A network collaboration implementing technology to improve medication dispensing and administration in critical access hospitals

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ABSTRACT

We report how seven independent critical access hospitals collaborated with a rural referral hospital to standardize workflow policies and procedures while jointly implementing the same health information technologies (HITs) to enhance medication care processes. The study hospitals implemented the same electronic health record, computerized provider order entry, pharmacy information systems, automated dispensing cabinets (ADC), and barcode medication administration systems. We conducted interviews and examined project documents to explore factors underlying the successful implementation of ADC and barcode medication administration across the network hospitals. These included a shared culture of collaboration; strategic sequencing of HIT component implementation; interface among HIT components; strategic placement of ADCs; disciplined use and sharing of workflow analyses linked with HIT applications; planning for workflow efficiencies; acquisition of adequate supply of HIT-related devices; and establishing metrics to monitor HIT use and outcomes.

INTRODUCTION

Effective execution of all aspects of the medication management process (prescribing/ordering, dispensing, and administration) is necessary to achieve high quality and safe medication practices. Many regulatory, advisory, and purchasing groups (eg, Joint Commission,[1] National Quality Forum,[2] Leapfrog Group[3]) recommend the use of health information technologies (HITs), including computerized provider order entry (CPOEs) systems, electronic health records (EHRs), pharmacist medication order reviews, automated dispensing cabinets (ADC), and barcode medication administration (BCMA) systems. To date, there has been limited progress in implementing HIT systems,[4–6] and large, urban, and/or teaching hospitals account for a large percentage of hospitals that have implemented HIT[4 7 8]. Small rural hospitals have been particularly challenged.[7] One factor that has increased many small rural hospitals' ability to invest in HIT is their conversion to critical access hospital (CAH) status. For the 1300 hospitals nationally that have converted, their Medicare payment methodology was changed from a prospective payment system to retrospective cost-based.[9] The change in reimbursement resulted in many CAHs transitioning from negative to positive profit margins,[10] which permitted some to enhance patient quality[11] and invest in HIT.[12] However, widespread implementation of HIT in CAHs to improve medication processes faces a number of challenges: purchase and implementation costs, limited expertise in HIT implementation and integration into workflow, and limited availability of pharmacists.[13] The limited availability of pharmacists in small rural hospitals is particularly endemic and creates a unique quality and safety issue in that medication filling, retrieval, dispensing, and administration duties are often transferred to patient care nurses. Research on this issue is limited and examining successful approaches to implementing HIT to enhance medication processes in CAHs is particularly important. This implementation brief describes the experience of seven CAHs and a large rural referral hospital that collaborated to enhance their medication administration and dispensing systems.

METHODS

Data collection for this implementation brief included reviewing documents (eg, meeting minutes, reports, project management plan, flowcharts, policies, and procedures) and telephone and in-person interviews. Six pharmacists, seven directors of nursing, and three administrators were interviewed between January and May 2009 using semi-structured interviews, including closed and open-ended questions. Interview responses were hand recorded. Themes were developed from review of interview notes and other documents and discussed among the study team, including two members (JL, JO) who were directly involved in the HIT implementation processes. Study methods received Institutional Review Board approval.

Study hospitals

Mercy Health Network-North Iowa consists of Mercy Medical Center-North Iowa (MMC-NI), one owned and eight contract-managed CAHs, and a primary physician network. The MMC-NI is the 'hub hospital' for this network. Appendix A of the online supplementary material (available at http://jamia.bmj.com) provides a summary of the operating characteristics in MMC-NI and the seven CAHs that participated in this collaborative HIT implementation.

RESULTS

HIT implementation

Mercy Medical Center-North Iowa, a member of Trinity Health (Novi, MI), implemented its EHR and CPOE systems in July 2005.[15] Building on the

experience of MMC-NI,[14] CAH HIT readiness assessments, workflow redesign, and implementation planning began in 2006. All seven CAHs implemented the same EHR and CPOE systems during the summer of 2008 using a 'big bang' approach in two cohorts (eg, cohorts of 3 and then 4 CAHs). During implementation planning and preparation phases, selected staff from MMC-NI met regularly with work teams from the CAHs. Training and the use of super-users across CAHs were standardized. At go-live, MMC-NI assigned staff experienced in using the HIT applications to be onsite at the CAHs. A similar process was followed for ADC and BCMA implementation in early 2009. This sharing of HIT expertise and personnel across the network facilitated a more rapid and effective system activation, updates, and modifications.

