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Development and Implementation of an Electronic Decision Support to Manage the Health of a High-Risk Population: The enhanced Electronic Medical Record Aging Brain Care Software (eMR-ABC)

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Methods: Using the lenses of the Complex Adaptive System and the Reflective Adaptive Process, we assembled an interdisciplinary team of clinicians, health services researchers, and software developers who designed, implemented, evaluated, and continuously modified the eMR-ABC to meet the needs of care coordinators who manage the health of a targeted high-risk population.

Results: The eMR-ABC captures and monitors the cognitive, functional, behavioral, and psychological symptoms of a registry of patients suffering from dementia or depression as well as the burden of patients' family caregivers. It provides decision support to care coordinators to create a personalized care plan that includes evidence-based nonpharmacological protocols, self-management handouts, and alerts of medications with potentially adverse cognitive effects. The software's built-in engine tracks patient visits and on-demand functionality to generate population reports for specified indicators.

Discussion: Population health programs depend on data collection and information systems with the ability to provide valuable and timely feedback on an ongoing basis. Following these guidelines, the eMR-ABC was designed specifically to meet the management needs of a high-risk population./

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Keywords

Informatics, evidence based medicine, health information technology, decision support, Indiana PROSPECT

Disciplines

Health Services Research

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Introduction

Despite ongoing quality improvement efforts and the publication of best practice guidelines, the Institute of Medicine (IOM) has concluded that our health care system suffers from waste, compromised patient safety, and suboptimal quality.¹ Accordingly, the IOM has recommended the adoption of information technology-based solutions to improve 21st century U.S. health care systems.²

Alzheimer's disease (AD) and related dementias are just one example of a looming public health challenge that will place increasing strain on the U.S. health care system in coming years. Currently, most patients with AD receive care in non-academic clinical practices and present with challenging biopsychosocial needs that go unmet.²⁻⁵ Such patients' suffer from several chronic medical conditions; receive numerous inappropriate medications with adverse cognitive effects; and lack effective access to community resources and services.³⁻⁶

Improving care for AD patients demands two crucial steps. First, we must adopt a collaborative care model that supports current clinical care practices with additional resources. Second, we must efficiently implement this collaborative model in accordance with the ever-changing local resources and demands of complex adaptive health care practices.⁷⁻¹⁰

Following several clinical trials, we have successfully developed and demonstrated the efficacy of an AD Collaborative Care Model called the Aging Brain Care Medical Home (ABC-MedHome). ABC-MedHome provides case identification and management processes and protocols for patients with AD who receive care in local primary care practices. A randomized controlled trial demonstrated that the processes used within the ABC-MedHome improved the quality of AD care and decreased its burden.⁴ However, both a substantial financial investment and an innovative delivery system are required for effectively applying the ABC-MedHome model within real-world health care practices.

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In early 2009, clinical investigators from the Indiana University Center for Aging Research and Regenstrief Institute initiated the development of a comprehensive, electronic population health management support application to facilitate the successful implementation of ABC-MedHome protocols and processes in an urban health care system in Indianapolis. The new software application, called eMR-ABC, provides ABC-MedHome population health managers and coordinators with an automated decision support system to aid them in meeting the complex biopsychosocial needs of their patients and their patients' informal caregivers. The eMR-ABC has converted patient assessment processes into electronic assessments; translated treatment protocols and algorithms into a computerized and individualized decision support system; and synchronized patient assessments, protocols, and algorithms within one bench-top model.¹¹

This paper describes the development and implementation of the population health management software. Further, we share the lessons learned from this experience with scholars interested in using health information technology to manage high-risk populations while achieving the triple aim of better health and better care at lower cost.

Methods

Introducing a New Technology in Our Health Care System

Health care delivery organizations, such as primary care clinics and memory care practices, may be considered complex adaptive systems¹²⁻¹⁴ that are governed by the dynamics of an interconnected, collaborating, and at times competing membership of individuals who exhibit emergent, inherently complex behaviors.¹⁵⁻¹⁷ A complex adaptive system learns from experience and is flexible in both its behavior and the connecting pattern of its members, ultimately allowing the system to change and adjust appropriately to its environment.^{18,19}

