to have a significant verifiable impact on healthcare costs or quality. No deterioration of quality was detected in the setting of reduced ED utilization for low severity issues.

**Aim 2.** With regard to this study's primary stakeholders (patients, providers, hospitals, payers, and purchasers), the net effect of the intervention was to decrease emergency department utilization and inpatient reimbursements (for emergency department and hospital care) for patients randomized to the group whose care managers received weekly email notifications about sentinel events. There were no hospital effects for patients in the two other intervention groups. There also was an increase in outpatient costs; however, these were for mental health services that were not associated with the interventions provided in this study. The cost changes observed in this study were associated with reductions in co-payments for study patients randomized to care manager notices and with increases in payer reimbursements for patients randomized to patient letters. The net results on stakeholder groups are that patients may get more appropriate care which could mean higher quality; providers could see patients in more appropriate settings and feel that they are delivering better care; hospitals (and their EDs) may save money by handling fewer Medicaid cases; and payers and purchasers experience no benefits or detriments because there were no net changes in total costs.

**Aim 3.** The findings of this study have been disseminated through multiple venues including national teleconferences and several peer-reviewed publications. Additional publications and presentations are anticipated as the analyses of the study data are finalized.

## Quantitative Outcomes

The combined interventions did not significantly decrease overall emergency department utilization or hospitalizations relative to controls (primary study measure) (Table 11). However, e-mail notices to care managers significantly lowered emergency department encounters for low severity conditions ( $p=0.001$ ) (Table 12). These email notices were also associated with a decrease in hospitalization costs ( $p=0.045$ ) and a trend toward decreasing emergency department costs ( $p=0.07$ ), but no significant difference in total costs ( $p=0.39$ ) (Table 11). Of note, total costs were statistically significantly higher in the group that received patient letters ( $p=0.009$ ). On further analysis, the decrease in ED encounters for low severity conditions correlated with individuals who actually received notices (Table 13), and NOT with individuals who did not receive notices (Table 14). In contrast, the cost changes did not correlate with the receipt of

notices (Table 13), and the increased costs associated with the letter recipient group was detected among individuals who did not receive any letters ( $p= 0.024$ ) (Table 14), implying that some other factor may be responsible for this cost increase. We further determined that the specific costs contributing to his increase were associated with outpatient mental health costs and were associated predominantly with the federally qualified health center (LCHC) in our network.

We observed that the decreased costs for the e-mail recipient group for ED encounters ( $p=0.022$ ) and hospitalizations ( $p=0.005$ ) were also detected among non-notice generating family members of individuals for whom e-mail notices were generated (Table 15), but not among family groups for which no notices were generated for any family member (Table 16). Non-notice generating family members of notice generating individuals in the e-mail group were found to have a significant decrease in hospitalizations ( $p= 0.015$ ); however, the overall rate of hospitalization was low (3 to 12 per 1000 patients) and may be subject to spurious results.

No differences in care quality based on Medicaid HEDIS measures for preventive services and diabetes were detected between the control group and the combined intervention groups (Table 17). Additionally, the Patient Quality Indicators for diabetes and asthma did not reveal any differences (Table 18).

On subset analysis by clinic site, the decrease in ED utilization for low severity conditions was statistically significant at the two sites with the most Medicaid beneficiaries (LCHC and Duke Children's Primary Care).

**Table 12: Primary clinical and economic outcomes from Phase 1 (results show the mean followed by the 95% confidence interval and the p-value relative to the control group.)**