Automated dispensing cabinets (ADCs)

The ADCs decentralize pharmacy dispensing functions and reduce the need for nurses to retrieve medications from the pharmacy when pharmacists are unavailable.[15–17] Access to all ADC units is electronically controlled and requires identification of both the nurse withdrawing the medication and the patient for whom the medication is being dispensed. Retrieving controlled medications from the ADCs requires a 'blind count' to be performed (the user enters the number of remaining doses) and the documentation of wasted medications requires a second user to 'witness' the amount wasted by entering their password into the ADC. All interviewees reported that the ADCs were generally well received by both pharmacists and nurses. For pharmacists, the ADCs reduced the amount of time needed to dispense medications using the traditional medication cart and wall systems, allowing pharmacists to spend more time on clinical pharmacy-related work (eg, consulting with physicians, nurses). The ADCs also improved narcotic and controlled substance monitoring and saved nurse time by instituting a 'blind count' when the controlled substances are removed which took the place of several daily counts independent of drugs being removed.

Bar-coded medication administration (BCMA)

The HIT-integrated BCMA technology is effective at reducing medication administration errors by providing increased verification of the five rights of medication administration: right patient, right medication, right dose, right time, and right route.[16–30] The BCMA has also been found to be effective in ensuring accurate identification and verification of blood transfusions,[29 30] increased accuracy of patient specimen collection and laboratory data,[29 31] while enhancing medication error reporting, pharmacist intervention records,[32] and electronic medication administration record (e-MAR), and streamlining the medication inventory process.[21 23 26 27 32–34]

All study CAHs implemented the same BCMA that was interoperable with their EHR. The BCMA provides automatic documentation through its link to the e-MAR, which was created as part of the EHR implementation, and interfaced with the billing system. The latter is an important improvement because it allowed transition from charging for medications at the time they are dispensed to charging for medications when they are actually administered. This has resulted in a more streamlined and accurate billing process, because of a more accurate capture of medications being administered, and a reduction in the need to delete charges for medications dispensed but not administered to patients. All interviewees indicated that the use of the BCMA devices and change in workflow have been generally well-received by the nurses, and have prevented medication administration errors. The CAHs use the automated reports generated by use of the BCMA application to track on a monthly basis the per cent of medications being scanned. All CAHs have implemented and maintained a target medication administration scanning rates of at least 90%.

DISCUSSION

Factors related to effective implementation of ADC and BCMA

A number of factors facilitating the CAHs' successful collaboration on medication administration and dispensing are of note.

Culture of collaboration

The literature supports that small hospitals owned by large systems have some advantages in HIT implementation.[35] The collaboration discussed here had over 20 years of inter-organizational relationships and sharing. This collaboration originated as part of MMC-NI's market strategy to strengthen its historic role as a regional referral hospital. Operationally it began by developing management service contracts for senior leadership positions (ie, CEO, CFO, CNO) as a way of helping the rural hospitals recruit and retain key leadership talent. The rural hospitals, with one exception, remained independent organizations with their own local governing boards to which the contracted managers would report. Additional network services emerging over time included assistance in recruiting other key personnel, development of a network of primary care physicians working in the rural communities, ongoing management and clinical information exchange, and group purchasing/contracting arrangements. A key operating principle of the network is that each hospital decides whether and to what extent it participates in network activities. Preservation of this 'opt-out' option has been a key to sustaining local hospital independence and an effective collaborative environment. Referrals from the rural facilities to MMC-NI are not required, although the many connections between the institutions and their respective medical staffs do result in significant numbers of patients receiving specialized care at MMC-NI. The many different relationships and linkages previously established by the study CAHs furthered the level of information sharing, trust, and consensus building. Having a clearly articulated rationale for a collaboration helps avoid misaligned organizational goals, minimize inter-organizational conflict, and 'holding the course'.[36–38] Major reasons supporting the CAHs' collaboration on HIT implementation included a culture of patient safety and quality throughout the network; a shared goal for using HIT applications to improve patient care quality, safety and efficiency; absence of significant CAH in-house HIT expertise; limited financial resources to invest in HIT hardware and software; and limited local expertise in integrating HIT into redesigned work processes.

