Designing and Implementing an Electronic Health Record Based Intervention to Reduce Hospital-Acquired Infections at BWH: Considerations and Lessons Learned

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Scholarly Report submitted in partial fulfillment of the MD Degree at Harvard Medical School

Date: 28 February 2018

Student: Abhayjit Singh, BA

Title: Designing and Implementing an Electronic Health Record Based Intervention to Reduce Hospital-Acquired Infections at BWH: Considerations and Lessons Learned

Mentor: Christian Dankers, MD, MBA, Associate Chief Quality Officer, Department of Quality and Safety, Brigham and Women’s Hospital
Abstract

Designing and Implementing an Electronic Health Record Based Intervention to Reduce Hospital-Acquired Infections at BWH: Considerations and Lessons Learned

Abhayjit Singh, Christian Dankers, MD, MBA

Purpose: Nosocomial C. difficile infection is the most common hospital-acquired infection in the United States, and has implications for clinical care, quality assurance, and healthcare expenditure. The increase in molecular testing for C. difficile infection, which cannot distinguish true infection from asymptomatic colonization, may be partly responsible for overdiagnosis and overtreatment of C. difficile. Consequently, health care providers are responsible for deciding which patients should be tested for C. difficile infection. We sought to design and pilot a clinical decision support tool that would make use of the electronic health record to assist clinicians in making those decisions at Brigham and Women’s Hospital.

Methods: We designed and implemented an intervention with the goal of reducing inappropriate C. difficile testing (based on nationally accepted testing guidelines). Once per day, the “operator” (an individual from the Department of Quality and Safety) runs an EPIC report that locates all admitted patients who have had C. difficile testing ordered but not collected. The operator then manually ascertains certain data from the patient chart (laxative use, recent testing, formed stool) that would define the test as inappropriate. If a contraindication is found, the operator pages the responding clinician to discuss C. difficile testing. The operator then follows up on the patient (via EPIC) to determine the diagnosis and clinical outcome.

Results: This project was piloted from 1/2/2017 to 1/27/2017 at BWH. In total, 8 patients were identified and intervened upon. Reasons for intervening included recent laxative use (3), recently documented test result (1), and lack of diarrhea per provider notes (4). Of the 8 patients, 2 had C. difficile testing cancelled and 6 proceeded with testing; of the 6 tests conducted, 2 were positive and 4 negative. No patients experienced complications of C. difficile infection at 4-week follow-up. The number of patient cases was too low for any significant statistical analysis, and the pilot was subsequently discontinued.

Discussion: We successfully designed and piloted an EHR-based clinical decision support tool aimed at reducing inappropriate C. difficile testing. Though the project was not continued beyond the 4-week pilot, there were many operational and quality lessons gleaned from the experience. In particular, this project highlighted the importance of operational thoughtfulness and robust data measures when designing a quality improvement initiative, while balancing the priorities of various project stakeholders, including the institution, the department, and those directly affected by the intervention.
Glossary of Abbreviations

BWH: Brigham and Women’s Hospital
CMS: Center for Medicare and Medicaid Services
EHR: electronic health record
EIA: enzyme immunoassay
GDH: glutamate dehydrogenase
IDSA: Infectious Disease Society of America
PCR: polymerase chain reaction
RC: responding clinician
SHEA: Society for Healthcare Epidemiology of America
Introduction

*Clostridium difficile* infection is the leading cause of hospital-associated gastrointestinal illness, and has become the most common health care–associated infection in United States hospitals. In addition to being a significant source of patient morbidity, nosocomial *C. difficile* infection is a major contributor to the cost of hospitalizations, and may be responsible for increasing annual healthcare expenditures by approximately $4.8 billion in the U.S.\(^1\) As such, hospitals have invested heavily in identifying *C. difficile* infection in an accurate and timely manner, preventing the spread of infection to other patients and hospital staff, and treating *C. difficile* infection quickly and appropriately.