Primary care clinics face persistent internal and external challenges, including, among others, changes in provider membership and patients' health as well as new regulations, insurance rules, and research findings that aim to reform primary care practice,²⁰⁻²² all of which influence how primary care clinics conduct business. Reliance on traditional organizational theory makes it tempting to see primary care clinics as factory-like, with staff behavior that can be studied, predicted, and standardized and with assigned roles carried out by replaceable employees subject to a combination of financial incentives, regulatory policies, detailed protocols, or best practice initiatives.^{23,24} Nonetheless, experience tells us that primary care clinics are far from static, and research demonstrates that standardized protocols are often not practical or effective because of the complex interplay and adaptation that occurs between/among providers, patients, and resources in clinic systems.²⁵⁻³¹ When, however, we view clinics as complex adaptive systems, we understand why it has been so difficult to adopt innovative health information technologies.³²⁻³⁸

Given the difficulty in adopting new technologies within the primary care clinical environment, we sought an organizational change strategy that recognizes the complexity of primary care clinical settings. Amid the many strategies for managing organizational change, we looked to our experience and selected the Reflective Adaptive Process (RAP), developed by the National Institutes of Health (NIH) and the Agency for Healthcare Research and Quality (AHRQ).³⁹ Based on the principles of the complex adaptive system, the RAP is a practical method to "select, develop, and implement a change in health care delivery systems."⁴⁰⁻⁴² Its framework incorporates five guiding principles:

1. "Vision, mission, and shared values are fundamental in guiding ongoing change processes."
2. "Creating time and space for learning and reflection is necessary."
3. "Tension and discomfort are essential and normal during change."
4. "Improvement teams should include a variety of systems agents with different perspectives of the system and its environment, including patients."
5. "System change requires supportive leadership that is actively involved in the change process, ensuring full participation from all members and protecting time for reflection."⁴³⁻⁴⁹

Using the RAP within the context of a complex system such as the ABC-MedHome, we assembled a team of representatives from across the health care system to provide feedback on the development and implementation of the eMR-ABC. The team comprised a primary care physician, a memory care provider, an implementation scientist, a practice manager, a care coordinator, and an information technology expert. Over the course of six meetings, the team identified the following critical elements needed to build and implement an efficient and successful eMR-ABC, compliant with the Health Insurance Portability and Accountability Act (HIPAA) regulations:

1. Translate patient's biopsychosocial need assessment processes into electronic assessments
2. Translate treatment protocols and algorithms triggered by the need assessment into a computerized and individualized decision support system
3. Synchronize the eMR-ABC assessments, protocols, and algorithms with any electronic medical record platform used within the overall health care system
4. Assemble all these methods into a bench-top model and beta test at an ambulatory care practice affiliated with the Indianapolis Discovery Network for Dementia⁵⁰

Within three months of the initial planning meetings, the team deployed the first prototype of the eMR-ABC during January 2010 within the Regenstrief Institute's network. It developed the eMR-ABC in accordance with HIPAA guidelines. The team provided network access to all key personnel on the ABC Medical Home care team and established all security measures, including pass-

word rules, in accordance with Regenstrief's guidelines. Initially, the Regenstrief Intranet hosted the application during beta testing and then moved into the targeted health care system, with access granted via Virtual Private Network (VPN). The application was designed for use across several clinics in a hospital system, with a focus on intuitive user interface for providers without a large knowledge base of eMR-ABC functionalities. Within the initial design, a practitioner could update patient data and contact information as needed and track patient appointments and patient and caregiver symptom scores. The practitioner could view the scores over time and offer decision support recommendations by triggering treatment protocols.⁵¹

Field Testing

Following the application's integration, the development team shadowed users of the application with the purpose of collecting feedback on needed improvements. Testing identified minor operational challenges that lent themselves to easy resolution. In particular, testing surfaced the need for some process flow improvements such as Patient Tracking and Appointment Reminders, which were added to the original design. The original design successfully met the goals of ABC-Med Home on the patient level; however, ABC-Med Home the care coordination team was interested in expanding the system to include management of its entire patient population. With the capacity to observe and assess trends among the clinic's patient population, the care coordination team could better monitor and evaluate the processes and operation of the ABC program, its successes in improving the management of patients' symptoms longitudinally, and, on a larger scale, potentially reducing acute care utilization and overall costs.