Sequencing of HIT component implementations

The sequence and timing of the various HIT activations influenced the success of the CAH's implementation efforts. The expertise developed by MMC-NI in using the HIT implementation and ongoing operational processes developed by the parent Trinity Health system[14] played an invaluable role in informing decisions about the implementation sequence used by the CAHs. For example, activation of the EHR, e-MAR, and Pharmacy Information System set the stage for BCMA implementation. Likewise, implementing CPOE and Pharmacy Information Systems facilitated transition to ADC devices for decentralized medication dispensing.

Interface among HIT components

The ADCs can operate in either the 'profile mode' (ie, each patient's prescribed medications are available for dispensing once a pharmacist has reviewed and verified the order), or non-profile mode (ie, all medications are available for retrieval for a patient regardless of whether a pharmacist has reviewed/verified the order). A major limitation of the non-profile mode is the potential for a nurse to inadvertently select an incorrect drug, dose, or dose form from the ADC. Use of the profile mode of the ADC is a safety measure to ensure that the medication has been ordered for the patient for which it is being requested/dispensed. These sites use a barcode scanning product to validate that the medication has been ordered for the patient, is at the ordered dose/strength, dose form, and is being administered at the ordered time. This validation occurs at the point of medication administration versus at the location of an ADC. Therefore, in this instance the decision was made by the study CAHs to defray the substantial costs and time needed to program the automated dispensing consoles as the sites had a more favorable solution to verify correct selection of medications. Clearly, careful consideration of these trade-offs is important. The concurrent use of EHR-linked BCMA was viewed as an appropriate back-up system because of the ability to detect errors at the point of medication administration.

Strategic placement of ADCs

Because ADCs are expensive, careful planning for the efficient placement of ADCs was important. In these CAHs, the number of ADCs implemented varied. All CAHs implemented ADCs on their adult medicine/surgery units, usually consisting of one or two base units for pills and creams, a tower unit for bulkier items, and a refrigerated unit for liquids. Emergency department-based ADCs were implemented in all but one CAH for first-dose medications, to provide up to a 72-hour medication supply, and to provide a limited after-hours retail pharmacy presence. One CAH uses a smaller tabletop ADC in the obstetrics unit. The CAH with an inpatient behavioral health unit added an ADC containing PRN medications. In most of the CAHs, the ADC units replaced traditional medication carts and wall units.

Disciplined use and sharing of workflow analyses linked with HIT applications

A hallmark of both the hub hospital's and CAH's subsequent HIT implementation was strong project management[39] and the systematic sharing and disciplined use of workflow analyses, HIT integration, and standardization of workflow and documentation processes. Well over 100 different flowcharts depicting how specified work tasks interact with one or more of 14 different HIT-enabled systems (eg, EHR, CPOE, pharmacy–laboratory–radiology systems, registration systems, BCMA, ADC) were shared by MMC-NI with the network hospitals (see online supplementary material, available at http://jamia.bmj.com, for examples). These flowcharts were developed as part of the hub hospital's earlier HIT implementation and subsequent refinements. The flowcharts described a wide range of workflows and tasks touching on medication related processes. For example, separate flowcharts describing the medication administration processes were developed when using the BCMA technology to address medication administration for medication orders under different conditions: (1) orders already entered into the pharmacy information system; (2) orders not yet entered; (3) orders requiring a nurse witness when the BCMA device is used; and (4) orders requiring a nurse witness for entries in the e-MAR. Rather than each CAH conducting separate workflow analyses and developing their own flowcharts for different contingencies, the CAHs used the same hub-hospital flowcharts, making minor changes to reflect unique local circumstances. Sharing flowcharts linking the HIT applications to key workflow processes greatly expedited the CAH's planning and implementation preparation and had many advantages, including access to more detailed and efficient/less expensive process workflow analyses and HIT integration documentation; enhanced workflow vetting and understanding; and standardization of task specification, workflow, and HIT integration.