	<b>Control Group (N=10048)</b>	<b>Combined Intervention Groups (N=10060)</b>	<b>Emails to Care Managers (N=3322)</b>	<b>Feedback Reports to Clinics (N=3351)</b>	<b>Reminder Letters to Patients (N=3387)</b>
Emergency department encounters per 100 patients	30.8 (29.0, 32.7)	30.8 (28.8, 32.8) 0.99	27.7 (24.4, 30.9) 0.13	31.0 (27.7, 34.2) 0.95	33.7 (30.5, 36.9) 0.18
Low-severity ED encounters per 100 patients	10.6 (9.8, 11.4)	9.9 (9.1, 10.7) 0.25	<b>8.1</b> <b>(6.7, 9.4)</b> <b>0.001</b>	11.0 (9.6, 12.3) 0.71	10.8 (9.4, 12.1) 0.88
Count of 3 or more ED visits within 90 days per 100 patients	5.9 (4.7, 7.1)	5.5 (4.3, 6.7) 0.60	5.9 (3.8, 8.0) 0.98	4.3 (2.3, 6.4) 0.084	6.2 (4.2, 8.3) 0.83
Hospitalizations per 100 patients	2.7 (2.2, 3.1)	2.4 (2.0, 2.8) 0.45	2.1 (1.4, 2.9) 0.17	2.5 (1.8, 3.2) 0.72	2.6 (1.9, 3.4) 0.95
Total costs per patient (\$)	2381 (2201,2561)	2634 (2420,2848) 0.083	2209 (1896,2521) 0.39	2670 (2359,2981) 0.13	<b>3015</b> <b>(2706,3325)</b> <b>0.009</b>
ED costs per patient (\$)	134 (112, 156)	150 (122, 179) 0.31	113 (75, 151) 0.07	151 (113, 189) 0.31	186 (148, 224) 0.19
Hospitalization costs per patient (\$)	306 (214, 397)	220 (156, 284) 0.19	<b>172</b> <b>(13, 331)</b> <b>0.045</b>	231 (73, 390) 0.40	255 (98, 413) 0.55

**Table 13. Primary clinical and economic outcomes for subset of individuals for whom events were detected in Phase 1 (Results show the mean followed by the 95% confidence interval and the p-value relative to the control group.)**

	<b>Control Group (N=10048)</b>	<b>Combined Intervention Groups (N=10060)</b>	<b>Emails to Care Managers (N=3322)</b>	<b>Feedback Reports to Clinics (N=3351)</b>	<b>Reminder Letters to Patients (N=3387)</b>
Emergency department encounters per 100 patients	121 (112, 129)	123 (114, 132) 0.69	119 (104, 134) 0.89	118 (103, 132) 0.69	132 (118, 146) 0.21
Low-severity ED encounters per 100 patients	48.7 (45.1, 52.3)	45.6 (42.0, 49.2) 0.25	<b>40.2 (33.7, 46.7) 0.019</b>	48.6 (42.4, 54.9) 0.99	47.3 (41.3, 53.4) 0.72
Count of 3 or more ED visits within 90 days per 100 patients	30.7 (24.2, 37.2)	28.5 (21.9, 35.0) 0.64	31.6 (19.8, 43.3) 0.91	21.9 (10.6, 33.2) 0.081	31.9 (20.9, 42.9) 0.86
Hospitalizations per 100 patients	10.0 (7.9, 12.0)	9.4 (7.5, 11.2) 0.69	9.4 (5.6, 13.1) 0.75	9.5 (5.9, 13.1) 0.84	9.2 (5.7, 12.7) 0.70
Total costs per patient (\$)	5032 (4369,5696)	5683 (5013,6353) 0.19	4625 (3424,5826) 0.46	5933 (4776,7089) 0.17	6376 (5250,7501) 0.11
ED costs per patient (\$)	522 (406, 639)	612 (457, 767) 0.29	481 (270, 691) 0.46	567 (364, 770) 0.55	771 (573, 968) 0.24
Hospitalization costs per patient (\$)	1040 (704, 1377)	881 (545, 1216) 0.51	729 (119, 1338) 0.20	980 (393, 1567) 0.88	920 (349, 1491) 0.73

**Table 14. Primary clinical and economic outcomes for subset of individuals for whom NO events were detected in Phase 1 (results show the mean followed by the 95% confidence interval and the p-value relative to the control group.)**