Translating the Collaborative Aging Brain Care Processes into Population Health Management Support

In 2010, AHRQ funded the Prospective Outcome Systems Using Patient-Specific Electronic Data to Compare Tests and Therapies (PROSPECT) initiative to support the enhancement of the existing information technology infrastructure in central Indiana and to improve the nation's capacity to conduct comparative effectiveness research (CER). Under the initiative, the eMR-ABC upgraded its system by adding several features, including the Population Health Statistics Reporting; a Patient Abstract, which is a graphical platform for viewing patient and caregiver assessment scores and results for all visits recorded in the system; and Care Giver's HABC-M scores,⁵² which permits a comparison of patient information compiled during visits with patients' Acute Care Utilization (ACU). The team translated the Healthy Aging Brain Care Monitor (HABC-M) and other forms into electronic versions to collect social and family history; medical and surgical history; a list of over-the-counter and prescribed medications; and caregiver burden and needs. The data collected by these tools feed into a decision support tree algorithm for conversion into a software package. The package enters and interprets the data and generates individualized patient-centric care plans. The software package was developed with the Software as a Service (SaaS) architectural model and Service-Oriented Architecture (SOA) to

enable various software applications to communicate with eMR-ABC. The key software architectural features of eMR-ABC meet the following criteria:

- *Customization*: Each practice should be able to use its own customized version of the e-MR-ABC application and run its own application on its servers.
- *Configurable*: The eMR-ABC should demonstrate considerable program flexibility through configurable metadata, permitting several clinicians to use separate instances of the same application code. It should also allow the eMR-ABC to meet the needs of each medical practice through detailed configuration options while simplifying maintenance and updating a common code base.
- *Scalability*: The eMR-ABC should operate with a multitier architecture that supports a load-balanced farm of identical application instances that run on a variable number of servers. We can increase or decrease the system's capacity to match demand by adding or removing servers without any further alteration of applications software architecture.
- *Centralized feature updating*: End-users should not have to download patches and upgrades to accommodate clinicians' or other users' individualized *new feature* requests. *Faster releases* of new features allow the entire community of users to benefit from new functionality, and the *embodiment of recognized best practices* means that the community of users drives the software publisher to support best practices.
- *Compatibility*: eMR-ABC should be able to communicate with any e-MR software.

We have also integrated eMR-ABC with the Indiana Network for Patient Care (INPC)⁵³ and with the Indiana Health Information Exchange (IHIE), the nation's largest information exchange, in order to generate Continuity of Care Documents (CCD) for patients who visit the ABC. The ACU data are incorporated into the calculations for the Population Health Statistics Report.

Within version two of the application, we also made efforts to alleviate data entry fatigue and automate flow by adding the use of scannable forms. We tested use of the forms within the CER and found that the process was 92 percent accurate. Even though we resolved some of the teleform's issues, the study leaders decided that an overall eight percent scanning error rate was not acceptable, based on discussion with a local expert in teleform development who set a two percent error rate as an acceptable threshold in the clinical setting. The error rate was also high compared to the rate associated with other data entry methods, including manual data entry. Consequently, the study discontinued use of the scanning process. We are currently exploring other automated data entry solutions, such as a mini-eMR-ABC application that clinical care providers can use via iPad or Tablet PC and Web-based or iPad applications that patients or family caregivers can use directly. These efforts will go into production by the end of April 2013.

Results

Patient Data

The eMR-ABC system includes two main information pages for the collection and review of patient data: the Patient Details page (Figure 1) and the Patient Visit Detail page (Figure 2). The Patient Details page includes eight unique tabs that comprise the patient's basic demographic and contact information. One of the key features of the page is its "Tracking" tab, which displays a list of all past and upcoming scheduled patient visits. For any new patient, upon registration, the tracking tab automates the initial visit and subsequent follow-up visits, specifically, the three monthly and three quarterly follow-up visits standard for ABC Med Home practice. The "Abstract" tab shows the Care Giver's HABC-Monitor and Self Report Monitor and the Dementia & Depression Message in both tabular and graphical form to permit a rapid view of the progress of both patient and caregiver (Figure 3). The upper-right quadrant of the Patient Details page displays two additional options: "View Visits" and "Create Visit." With the cursor over "View Visits," the option lists all visit dates and permits the selection of a visit date that enables a view of the details of that visit. Clicking on "Create Visit" permits the scheduling of a new visit for the patient.

Figure 1. Patient Details Page

Figure 2. Patient Visit Details Page

The Patient Visit Detail page allows for the entry of scheduled visits and needs assessment and protocol information. The page contains 16 tabs for capturing current medical information, medications, and the patient's cognitive and depression scores as well as caregiver burden. The page also contains a built-in process for comparison of the Self-Report Monitor and Care Giver Monitor

between visits. Selection of the "Compare Protocols b/n Visits" produces a color-coded calendar for visualization of protocol scores between appointments (Figure 4).