However, some experts believe that *C. difficile* is over-diagnosed and over-treated, especially in the era of molecular testing.\(^2\) Prior to 2017, Brigham and Women’s Hospital, in accordance with guidelines from the Infectious Diseases Society of America, used a two-step algorithm for *C. difficile* diagnosis (figure 1).\(^3\) This algorithm consisted of initial enzyme immunoassays to look for *C. difficile* toxins A/B and glutamate dehydrogenase (an antigen found in the *C. difficile* bacterium) in the stool, followed by reflexively using polymerase chain reaction testing to detect toxigenic *C. difficile* strains if the initial screening tests are discordant (i.e. if the toxin is not detected but GDH is). The rationale for this algorithm was that PCR has a higher sensitivity for detection of the *C. difficile* organism than toxin testing.\(^4\) A major limitation of PCR, and perhaps the reason it has failed to replace toxin testing, is that it does not distinguish between *C. difficile*–associated diarrhea and asymptomatic carriage of the organism. In fact, some experts estimate that up to 20% of hospitalized patients, and as high as 50% of patients in long-term care facilities, are asymptomatic *C. difficile* carriers.\(^5,6\) Although it is suspected that some proportion of patients who test negative by toxin EIA but positive by PCR have true infection while others are asymptomatic carriers, efforts to use clinical, laboratory, or imaging data to distinguish between toxin-positive and toxin-negative PCR-positive patients have been unsuccessful thus far.\(^7\) As a result, health care providers must use clinical judgment to determine which patients need to be tested and treated for *C. difficile* infection.
Inappropriate testing, diagnosis, and treatment of *C. difficile* infection have significant clinical and quality implications. From a clinical standpoint, nearly all patients with a positive *C. difficile* test receive antibiotic treatment, regardless of whether they test positive by toxin or by PCR. Given the side-effect profile of antibiotics and the fact that antibiotic resistance is a growing concern worldwide, it is important to avoid treating patients unnecessarily. On the other hand, failure to diagnose and treat *C. difficile* infection in a timely manner may result in severe complications, including severe hypokalemia, toxic megacolon, bowel perforation, lower gastrointestinal bleeding, intensive care unit transfer, or death.\(^8\) From a quality standpoint, *C. difficile* is a major nosocomial infection; accordingly, rates of hospital-acquired *C. difficile* infection are an important quality measure in most medical centers. Further, these metrics have financial implications, as infection rates are incorporated into government payment programs (examples include Value Based Purchasing and the Hospital Acquired Condition Reduction Program). It is therefore important that these rates reflect (as closely as possible) true *C. difficile* infection, rather than asymptomatic carriage of the organism.

*C. difficile* associated diarrhea is a diagnosis requiring both symptomatic and laboratory findings, and studies have suggested that the presence of symptoms affects the specificity of most *C. difficile* assays (when compared to a reference standard).\(^9\) While providers must ultimately use clinical judgment to decide which patients require testing and treatment for *C. difficile* infection, the most recent clinical practice guidelines from the IDSA and SHEA offer recommendations related to testing and treatment.\(^10\) These guidelines suggest that the following patients should not be tested for *C. difficile*: patients who do not have clinically significant diarrhea (defined as >2 episodes of loose stool in the last 24 hours), patients who have been tested for *C. difficile* within the last seven days, and patients whose diarrhea can be clearly attributed to an alternate source (therapies such as enteral tube feeding, intensive cancer chemotherapy, or laxatives). Adherence to these guidelines may decrease the number of inappropriate *C. difficile* tests ordered, and thus improve both patient care and reported quality measures.

In order to facilitate more appropriate clinical testing, hospitals have begun to take advantage of the tools and opportunities provided by electronic health records. For example, an informatics team at University of California-San Francisco has used EHR data to identify the source of
hospital-acquired infections by tracking the movements of more than 85,000 patients in one of its medical centers. More specific to *C. difficile* testing, Christiana Care Health System in Newark, Delaware recently piloted the use of “soft stop” and “hard stop” EHR protocols that were aimed at preventing clinicians from ordering a *C. difficile* test if laxatives had been ordered within the previous 24 hours. The group found that the “soft stop” reduced testing by 25%, while the “hard stop” reduced testing by 42%, without any incidences of delayed diagnosis resulting in adverse clinical consequences. We hope to design an intervention that similarly leverages the EHR to reduce inappropriate *C. difficile* testing.

**Student Role**

The overall goal of this experience was to research, design, and implement an EHR-based intervention to reduce hospital-acquired *C. difficile* infection rates, a nationally accepted quality measure, at BWH. I was responsible for researching and understanding the landscape of *C. difficile* infection and the work that had previously been published on the subject. Using that as a baseline, I was to design an intervention that would improve clinical and quality markers (namely, the *C. difficile* infection rate), implement said intervention at BWH, and analyze the results to determine effectiveness and scalability.

**Methods**

Following the research and design of an intervention aimed at reducing inappropriate *C. difficile* testing, the intervention was piloted for 4 weeks in January 2017.