	<b>Control Group (N=10048)</b>	<b>Combined Intervention Groups (N=10060)</b>	<b>Emails to Care Managers (N=3322)</b>	<b>Feedback Reports to Clinics (N=3351)</b>	<b>Reminder Letters to Patients (N=3387)</b>
Emergency department encounters per 100 patients	11.4 (10.4, 12.3)	11.3 (10.4, 12.2) 0.93	9.7 (8.1, 11.3) 0.08	12.5 (10.9, 14.2) 0.24	11.7 (10.1, 13.4) 0.73
Low-severity ED encounters per 100 patients	2.4 (2.0, 2.8)	2.4 (2.0, 2.8) 0.90	1.8 (1.2, 2.3) 0.07	2.9 (2.2, 3.7) 0.20	2.5 (1.9, 3.2) 0.69
Count of 3 or more ED visits within 90 days per 100 patients	0.6 (0.3, 0.8)	0.6 (0.3, 0.9) 0.77	0.9 (0.2, 1.6) 0.44	0.6 (0.2, 1.0) 0.97	0.4 (0.2, 0.7) 0.48
Hospitalizations per 100 patients	1.1 (0.8, 1.3)	1.0 (0.7, 1.2) 0.51	0.7 (0.4, 1.1) 0.11	1.0 (0.6, 1.4) 0.79	1.2 (0.7, 1.6) 0.76
Total costs per patient (\$)	1807 (1640,1973)	1990 (1828,2152) 0.16	1734 (1371,2098) 0.72	1975 (1695,2256) 0.31	<b>2261 (1904,2618) 0.024</b>
ED costs per patient (\$)	50 (42, 58)	53 (43, 62) 0.63	41 (31, 50) 0.15	63 (41, 84) 0.27	55 (39, 71) 0.57
Hospitalization costs per patient (\$)	147 (32, 261)	73 (44, 102) 0.76	63 (15, 110) 0.18	72 (24, 120) 0.24	106 (45, 167) 0.54

**Table 15. Primary clinical and economic outcomes for individuals without notices in family groups for whom events were detected in Phase 1 (results show the mean followed by the 95% confidence interval and the p-value relative to the control group.)**

	<b>Control Group (N=10048)</b>	<b>Combined Intervention Groups (N=10060)</b>	<b>Emails to Care Managers (N=3322)</b>	<b>Feedback Reports to Clinics (N=3351)</b>	<b>Reminder Letters to Patients (N=3387)</b>
Emergency department encounters per 100 patients	15.3 (12.7, 17.9)	14.9 (12.1, 17.7) 0.83	11.6 (7.1, 16.2) 0.16	14.6 (10.3, 19.0) 0.78	18.2 (13.9, 22.5) 0.39
Low-severity ED encounters per 100 patients	2.6 (1.7, 3.5)	2.1 (1.2, 3.0) 0.47	2.5 (0.9, 4.2) 0.94	1.6 (0.0, 3.2) 0.23	2.3 (0.7, 3.8) 0.71
Count of 3 or more ED visits within 90 days per 100 patients	0.6 (0.1, 1.1)	0.6 (0.1, 1.2) 0.87	0.5 (-0.4, 1.4) 0.90	0.5 (-0.4, 1.3) 0.77	0.9 (0.1, 1.7) 0.56
Hospitalizations per 100 patients	1.2 (0.7, 1.8)	0.7 (0.3, 1.2) 0.18	<b>0.3</b> <b>(-0.7, 1.2)</b> <b>0.015</b>	0.9 (0.0, 1.8) 0.57	0.9 (0.0, 1.8) 0.56
Total costs per patient (\$)	2842 (2379,3305)	3223 (2642,3803) 0.35	2090 (1276,2905) 0.12	2965 (2190,3740) 0.82	<b>4498</b> <b>(3725,5271)</b> <b>0.017</b>
ED costs per patient (\$)	68 (39, 98)	78 (42, 113) 0.65	<b>39</b> <b>(-12, 91)</b> <b>0.022</b>	83 (34, 132) 0.66	108 (59, 157) 0.36
Hospitalization costs per patient (\$)	84 (47, 121)	<b>28</b> <b>(9, 46)</b> <b>0.035</b>	<b>9</b> <b>(-56, 74)</b> <b>0.005</b>	36 (-25, 98) 0.13	36 (-26, 97) 0.12

**Table 16. Primary clinical and economic outcomes family groups for whom NO events were detected in Phase 1 (results show the mean followed by the 95% confidence interval and the p-value relative to the control group.)**