Figure 3. Abstract Tab Option



Figure 4. Compare Protocols B/N Visits Option

Care Giver Monitor

MRN No.: 39972429
Charles Mokri (04/29/1935 : 77 : Female)
 2954 S McClure St Indiana 46218

Care Co-ordinator: Jane Brooks

Visit Dates

Not at all Several days More than half the days Almost Daily

	03/12/2012	04/10/2012	08/20/2012
Total Score	15	4	3
Judgment or decision-making.	Green	Green	Green
Repeating the same things over and over such as questions or stories.	Yellow	Green	Green
Forgetting the correct month or year.	Red	Red	Green
Handling complicated financial affairs such as balancing checkbook, income taxes and paying bills.	Green	Green	Green
Remembering appointments.	Red	Yellow	Green
Thinking or memory.	Green	Green	Green
Learning how to use a tool, appliance, or gadget.	Green	Green	Green
Planning, preparing or serving meals.	Green	Green	Green
Taking medications in the right dose at the right time.	Green	Green	Green
Walking or physical ambulation.	Green	Green	Green
Bathing.	Red	Green	Green
Shopping for personal items like groceries.	Green	Green	Green
Housework or household chores.	Green	Green	Green
Leaving her/him alone.	Green	Green	Green
Her/his safety.	Green	Green	Green
Her/his quality of life.	Green	Green	Green
Falling and tripping.	Green	Green	Green
Less interest or pleasure in doing things, hobbies, or activities.	Green	Green	Green
Feeling down, depressed, or hopeless.	Green	Yellow	Green
Being stubborn, agitated aggressive or resistive to help from others.	Green	Green	Green
Feeling anxious, nervous, tense, fearful or panic.	Green	Green	Green
Believing others are stealing from you or planning to harm them.	Green	Green	Green
Hearing voices, seeing things or talking to people who are not there.	Green	Green	Green

Protocols and Handouts

The protocols and corresponding handouts are triggered according to answers to the questions on the Care Giver Monitor screen. There are 16 protocols and 30 handouts (Table 1).⁵³ Per the ABC Medical Home protocol, no more than two handouts are delivered per visit. The handouts are also available to the patient and caregiver on the Wishard Health website (<http://www.wishard.edu/our-services/senior-care/healthy-aging-brain-center/resources>).

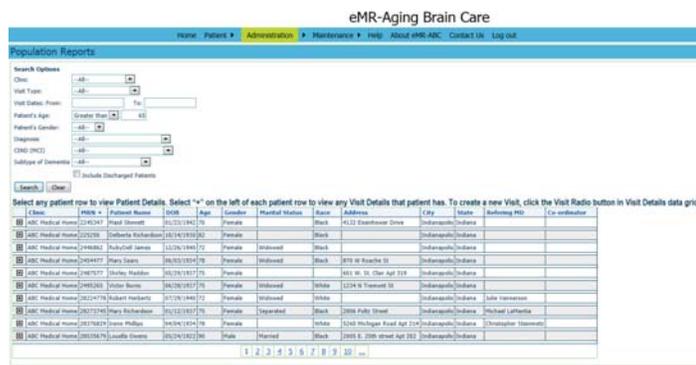
Figure 10. Population Health Statistics Report: Operational Data

Descriptive Data	
Measure	Value
Mean Age	76.29
Female Patients	182
Male Patients	94
Patients with No Care Giver	104
Patients with Care Giver	174
Visits with HABC CG Score	330
Mean HABC Score per Visit	22.87
Visits with HABC SR Score	185
Visits with PHQ Score	305
Mean PHQ Score per Visit	4.7

Population Reports

The Population Report allows users to generate reports based on any combination of the following seven parameters: Visit Type, Visit Date Range, Patient's Age, Patient's Gender, Diagnosis, CIND (MCI) (Cognitive Impairment no Dementia (Mild Cognitive Impairment)), and Subtype of Dementia (Figure 11). The reports provide an easy-to-read list of patients meeting the criteria of interest and may include discharged patients by selection of an additional parameter at the bottom of the screen. The managers of the eMR-ABC application may download the report into an Excel spreadsheet for facilitating study recruitment among eligible patients.

Figure 11. Population Health Report



System Evaluation

To date, we have successfully trained all 25 members of our clinical team at Wishard Health in the use of the software. As a result, the eMR-ABC records all our patient encounters, allowing for more efficient tracking of patient interactions and permitting us to monitor progress in achieving patient and caregiver goals. Clinical providers are better equipped to adhere to a patient's visit schedule and to respond quickly (within 48-72 hours) to caregiver stress and acute care utilization events. Furthermore, the system enables providers to monitor a patient's Patient Health Questionnaire (PHQ-9), ACB, and HABC scores and react accordingly. Monitoring trends in these and other scores will measure the

eMR-ABC's value and use in the clinic setting. We will continue to examine score trends, monthly for the population and at each patient visit, as we explore the development of Web-based electronic applications and the implementation of the eMR-ABC across several clinics.