Planning for workflow efficiencies

Integrating ADCs into workflow processes involves careful planning to maximize efficiencies. Workflow bottlenecks initially occurred during routine medication administration times because of multiple nurses needing to access the same ADC at the same time. Processes were reworked to enhance the flow of personnel and efficiency when accessing the ADC.

Supply of HIT devices

Because the study CAHs have limited financial resources to invest in HIT implementation, it is noteworthy that they purchased more than the 'minimum' necessary amount of needed equipment. With BCMA implementation the hospitals purchased enough scanning devices to ensure that each nurse had one to work with during her/his workshift as well as one reserve scanner in case any failed. These purchases were made to minimize disruptions to the nurses' workflow due to an inadequate supply of the BCMA scanners and to increase nurse satisfaction with BCMA.

Metrics to monitor HIT use and outcomes

A number of metrics are being used by the study hospitals to regularly monitor the progress made following their HIT implementations. Focusing specifically on the use of the ADCs and BCMA, the CAHs are tracking number and per cent of medication orders dispensed from the ADC, compliance with BCMA policies (eg, scanning both the medication and the patients' wrist bands), rate of wrong patient medication administration errors prevented (ie, near misses) by BCMA, and types, numbers, rates, and harm level of medication administration errors that occur. Monthly monitoring, based on automated reports, has allowed the hospitals to more easily and accurately track both usage trends and potential errors avoided, and to detect changes in how these technologies are being used.

Conclusions

This implementation brief describes factors contributing to the highly successful collaboration between seven CAHs and a hub hospital in the rapid implementation of ADC and BCMA technologies. These hospitals have improved medication process quality and safety by changing how medications are retrieved and by providing automated point-of-care medication administration checking and automated billing.

While there are many advantages associated with a collaborative approach involving a larger 'hub hospital', work of the Rural Wisconsin Health Cooperative[40] demonstrates an alternative approach for CAHs to collaborate independent of a single, larger, outside facility. Regardless of the type of collaboration, it is essential to integrate HIT into redesigned workflows rather than just applying information technology to existing processes.[37 39 42]

If one compares these CAH's HIT capability to the checklist used in the recent Jha *et al* article,[5] these hospitals would be included among the very few in the USA taking full advantage

of HIT to improve care. As the definition of meaningful HIT use evolves with the intended implications for Medicare payments,[41–45] CAHs and all hospitals must find ways to employ HIT to improve patient care quality and safety to position themselves for the changing payment environment.