The intervention specifics are detailed below (also see figure 2):

1. Operator at BWH (physician, pharmacist, medical or pharmacy student) identifies patients with ordered but uncollected *C. difficile* tests using EPIC report titled “Uncollected C. difficile tests” at 10:00 AM Monday – Friday. [Report uses following queries: *User login hospital; uncollected laboratory test; C. diff lab*]
2. Operator checks the “MAR” tab (generated by the EPIC report) to determine whether the patient received any laxatives (bulking agents, osmotic agents, secretory agents, stool
softeners) or initiated parenteral feeding in the 24 hours prior to the C. diff test being ordered.

3. Operator checks the “Results” tab (generated by the EPIC report) to determine whether the patient has had a documented C. difficile test result in the 7 days prior to the C. diff test being ordered.

4. Operator scans the most recent MD and nursing notes to determine whether the patient is experiencing loose stools (yes/no/unk, not quantifying).

5. If operator determines that patient has received laxatives or initiated parenteral feeding in the last 24 hours, has a documented C. difficile test result in the last 7 days, or is not having loose stools per recent clinician notes, operator pages the responding clinician:

   [Page text: Please call Re: (Patient Name & MRN) C. difficile testing. Thanks! -BWH Quality and Safety]

6. Operator has a conversation with the responding clinician:

   [Hello (RC), my name is (operator) and I am calling from the Department of Quality and Safety regarding your patient (patient name). We noticed that your patient is ordered for C. diff testing but [describe contraindication as identified]. Current evidence and guidelines suggest that these patients should not be tested for C. diff as it often leads to overdiagnosis and overtreatment. We encourage clinicians to cancel C. diff testing as the sample has not yet been collected. If you have questions, would you like to speak with one of our infection control or quality/safety physicians? (wait for answer) If not, can I ask whether this information changes your testing plan?]

7. If RC would like to speak with Infection Control or Quality and Safety MD, operator sends page to facilitate contact [Christian Dankers].

8. All patients identified by the operator as meeting the above criteria are placed on a separate “patient list” within EPIC [BWH Medicine, C. diff intervention pilot]. Operator proceeds to gather the following follow-up information using the EHR, namely EPIC, on the identified patients 4 weeks after the conversation:

   • Was the C. difficile test ultimately run or cancelled?
   • If run, what was the final result of the test?
   • Did the patient receive antibiotics during the index hospitalization?
   • Did the patient experience any severe complications of C. difficile infection (hypokalemia with potassium level lower than 2.5, toxic megacolon, bowel perforation, lower gastrointestinal bleeding, intensive care unit transfer, or death) during the index hospitalization?
This 4-week pilot was conducted using the above protocol from 1/2/2017 to 1/27/2017 (excluding weekends), with Abhayjit Singh (4th year medical student) acting as the operator. The results were compiled and are shown below (also displayed in table 1).

**Results**

In total, eight (8) patients were identified by the above protocol. Of those 8, three patients (37.5%) were identified due to laxative use in the previous 24 hours, one patient (12.5%) was identified due to a documented test result in the previous 7 days, and four patients (50%) were identified due to a provider note indicating the patient was no longer experiencing loose stools. Out of the 8 pages sent to responding clinicians, 8 clinicians (100%) responded to the page and engaged the operator in conversation. Following the conversation, 1 clinician (12.5%) indicated she would cancel the order, while 7 clinicians (87.5%) indicated they were unsure whether or not they would continue with testing.

Of the 8 patients identified during the intervention, 2 patients (25%) had their *C. difficile* testing orders cancelled, while 6 patients (75%) underwent *C. difficile* testing; 2 tests (33%) were positive by toxin, while the remaining 4 tests (66%) were negative. At the 4-week follow-up mark, all patients (100%) had been discharged from the hospital. During the index hospitalization, 4 patients (50%) received at least 1 dose of antibiotics (intended to treat *C. difficile* infection) and 2 patients (25%) completed a course of antibiotics. None of the patients (0%) experienced a severe complication of *C. difficile* infection (hypokalemia with potassium level lower than 2.5, toxic megacolon, bowel perforation, lower gastrointestinal bleeding, intensive care unit transfer, or death) during their hospitalization.

Ultimately, it was decided that intervening on 8 patients over the course of 4 weeks, with a significant amount of time spent going through patient records to identify patients of interest, was not a high-value proposition for the department or the hospital. In addition, the total number of cases intervened on was too low for any significant statistical analysis. Therefore, the pilot was not continued or expanded.
**Discussion**

While our pilot was not particularly robust from an academic standpoint, there were many operational and quality lessons learned. There are several considerations when attempting to design and implement a quality improvement intervention aimed at reducing hospital-acquired infections. In this section, we highlight some of the important concepts that presented both opportunities and challenges during this experience, which include thoughtfulness about goals and the path to them, robust data measures, accountability to stakeholders, and whether the value of a project is in line with institutional priorities. By reflecting on the aforementioned issues, we hope to provide meaningful suggestions for future quality improvement initiatives.