	<b>Control Group (N=10048)</b>	<b>Combined Intervention Groups (N=10060)</b>	<b>Emails to Care Managers (N=3322)</b>	<b>Feedback Reports to Clinics (N=3351)</b>	<b>Reminder Letters to Patients (N=3387)</b>
Emergency department encounters per 100 patients	10.7 (9.7, 11.7)	10.7 (9.7, 11.7) 0.97	9.4 (7.7, 11.1) 0.21	12.1 (10.4, 13.9) 0.17	10.5 (8.8, 12.2) 0.85
Low-severity ED encounters per 100 patients	2.3 (1.9, 2.8)	2.5 (2.0, 2.9) 0.68	1.6 (0.9, 2.4) 0.052	3.2 (2.4, 3.9) 0.085	2.6 (1.9, 3.3) 0.57
Count of 3 or more ED visits within 90 days per 100 patients	0.6 (0.3, 0.9)	0.6 (0.3, 1.0) 0.79	0.9 (0.4, 1.5) 0.42	0.6 (0.1, 1.1) 0.90	0.3 (-0.2, 0.9) 0.26
Hospitalizations per 100 patients	1.1 (0.8, 1.3)	1.0 (0.7, 1.3) 0.83	0.8 (0.3, 1.3) 0.32	1.0 (0.6, 1.5) 0.94	1.2 (0.7, 1.7) 0.61
Total costs per patient (\$)	1626 (1454,1799)	1767 (1564,1969) 0.30	1675 (1380,1971) 0.83	1789 (1490,2088) 0.34	1837 (1538,2137) 0.28
ED costs per patient (\$)	47 (38, 55)	48 (39, 57) 0.79	41 (26, 56) 0.43	59 (44, 74) 0.32	45 (30, 60) 0.83
Hospitalization costs per patient (\$)	158 (59, 256)	90 (54, 125) 0.34	72 (-98, 241) 0.25	79 (-92, 250) 0.29	119 (-52, 290) 0.62

**Table 17. Quality assessment based on Medicaid HEDIS metrics calculated across total study population (results show the mean followed by the 95% confidence interval. P-values compare the combined interventions to the control group.)**

	Control Patients	Intervention Patients	p-value
Live Births / 100 patients	0.58 (0.43, 0.72)	0.54 (0.39, 0.68)	0.70
Mammogram / 100 patients	0.95 (0.74, 1.16)	0.99 (0.78, 1.21)	0.75
Pap Smears / 100 patients	3.92 (3.49, 4.35)	3.69 (3.25, 4.12)	0.46
Chlamydia / 100 patients	5.22 (4.58, 5.87)	5.12 (4.51, 5.73)	0.82
Post-partum visits / 100 patients	4.77 (4.27, 5.27)	4.49 (3.99, 4.99)	0.45
Hg A1c measurements / 100 patients	2.99 (2.55, 3.42)	2.98 (2.51, 3.45)	0.99
LDL cholesterol / 100 patients	3.95 (3.52, 4.41)	3.61 (3.19, 4.03)	0.28
Albumin / 100 patients	1.21 (0.98, 1.45)	1.22 (0.97, 1.48)	0.96
Eye exams / 100 patients	5.11 (4.35, 5.86)	5.22 (4.67, 5.77)	0.81
Well-child visits / 100 patients	11.35 (10.54, 12.15)	11.09 (10.30, 11.88)	0.66

**Table 18. Patient quality indicators for diabetes and asthma (results show the mean followed by the 95% confidence interval. P-values compare the combined interventions to the control group.)**

	Control Patients	Intervention Patients	p-value
PQI1 - Diabetes Short-term Complications Admission Rate (per 1000 patients)	8 (2, 14)	3 (0,6)	0.17
PQI3 - Diabetes Long-term Complications Admission Rate (per 1000 patients)	14 (0, 29)	3 (0, 6)	0.15
PQI14 - Uncontrolled Diabetes Admission Rate (per 1000 patients)	12 (4, 20)	4 (0, 8)	0.07
PQI15 - Adult Asthma Admission Rate (per 1000 patients)	6 (0, 13)	1 (0, 3)	0.17

## Patient Surveys

CAPHS-Medicaid patient surveys were completed by 146 adults and on behalf of 174 children by a parent or guardian. There were no statistically significant differences except that adult respondents in the control group indicated a greater need for specialists relative to the intervention group (p=0.0393). The EuroQol quality of life survey was completed by 143 adults. When compared with the combined intervention groups, the control group had higher scores for pain/discomfort (p=0.0379) and for anxiety/depression (p=0.0237).

