Interventions to decrease catheter-related bloodstream infections in the ICU: The Keystone Intensive Care Unit Project

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Background: A quality improvement initiative that included rigorous measurement, feasible interventions, and cultural change was shown to nearly eliminate catheter-related bloodstream infections (CR-BSIs) in patients in a surgical intensive care unit (ICU). To build on this research, a statewide collaborative cohort study was conducted using the same evidence-based interventions.
Methods: Interventions included handwashing, using full barrier precautions during the insertion of central venous catheters, cleaning the skin with chlorhexidine, avoiding the femoral site if possible, and removing unnecessary catheters. Both technical and adaptive (cultural) aspects of implementing the intervention were addressed through engagement, education, execution, and rigorous evaluation. A ''team checkup tool'' was developed to help senior leaders assess their role in ensuring compliance.
Results: Of 108 ICUs in the study, 103 reported data. Analysis included data from 1981 ICU-months and 375,757 catheter-days. The regression model showed a significant decrease in CR-BSI rates from baseline, with incidence-rate ratios decreasing from 0.62 at zero to 3 months after implementing the intervention to 0.34 at 16 to 18 months. Preliminary analysis suggested CR-BSI rates were sustained 4 years after implementation of the intervention.
Conclusion: Results suggest that this program model can be generalized and be implemented on a large scale in the United States or the world to significantly reduce the rate of CR-BSIs and their associated morbidities, mortalities, and costs of care. (Am J Infect Control 2008;36:S171.e1-S171.e5.)

An estimated 80,000 catheter-related bloodstream infections (CR-BSIs) in patients in intensive care units (ICUs) in the United States result in as many as 28,000 deaths and increased health care costs of up to $2.3 billion per year.[1] The median rate of CR-BSIs in ICUs ranges from 1.8 to 5.2/1000 catheter-days.[1,2] At the Johns Hopkins University School of Medicine, a research team from the Quality and Safety Research Group (QSRG) developed a new approach to quality improvement that included rigorous measurement, feasible interventions, and cultural change intended to reduce the rate of CR-BSIs. A prospective cohort study in a surgical ICU showed that interventions that promote adherence to evidence-based infection control guidelines nearly eliminated CR-BSIs.[3]

The next step was to determine whether this approach could be generalized. The QSRG research team partnered with the Michigan Health and Hospital Association, Keystone Center for Patient Safety and Quality and conducted a statewide collaborative cohort study to determine the extent to which the incidence of CR-BSIs could be reduced using the same interventions.[4]

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EVIDENCE-BASED INTERVENTIONS

In developing an intervention model (Table 1), the evidence from published studies was reviewed, the interventions with a potential to improve outcomes were identified, the 5 interventions that had the strongest evidence and the lowest barriers to implementation were selected, and the interventions were transformed into specific behaviors.[5] The goal was to design a system that increased the possibility of patients receiving these interventions[5]:

- Wash hands;
- use full barrier precautions during the insertion of central venous catheters;
- clean the skin with chlorhexidine, a soap that decreases infections rates by 50%;

- avoid the femoral site when possible because of its potential infectious and mechanical complications; and
- remove unnecessary catheters.

These interventions can be performed easily, yet in most hospitals the care of patients using these 5 procedures occurs only approximately 30% of the time.

COMPREHENSIVE UNIT-BASED SAFETY PROGRAM

When implementing research in a clinical setting it is important to address both technical and adaptive (cultural) aspects to gain a willingness to comply and ultimately sustain use of the 5 procedures. The Comprehensive Unit-Based Safety Program (CUSP)[6,7] was designed to improve safety culture, including communication and teamwork in working together toward the common goal of eliminating CR-BSIs. The Comprehensive Unit-Based Safety Program is coupled with a strategy to translate evidence into practice[8] that summarizes the evidence, identifies local barriers, measures baseline performance, and ensures all patients received the evidence using the ''4Es'' model. This model targets senior leaders, ICU directors, and staff.

Engage

People need to be personally engaged in the program. If leaders, clinicians, or staff cannot answer the question, ''How does this make the world better?'' they will not participate. People are engaged by telling stories and sharing baseline data.