In the realm of hospital-acquired infections, the ultimate goal of quality improvement is to reduce infection rates (i.e. the *C. difficile* infection rates per 1000 patient days). However, there is a complex pathway from a patient admission to a reported hospital-acquired *C. difficile* infection, with multiple steps amenable to quality improvement along that pathway. Our intervention was predicated on the hypothesis that *C. difficile* infection was being overly diagnosed, treated, and reported at BWH. We chose to tackle the suspected overdiagnosis of *C. difficile*, and thus our more specific goal was to reduce inappropriate *C. difficile* testing. In deciding how to best approach achieving this goal, we examined the workflow of *C. difficile* testing and decided to focus on the step of the *C. difficile* laboratory test being ordered by a clinician. This decision was based on data from Northwestern Memorial Hospital, which suggested that over a one-year period, approximately 15% of reported hospital-acquired *C. difficile* infection cases were tested inappropriately. Additionally, part of the rationale was that intervening at this step would allow us to impact both clinical measures (diagnosis and treatment of *C. difficile* infection) and quality measures (reporting of *C. difficile* infection rates).

After deciding what the goal of the intervention would be, the next logical step is deciding how to achieve that goal. In an EHR-based intervention, specifically one aimed at changing behavior of hospital staff, the main question is how to drive and sustain the desired behavior change. For example, an intervention that involves changing hospital guidelines seen by providers is quite different from a project that makes use of the EHR to send providers an alert when they place an
order. There are multiple considerations to balance when deciding how passive or active an intervention should be. On one end of the spectrum, a completely passive intervention (e.g., a change in hospital guidelines) requires minimal effort on the part of the investigators (aside from the initial process of designing and implementing the change), and is also minimally intrusive to hospital staff. However, the downside is that these interventions may not have the intended effect of changing behavior. On the other end, a very active intervention (e.g., having required trainings for providers or individual conversations with patients) may be more effective in accomplishing the goal, but it is both time and resource intensive for the department of quality and potentially intrusive to health care providers or patients.

Our intervention, which involved both a search of the patient’s health record and individual conversations with providers, was on the more active end of the spectrum. Broadly, our intervention was meant to change provider behavior; more specifically, it was meant to be a clinical decision support tool. Our rationale for having a conversation (as opposed to a more passive intervention) was to minimize the risk of “alert fatigue”, the idea that care providers who receive too many alerts do not end up acknowledging or acting on any of them. The design of this project necessitated that someone (with the requisite training and knowledge) not only manually run the EPIC report and review the EHR daily, but also send messages and have conversations with individual providers as needed. This required a significant investment of time and energy by the operator during the intervention pilot. On the provider side, the receipt of a page (and engaging in a conversation) may take a significant amount of time, which can negatively impact the daily workflow of clinicians. In hindsight, it may have been more advantageous to design a more efficient and less laborious system for identifying patients who had been inappropriately ordered for *C. difficile* testing (e.g., one that could automatically search the EHR for the variables of interest and alert the operator). Building such a system, while possibly more time and cost intensive upfront, may have served to make this intervention more sustainable in the long run.

The next consideration for quality improvement initiatives, which serves as the backbone both for establishing a baseline and analyzing the effect of an intervention, is data. In the case of hospital-acquired infections, data is usually collected and reported on outcome measures
(generally with number infection cases per a certain number of patient day) or as process measures (attempting to track adherence to specific processes designed to minimize infection rates). It is not only important to be actively collecting this data, but to use the appropriate measures to best track the effect of a specific intervention. Selecting the appropriate clinical or quality measure (be it an outcome or process measure) depends on the disease process of interest and the aim of the planned intervention. In the case of *C. difficile*, goals of a quality project may range from preventing the spread of *C. difficile* infection by health care workers to minimizing treatment of asymptomatic *C. difficile* colonization. In the former example, a possible quality measure may be the rate of adherence to hygienic practice by hospital staff; in the latter, the best measure may involve assessing the number of patients treated inappropriately.