## Intervention Recipient Surveys and Contextual Evaluation

**E-mail Notice Recipients.** Usability surveys of the recipients of the e-mail notices reported that the messages were helpful in patient care (14 of 14) and enabled patients to receive better care (12 of 14). The average satisfaction score was 4.0 out of 5.0. Strong positive responses

included agreement that the system increased productivity, enabled users to accomplish tasks more quickly, provided accurate information, improved knowledge for patient management, and improved confidence in the investigation of patients. Several users agreed that the information provided was precise information but not sufficient. Strong negative responses included that the system was time consuming to use and increased workload.

**Feedback Report Recipients.** Feedback report recipients reported that the reports were used at four sites (LCHC, Duke Children's Primary Care, Duke Family Medicine, and the Duke Adult Medicine Outpatient Clinic). The feedback reports were reportedly not used at Duke Obstetrics and Gynecology, Durham Pediatrics and Regional Pediatrics. Among the report users, the average satisfaction of the report intervention was 5.0 out of 5.0. Positive feedback included that the reports provided precise and sufficient information, enabled recipients to accomplish tasks more quickly, increased productivity, improved knowledge for the management of patients, and increased confidence in the investigation of patients. As with the e-mails, the reports were associated with increased workload.

## Impact on Stakeholders

In this study, we proposed to differentiate stakeholders using Medicaid claims data from the State of North Carolina. Early in our negotiations with the State, it became evident that while the needed information was available to the State, the contractor assigned to provide information for this study was not able to provide all of the information required to calculate inpatient costs (emergency room visits and hospital stays). This deficiency necessitated that we substitute Medicaid reimbursement for actual inpatient costs in our analyses. This change in cost estimation methods meant that we needed to shift our primary analyses perspective from the societal to that of the payer (Medicaid) and that we had to use inpatient reimbursements as estimates for inpatient costs. While this substitution meant that we were no longer able to calculate differences between inpatient cost and reimbursements, we do not think that this limitation had a significant effect upon our overall findings.

We hypothesized in this study that the primary effect of the three information interventions would be to reduce inappropriate emergency room visits which in turn would increase appropriate outpatient care. We assumed that medical costs would be reduced for emergency care and increased for outpatient care. These assumptions meant that the major effects of our interventions would be to reduce the volume and costs for hospital stakeholders and increase the volume and costs of outpatient stakeholders. The effects of these interventions upon patients and the payer (Medicaid) would be secondary and would occur through changes in co-pays and reimbursements, respectively. We assumed that diverting patients from inappropriate inpatient to appropriate outpatient care would be associated with no differences in care quality. However, we speculated as to whether individual outpatient clinics might act as mediators and serve to accentuate or diminish the effects of the three information interventions upon clinical outcomes and medical costs.

The distribution of observed alerts in the HIT Value study served to validate our hypothesized mechanisms by which this study's information interventions would change patient outcomes within stakeholder groups. Approximately 17% of subjects (in both the treatment and control groups) experienced one or more sentinel events. Of patients generating a sentinel event, 60% had notices for low severity emergency department visits and 35% had notices for missing

more than two outpatient visits in 60 days. Thus, the information interventions were focused on behavioral changes that would decrease inappropriate emergency department visits and increase appropriate outpatient visits.

In the overall study population, there was a significant reduction in the number of low-severity emergency department visits for patients randomized to care manager notices; however, there were no changes for patients in the other intervention groups. The change in low-severity emergency department visits for subjects randomized to care manager notices was associated with reductions in emergency department and hospitalization costs. Patient randomized to receive alert notification via patient letters experienced an increase in total medical costs which was isolated to their outpatient cost component and appeared to be unrelated to this study's interventions. Further investigation revealed that the reduction in low severity emergency department visits occurred only in the subset of patients randomized to receive care manager notices who had one or more sentinel events; whereas, the increase in total costs occurred only in the subset of patients who did not meet an alert condition but were relatives of patients who had received an alert.

When we investigated associations between study outcomes and outpatient facilities, we found there were important interactions. Patients randomized to care manager notices had fewer low severity emergency department visits in two of six outpatient facilities and fewer occurrences of >3 emergency department visits in a 90 day period in another facility; however, there were no changes in emergency department visits in other combinations of information intervention group and outpatient facility. Outpatient costs were higher for patients randomized to receive patient letters in one facility and to periodic reports in another facility with no differences in outpatient costs for other intervention and facility combinations. Of note, all increases in outpatient costs were driven by differences in home-based mental health services which were not under the control of the care network and were not the target of the information interventions.