Educate

Educational programs describe the evidence that supports the 5 procedures, and participants are provided with articles, a 1-page fact sheet, and a PowerPoint (Microsoft Corp, Redmond, WA) presentation to share with their staffs.

Execute

Staff is asked the following: ''Given this evidence, how will you in your culture and with your resources ensure that every patient receives these five things?'' They are also given strategies based on sound theory that improve safety, such as standardization, independent checks, and learning from errors.

For example, the Centers for Disease Control and Prevention best practices for catheter insertion require 8 or more pieces of equipment. In most hospitals, staff may need to go to 8 different places to get those items; sometimes inventory is not stocked and often clinicians cannot find what is needed. A central line cart where all the equipment is stored in one place reduces these 8 steps to 1 step and reduces failures.

A checklist was created to ensure sterile procedures were followed, and nurses were empowered to stop nonemergent insertions if a physician did not comply with each sterile behavior. At first, there were objections to the policy. No one disputed the evidence, but there was a cultural or ''adaptive'' problem. To overcome this barrier, culture change was linked to evidence. When clinicians were informed of the harm and costs they may cause by not complying, they readily accepted the practice change.

When staff is asked, ''Is it tenable that we harm patients in this hospital?'' the answer, of course, is no. The follow-up question is, ''Then, how could you as a nurse see someone not wash their hands and not speak up, if your role is an obligation to the patient?'' When practices are framed as a patient issues rather than power or political issues, the barriers are more likely to be overcome.

Evaluate

There was rigorous evaluation to determine whether safety was actually improved.

IMPORTANCE OF ADDRESSING TECHNICAL AND ADAPTIVE WORK

Ron Heifetz, a renowned leadership expert at Harvard, in one of his models separates problems into technical problems (problems for which scientific evidence exists) and adaptive problems (problems that require changes in values, attitudes and beliefs, culture change). A major mistake is to treat adaptive problems as though they were technical problems. Technical work summarizes the evidence, defines the measures, and standardizes these across all hospitals. Adaptive work implements the measures and interventions and must be modified to fit the local context of a clinical area. Both of these need to be done well. In the 4E model, the technical aspects are education and evaluation, and the adaptive elements are engagement and execution.

The technical aspect is often difficult and resource intensive for a single hospital. In this study, the technical functions were centralized through the QSRG research team and through the Keystone Center for Patient Safety and Quality at the Michigan Health and Hospital Association. When the study began, no single hospital had a data management system that could quickly show the worst infections for the past year

sorted either by a particular ICU or for an entire health care system.

A very simple Web-based data tool was developed that enabled participants to aggregate the results for any ICU, hospital, or the entire state. The only 2 data elements were the number of infections and number of catheter-days. This simplified the burden of data collection so the teams could focus on the adaptive aspects of engaging their staff and executing the inventions so that people acted on the need for change.

KEYSTONE ICU PROJECT: INTERVENTION TO DECREASE CR-BSIs

High reporting rates

The very high reporting rate for the ICUs was remarkable. When the grant application was submitted, a letter was sent asking for participants, and 35 hospitals volunteered. Within a month, well over one hundred ICUs from 77 hospitals had agreed to participate—almost all the hospitals in the state. There were 3 reasons for this participation: (1) the procedures were evidence based, (2) rigorous evaluation was wanted to demonstrate that the procedures worked, and (3) the project was based on the concept of inclusiveness so that success would be measured by improvements state-wide and not just at the individual hospital level. Safety is a patient right, and hospitals need to learn from each other and work together to ensure that all patients receive safe care.

Despite this, we found some errors in the reported data, and it was essential to implement a data quality control plan. This included training on definitions for CR-BSI and catheter-days, range checks in the database, follow-up for missing data, and review of repeat catheter-days. The most common data problems were missing data, repeating the same number of catheter-days for several months, and having a dramatic change in either catheter-days or infections. Although methods of data quality control used in clinical research are likely not feasible for use in quality improvement studies, some practical data quality control measures are not only feasible but essential if we want to make inferences regarding whether safety has been improved.