We sought to implement an intervention aimed at changing *C. difficile* testing practices to be more in accordance with national guidelines, as described above. We decided to use *C. difficile* infection rates per 1000 patient days as our outcome measure, both because this measure was readily available and because we reasoned it would serve as a decent proxy for reduced rates of inappropriate testing. In retrospect, it may have been more ideal to use a different and more specific measure, such as the proportion of tests *C. difficile* ordered inappropriately, to more accurately reflect the issue we were attempting to tackle. However, such a measure was not being recorded at the time of this project, meaning it would have been both time and resource intensive to establish a baseline and continue tracking this measure throughout the course of the intervention. Use of imperfect measures is a very common limitation of quality improvement initiatives, as institutions generally track only a handful of measures regularly.

Another consideration when working in the quality sphere, which often involves projects that affect multiple departments, is accountability to multiple stakeholders, either those setting the agenda or those affected by the intervention. For projects in quality improvement, perhaps opposed to projects in other disciplines, the financial considerations of the hospital and incentives determined by outside bodies (e.g., Center for Medicare and Medicaid Services) are hugely important. At the same time, there are multiple stakeholders within the hospital itself (executive leadership, individual departments, trainees, nurses, etc.) who need to come together in order for a broad-reaching intervention to succeed. Too little consideration of the wishes of
various stakeholders results in a project operating without support, while too much placation to external demands may result in a project that is ineffective.

Our proposed intervention required input from clinicians, infection control, the department of quality and safety, and the microbiology lab, and affected orders placed by all clinicians (spanning nearly every medical and surgical department). The fact that such a wide array of stakeholders were required to come together and provide feedback about the intervention meant that the timeline for the design and implementation of the project was stretched. It also opened the door for conflict between the various stakeholders, as a clinician from a surgical department may have a different view of this issue and how best to approach it than a laboratory technician from the microbiology lab. We felt strongly that none of the major stakeholders affected by this intervention express major reservations, which inevitably resulted in too much effort being spent trying to appease each party and made it challenging to get the project off the ground. For the future, it is important remember the importance of striking a balance when considering stakeholder input and priorities.

A final consideration when working in quality improvement, or any other department for that matter, is the limited resources available to the department. Limited resources with which to accomplish a set of goals forces prioritization of projects that address the highest needs in the department and are projected to be the most impactful. In the department of quality and safety, projects that succeed in improving quality measures have a strong financial incentive as well, while projects that fail end up being a poor investment for the department. It is expected that a number of projects or possible interventions will not be continued long-term, so projects must demonstrate value for the institution in order to be supported. For this reason, projects in quality improvement often operate fail-fast systems, which are designed to detect limitations or failures early and avoid attempting to continue a possibly flawed process.14 This sort of system allows a department to undertake both more and riskier projects, because the potential loss from a project that fails is much smaller than with a traditional approach.

Our intervention not only required resources for the design and implementation of the pilot, but ultimately would have continued to require resources were the project to continue indefinitely. In
the end, we invested a significant amount of resources to pilot this project, and yet only impacted a handful of patients over the month-long pilot. The calculus for determining the value of a project is complex and involves considering the time, effort, and finances of multiple parties. Nevertheless, projects may be deemed poor value due to many factors, and it was important to evaluate the project following the 4-week pilot and allow it to “fail fast” if resources could be better utilized elsewhere.

Through this experience, I have learned a great deal about operations. In particular, there are a few essential considerations for projects aimed at quality improvement, especially those hoping to leverage the electronic health record. These include having a broad vision but a more narrow and specific goal that can be measured at each step in the process, an appropriate amount of input from the stakeholders in the project, and designing an intervention that will generate value for the institution as a whole.

**Acknowledgements**

My mentor, Christian Dankers, MD, MBA, who serves as the Associate Chief Quality Officer in the Department of Quality and Safety at Brigham and Women’s Hospital was instrumental in this experience. Not only did he devote his time and energy to teaching me the principles of quality improvement and just culture, he also gave me the freedom to use creativity and take ownership of this project.

The Department of Quality and Safety at BWH, which provided me with office space, essential supplies, and the opportunity to research, design, and implement this pilot intervention.

The Scholars in Medicine Office, which both supported and guided my research interests, and also provided me with funding to make this project possible.
Tables and Figures

Figure 1

Figure 2

Operator flowchart

Operator finds admitted patients with *C. difficile* test ordered but not collected

Operator opens record of each identified patient

Operator determines if patient has any of:
- Laxatives (24h)
- Previous test (7d)
- Formed stools (per recent clinical note)

If NO intervention, then:

If YES, then:
- Operator adds patient to EPIC list
- 4-week follow-up

Operator pages responding clinician and has conversation about testing indications
Table 1

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<th>Result of testing?</th>
<th>Abx (≥1 dose)</th>
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