Discussion

Population health management relies heavily on data collection and information systems that can drastically decrease the time and resources needed to care for an entire population.⁵⁶ These systems need to provide usable, actionable information not just at the point of care but also between patient visits by incorporating a wide variety of metrics.⁵⁷ The information should be delivered to all providers automatically and continuously to permit monitoring of the effectiveness of the health program, the identification of trends, and forecasting.^{58,59} The eMR-ABC software has successfully transitioned the paper-based process of the collaborative aging brain care model into an electronic decision support system that can facilitate both personalized patient care and effective population health management while encouraging the achievement of the triple aim of better health and better care at lower cost. Ongoing studies will quantify the extent of improvement in key patient outcomes.

Even though electronic medical records have yet to be fully implemented in practices across the country, their adoption holds great promise for decreasing health care costs, improving health care quality, and increasing patient safety, particularly among vulnerable patients as they transition across sites of care.^{60,61} Within the ABC Medical Home program, we have developed, tested, implemented, and improved an eMR that is sensitive to the clinical needs of a multispecialty team of professionals who provide care to complex patients across a variety of settings. Our software is sufficiently agile to allow tracking of individual patient health outcomes while remaining broad enough in its perspective to follow the status of an entire patient population with key quality, health, and cost metrics. We believe that these characteristics are the central features that will distinguish electronic health records as they successfully manage population health in our evolving health care environment.

Integration of the eMR-ABC program within the Wishard health care system was pivotal to the receipt of a Health Care Innovation Challenge award from the Centers for Medicare & Medicaid Services. The award will expand the utility of the eMR-ABC from serving 250 patients and family cared for in one primary care center to approximately 2,000 patients and family cared for by our health system in the city of Indianapolis. We are currently exploring dissemination of the eMR-ABC and our ABC-MedHome care model to sites outside our health system and determining the infrastructure needed for sharing data among several clinics. Thus far, however, the software has been invaluable to our clinical teams and allows clinicians to provide personalized medical care to individual patients without losing sight of trends in the health of an expanded patient population.

Limitations

Our experience in developing and implementing the eMR-ABC has been shaped by several factors that may influence the generalizability of the lessons we have learned and the ease with which a similar process may be introduced in other settings. First, we have developed the eMR-ABC in a hospital system whose robust information technology support is served by one of the nation's oldest electronic medical record systems. It is not clear that health care systems with less experience with the use of electronic medical records may be able to assemble the personnel or data resources needed to support a similar project. Second, we have built the eMR-ABC in partnership with our local health care system and with colleagues experienced in medical informatics with whom we have partnered on other research projects, including those providing care to vulnerable older adults. Thus, our development team has experience in both working together and working on similar issues. Finally, our eMR-ABC was developed for use in an urban, academic hospital system that provides care to a diverse population of older adults, many of whom are low-income. As a result, it may not be possible to apply our experience with the development of the eMR-ABC to more rural settings or settings with a different patient population profile.

Conclusion

New models of care, supported by population health management tools, are needed if we are to provide improved quality of care that is cost-sensitive and encourages better health outcomes for our patients. Acknowledging that health care delivery systems are complex adaptive systems, we have employed the RAP to design and implement an innovative and responsive decision support system to aid care coordinators in our Aging Brain Care Medical Home. Our eMR-ABC software provides continuous feedback to providers on the health, quality, and cost of care that individual patients and our entire patient panel receive in our program. Such feedback will be critical to providers and population health managers as we build systems of care that turn from volume-based models to value-based models.

Key Terms and Definitions

Population Health: According to Kindig and Stoddart (2003), population health is defined as “the health outcomes of a group of individuals, including the distribution of such outcomes within the group.”⁶²

Clinical Decision Support: Clinical decision support (CDS) “is most widely used for computer-based interventions delivered through clinical information systems.”⁶³

Dementia: A progressive decline in memory, according to the Diagnostic and Statistical Manual-IV-TR, accompanied by apraxia, agnosia, aphasia, or executive dysfunction that impairs functional abilities, represents a decline from baseline, and is not better explained by another psychiatric or medical condition.

Depression: A mood or state, according to the Diagnostic and Statistical Manual-IV-TR, in which patients manifest the following symptoms:

- Low mood
- Lack of interest in activities
- Excessive or lack of sleep
- Change in appetite or weight
- Agitation or slowing of activity
- Low energy
- Lack of concentration
- Feelings of worthlessness or guilt
- Thoughts about death or suicide

Elders: Older adults age 65 and above.

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