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REFERENCES

1. JCAHO accreditation program: hospital national patient safety goals. 2009. http://www.jointcommission.org/NR/rdonlyres/31666E86-E7F4-423E-9BE8-F05BD1CB0AA8/0/HAP_NPSG.pdf (accessed 28 Mar 2009).
2. National quality forum safe practices for better healthcare—2009 Update A CONSENSUS REPORT, 2009. http://www.ahrq.gov/qual/nqfpract.htm (accessed 28 Mar 2009).
3. The Leapfrog Safety Practices, 2009. http://www.leapfroggroup.org/for_hospitals/leapfrog_hospital_survey_copy/leapfrog_safety_practices (accessed 28 Mar 2009).
4. AHA, continued progress hospital use of information technology, 2007. http://www.aha.org/aha/content/2007/pdf/070227-continuedprogress.pdf (accessed 28 Mar 2009).
5. **Jha AK,** DesRoches CM, Campbell EG, *et al*. Use of electronic health records in U.S. hospitals. *N Engl J Med* 2009;**10**:1—11.
6. **Robert Wood Johnson Foundation.** Health information technology in the United States: where we stand, 2008. http://www.rwjf.org/files/research/3297.31831.hitreport.pdf (accessed 6 Jul 2009).
7. **Ward MM,** Jaana M, Bahensky JA, *et al*. Clinical information systems availability and use in urban and rural hospitals. *J Med Sys* 2006;**30**:429—38.
8. **Houser SH,** Johnson LA. Perceptions regarding electronic health record implementation among health information management professionals in Alabama: a statewide survey and analysis. *Perspec Health Inf Manag* 2008;**5**:6.
9. **Medicare Payment Advisory Commission.** *Report to the congress: medicare in rural America*. Washington, DC: MedPAC, 2001.
10. **Li P,** Schneider JS, Ward MM. Effects of critical access hospital conversion on the financial performance of rural hospitals. *Inquiry* 2009;**46**:46—57.
11. **Li P,** Schneider JS, Ward MM. The effect of critical access hospital conversion on patient safety. *Health Serv Res* 2007;**42**:2089—108.
12. **Bahensky JA,** Frieden R, Moreau B, *et al*. Critical access hospital informatics. How two rural Iowa hospitals overcame challenges to achieve IT excellence. *J Healthc Inf Manag* 2008a;**22**:16—22.
13. **Bahensky JA,** Jaana M, Ward MM. Healthcare information technology in rural America: electronic medical record adoption status in meeting the national agenda. *J Rural Health* 2008;**24**:101—5.
14. **Crandall D,** Brokel J, Schwichtenberg T, *et al*. Redesigning care delivery through health IT implementation: exploring Trinity Health's IT model. *J Healthc Inf Manag* 2007;**24**:41—8.
15. **Casey MM,** Moscovice I, Davidson G. *Pharmacist staffing and the use of technology in small rural hospitals: implications for medication safety*. Minneapolis, MN, USA: Upper Midwst Rural Health Research Center, 2005:1—39.
16. **Hartzema AG,** Winterstein AG, Johns TE, *et al*. Planning for pharmacy health information technology in critical access hospitals. *Am J Health Syst Pharm* 2007;**64**:315—21.
17. **Kimber MB,** Peterson GM. Telepharmacy—enabling technology to provide quality pharmacy services in rural and remote communities. *J Pharm Pract Res* 2006;**36**:108—33.
18. **Cochran GL,** Jones KJ, Brockman J, *et al*. Errors prevented by and associated with bar-code medication administration systems. *Jt Comm J Qual Patient Saf* 2007;**33**:293—301.
19. **Johnson CL,** Carlson RA, Tucker CL, *et al*. Using BCMA software to improve patient safety in Veterans Administration Medical Centers. *J Healthc Inform Manag* 2002;**16**:46—51.
20. **Lawton G,** Shields A. Bar-code verification of medication administration in a small hospital. *Am J of Health Syst Pharm* 2005;**62**:2413—15.
21. **Paoletti RD,** Suess TM, Lesko MG, *et al*. Using bar-code technology and medication observation methodology for safer medication administration. *Am J Health Syst Pharm* 2007;**64**:536—43.
22. **Poon EG,** Cina JL, Churchill W, *et al*. Medication dispensing errors and potential adverse drug events before and after implementing bar code technology in the pharmacy. *Ann Int Med* 2006;**145**:426—34.