With regard to this study's primary stakeholders, the net effect of the intervention was to decrease emergency department utilization and inpatient reimbursements (emergency department and hospitalization) for patients randomized to care manager notices. There were no effects for patients in the two other intervention groups with regard to ED utilization, hospitalizations or care quality. There was an increase in outpatient costs; however, these were for mental health services that were not associated with the study interventions. Cost changes were associated with reductions in co-payments for study patients randomized to care manager notifications and with increases in payer reimbursements for patients randomized to patient letters. Other than these cost changes, there were no additional stakeholder effects on costs.

## **Dissemination**

The development, methodology and findings from this study have been disseminated through a variety of mechanisms including six publications, over a dozen presentations and several news stories. The six project publications to date are listed below. One of these publications received the award for the best student paper at the AMIA Annual Fall Symposium in 2005. Major presentations included a site visit at Duke for 25 outside guests in September 2005 and a two part teleconference through the AHRQ National Resource Center in September 2006. In addition, the project has been written up in local newspapers at Duke and on the Web at AHRQ.

## Discussion

In this large randomized controlled trial, we demonstrated that selected types of decision support can successfully enable the management of the health of a population of patients. Specifically, we have shown that weekly electronically mailed notices to care managers about ED encounters, hospitalizations and missed appointments can significantly lower ED use for low severity issues. Accordingly, care for non-emergent issues can be shifted from the ED to other venues. No statistically significant increase in ambulatory care visits was detected, implying that the care issues not addressed in the ED were addressed at home and/or through other mechanisms of communication with the healthcare system. No statistically significant decrease in costs was detected; however, a trend for lower costs was observed among family units who were touched by the intervention.

Further analysis of these findings shows that the detected changes in ED utilization correlate directly with the family units who were touched by the intervention and not with the family units who were not touched by the intervention. Not surprisingly, we detected evidence of “contamination” of the intervention within a family unit. If the effect of the email notices to care managers is analyzed across individuals, there is a less clear distinction between individuals touched by the intervention, because individuals whose families were touched

Interestingly, we found that the combined interventions failed to show a difference in the primary study outcome of overall ED utilization when compared to usual care. Based on the sample size and estimated standard errors in the evaluation data, our study had roughly 50% power to detect a reduction in ED utilization of 3.0 visits per 100 patients and 80% power to detect a reduction of 4.2 visits per 100 patients. Translating these power estimates from an absolute to a relative scale, we had 80% power to detect a 15% reduction in ED utilization. Therefore, we conclude that the difference demonstrated by the emailed notices sent to care managers was diluted by the lack of difference resulting from the feedback reports to the clinics or the letters mailed to patients and by the lack of impact on ED use for issues other than low severity. Additionally, the impact on low severity ED utilization may have been significant because the low severity ED notices account for 38% of the sent email notices and 60% of patients who generated an email notice received at least one notice for low severity ED utilization. Furthermore, behaviors related to ED use for low severity issues may be more amenable to modification than behaviors related to frequent ED utilization, ED utilization for diabetes or asthma, or missing appointments.

We hypothesize that email notices to care managers were more effective than the quarterly feedback reports to clinic managers and the letters mailed to patients because the email notices were more amendable to action. While the content in the feedback reports was very similar to the content in the notices, the feedback reports were less timely (quarterly vs. weekly) and more voluminous (hundreds of notices per report vs. a maximum of 25 notices per email). Additionally, the email notices were received by care managers who were specifically allocated time and resources to address care coordination issues in contrast to clinic managers who had to respond to the feedback reports around many other competing demands. The letters to patients concerning their ED utilization, hospitalizations and missed appointments promoted the action of contacting their clinical homes for further appointments. It is likely that these letters provided little new actionable information to the patients.