23. **Sakowski J,** Leonard T, Colburn S, *et al*. Using a bar-coded medication administration system to prevent medication errors in a community hospital network. *Am J Health Syst Pharm* 2005;**62**:2619—25.
24. **Sakowski J,** Newman JM, Dozier K. Severity of medication administration errors detected by a bar-code medication administration system. *Am J Health Syst Pharm* 2008;**65**:1661—6.
25. **Wright AA,** Katz IT. Bar coding for patient safety. *N Engl J Med* 2005;**353**:329—31.
26. **Larrabee S,** Brown MM. Recognizing the institutional benefits of bar-code point-of-care technology. *Jt Comm J Qual Saf* 2003;**29**:345—53.
27. **Puckett F.** Medication-management component of a point-of-care information system. *Am J Health Syst Pharm* 1995;**52**:1305—9.
28. **Anderson S,** Wittwer W. Using bar-code point-of-care technology for patient safety. *J Healthc Qual* 2004;**26**:5—11.
29. **Weilert M,** Tilzer LL. Putting bar codes to work for improved patient care. *Clin Lab Med* 1991;**11**:227—38.
30. **Turner CL,** Casbard AC, Murphy MF. Barcode technology: its role in increasing the safety of blood transfusion. *Transfusion* 2003;**43**:1200—9.
31. **Grotting JB,** Yang M, Kelly J. The effect of barcode-enabled point-of-care technology on patient safety, 2002. http://www.premierinc.com/quality-safety/tools-services/safety/topics/bar_coding/downloads/whitepaper_barcode.pdf (accessed 9 Apr 2009).
32. **Scott MG,** McElnay JC, Burnett KM. Using bar-code technology to capture clinical intervention data in a hospital with a stand-alone pharmacy computer system. *Am J Health Syst Pharm* 1996;**53**:651—4.
33. **Cina J,** Fanikos J, Mitton P, *et al*. Medication errors in a pharmacy-based bar-code-repackaging center. *Am J Health Syst Pharm* 2006;**63**:165—8.
34. **Cescon DW,** Etchells E. Barcoded medication administration: a last line of defense. *JAMA* 2008;**299**:2200—2.
35. **Li P,** Bahensky JA, Jaana M, *et al*. Role of multihospital system membership in electronic medical record adoption. *Health Care Manage Rev* 2008;**33**:169—77.
36. **Sicotte C,** Pare G, Moreault MP, *et al*. A risk assessment of two interorganizational clinical information systems. *J Am Med Inform Assoc* 2006;**13**:557—66.
37. **Reggy MC,** Purao S, Kelly M. Developing IT Infrastructure for rural hospitals: a case study of benefits and challenges of hospital-to-hospital partnerships. *J Am Med Inform Assoc* 2008;**15**:554—8.
38. **Ahmad A,** Teater P, Bentley TD, *et al*. Key attributes of a successful physician order entry system implementation in a multi-hospital environment. *J Am Med Inform Assoc* 2002;**9**:16—24.
39. **Zarn D.** MOE/MAR project management: a (Well-Informed) bird's eye view. *Healthc Q* 2006;**10**(Special Issue):27—38.
40. **Wenzlow L.** *Density of HIT adoption in Wisconsin rural hospitals*. Rural Wisconsin Health Cooperative, 2009. http://www.rwhc.com/Papers/Density.pdf (accessed 30 Sep 2009).
41. **Health and Human Services.** HealthIT.hhs.gov information related to the American recovery and reinvestment Act of 2009. http://www.healthit.hhs.gov/portal/server.pt?open=512&objID=1233&parentname=CommunityPage&parentid=1&mode=2&in_hi_userid=10741&cached=true. (accessed 15 Jul 2009).
42. **Health and Human Services Workgroup to the Health IT Policy Committee.** *"Meaningful use: a definition" recommendations from the meaningful use workgroup to the Health IT Policy Committee*. June 16, 2009. http://www.healthinformaticsforum.com/forum/topics/definition-of-meaningful-use (accessed Jul 2010).
43. American recovery and reinvestment Act of 2009. http://fdsys.gpo.gov/fdsys/pkg/BILLS-111hr1ENR/pdf/BILLS-111hr1ENR.pdf.
44. **Blumenthal D,** Tavenner M. The "Meaningful Use" Regulation for Electronic Health Records. *NEJM*, 2010. http://healthcarereform.nejm.org/?author=9 (accessed Jul 2010).
45. **Centers for Medicare & Medicaid Services.** *Medicare and Medicaid Programs. Electronic Health Record Incentive Program*. 42 CFR Parts 412, 413, 422 and 495, CMS-0033-F, RIN 0938-AP78. July 13, 2010. http://www.ofr.gov/OFRUpload/OFRData/2010-17207_PI.pdf (accessed Jul 2010).