**Lessons Learned.** We have learned several valuable lessons through the development, implementation and operational support of this population health management system. In the area of system development, we have discovered that resolving political issues related to the exchange of clinical information and identifying resources to implement the data exchange are often more challenging and time consuming than the technical aspects of information exchange. We also noticed, however, that once the exchanged information was in use for proactive care management, clinical sites began to offer their information to the HIE so that they could reap the benefits of the proactive care notices. As we began to implement the proactive notification rules, we detected two distinct types of events requiring follow-up: events of commission (e.g., ED encounters) and events of omission (e.g., missing preventive care services). We also discovered that components of knowledge could be reused across rule sets, e.g., a rule for determining if a patient has diabetes was useful for both notices for hospitalization and notices for ED utilization. Finally, with regard to development, we observed that the perceived value of the generated notices to the recipients was dependent on the timeliness and completeness of the underlying HIE dataset. Notices had the greatest value if they were proximal to the event and highly accurate. This observation compelled us to obtain billing data directly from clinic sites within 24 to 72 hours after an event, rather than relying on processed claims data that could be several months old.

With regard to system implementation, we have observed that asynchronous population health management is complex. In a real-world setting, it is often difficult to determine who should be notified about sentinel health events for a specific patient. It is often unclear which providers are assigned to a specific individual, and providers frequently change. Another level of complexity was how frequently notices should be re-sent. For events of commission, we routinely sent only one notice immediately following the event. A third challenge with implementation was determining how to prioritize the order of notices sent to care managers. Ultimately, we empirically developed a prioritization scheme that resulted in the most concerning issues appearing on the top of the weekly notification lists. We also empirically selected a cut off of 25 notices per care manager per week.

From our experience supporting the system operationally, we learned that an increased amount of available information promotes increased use of the system. Additionally, as users became increasingly dependent on the notification system, they restructured their work practices to allow the system to direct their care management activities.

## **Conclusions**

In this large randomized controlled trial, we demonstrate that decision support can be effectively used to enable the management of the health of a defined population of patients irrespective of whether or not these individuals seek clinic based care. Specifically, we have shown that emergency department utilization for low severity conditions can be reduced through email notices to care managers about ED utilization, hospitalizations and missed appointments. We have directly associated the impact of the intervention to the family units that were touched by the intervention. Through this analysis, we also have shown the importance of randomizing subjects and analyzing results at the level of the family unit for population health-based interventions.

In this project, we have developed and implemented an approach for proactive population-oriented health care management using standards-based decision support in the context of a

regional health information exchange for Medicaid beneficiaries. Through this system, we have demonstrated that we can detect important care needs of a population without requiring patients to have clinic-based encounters. Specifically, we detected 4,880 sentinel health events in 3,543 unique individuals over a nine-month period. This work builds upon previous publications in that data from a HIE was used to facilitate care management

## Significance

This study is one of the largest randomized controlled trials to date that investigates the emerging model of healthcare referred to as population health management.

Furthermore, the successful implementation of the study interventions demonstrates that the management of the healthcare of a population is feasible through a regional health information exchange primarily populated with claims data and through a decision support system based on the emerging HL7 Decision Support Service standard.

Moreover, we have demonstrated that notifications about sentinel health events can be used to modify care seeking behaviors among patients when conveyed to individuals who are positioned to respond to the identified event. These findings provide evidence that decision support-enabled population health management may be an effective approach for addressing the health needs of patients outside of traditional clinic-based models of care.

## Implications

New approaches to care delivery are needed to improve healthcare quality and the coordination of services across populations. CDS can be used in the context of a regional HIE in order to promote proactive population health management. Through this study, we have shown that sentinel health events can be identified from billing/claims data and clinical data. Further analyses are in progress to determine the impact of this information technology-based approach on care quality and costs.

We conclude from this project that population health management enabled through decision support is a viable care model that could be expanded to shift care away from the current episodic clinic-based provider-centered approach to healthcare. Accordingly, expansion of population surveillance and augmentation of the available data could allow more extensive patient-focused care management external to clinics in venues such as the patient's home. These new models of care could lower costs and increase accessibility, as they are not dependent on scarce and expensive clinic and clinician resources.

This project has also demonstrated an additional context for using the evaluating HL7 Decision Support Service as a feasible tool for applied decision support. For this project, the knowledge rules for detecting sentinel events were reusable across three distinct applications (email notices, feedback reports and patient letters), further illustrating the portability and flexibility of the DSS approach. DSS has also been used for chronic disease management<sup>13</sup> and breast cancer surveillance.<sup>14</sup>

In light of the success of this project, additional resources should be invested in determining how the management of the health of a population enabled through decision support can be extended to improve the coordination, quality, efficiency and even outcomes of healthcare delivery in the United States and abroad.

## List of Publications and Products

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