Methods

The NNIS definition of CR-BSI[2] was provided to hospitals (Fig 1). A central catheter was defined as a catheter that ends at or near the heart or in a great vessel close to the heart including peripherally inserted central catheters. To simplify data collection, the average duration of catheter use in individual patients and the microorganism were not monitored.

RESULTS

The results of the 18-month study showed a 95.4% reporting rate (Table 2). The analysis included data from 1981 ICU-months and 375,757 catheter-days. The regression model showed a significant decrease in CR-BSI rates from baseline, with incidence-rate ratios decreasing from 0.62 at zero to 3 months after implementing the intervention to 0.34 at 16 to 18 months.[4]

Preliminary analysis demonstrates that results may have been sustained at 4 years post implementation of the intervention. Rhode Island implemented a similar program with every hospital in the state participating and reported similar results as Michigan. This suggests that this program model can be generalized and can also be implemented successfully in other states.

Study limitations

The data collected did not include the duration of catheter use or the number of lines in individual patients. Data collection was designed to be consistent with the patient privacy act (HIPAA). Tracking individual patients would have required patient identification, whereas the data collected for this study were deidentified.

In quality improvement projects, it is necessary to balance what data are needed to be scientifically sound compared with what is feasible to collect. Many quality improvement studies involve the collection of a wide variety of data; but data collection is often not rigorous and many have 60% to 80% missing data that limits making inferences.

Many funded academic studies are scientifically sound but are not feasible for broad-scale implementation. To balance scientific soundness and feasibility, the quantity but not the quality of data collection was reduced in study, that is, fewer data elements were collected, which reduced our missing data to 12%.

Similarly, data were not collected about the organisms causing CR-BSIs, including multidrug-resistant organisms, which were identified as causing an infection.[1] Approximately 40% of Michigan facilities are rural hospitals, and some have limited resources. The study advisory group felt it would be too burdensome to collect information about every infection type. Data systems are currently being developed to monitor the incidence of these infections.

Lessons learned

After completing the study, focus groups or interviews were done with the ICU research teams. Four themes repeatedly came up when they were asked

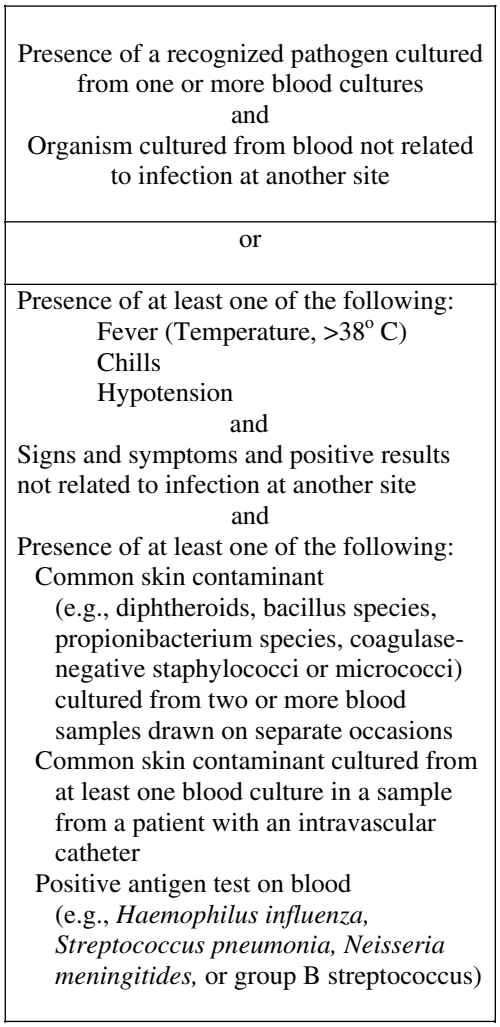

Fig 1. Catheter-related bloodstream infections in adults, as defined by the National Nosocomial Infections Surveillance System.

what made this collabrative successful: (1) the interventions were driven by evidence, (2) feedback to teams presented data that was important to them (valid), (3) efforts were made to improve culture and teamwork, and (4) was ''o'hana'' or ICU teams were all in it together as a state. Several lessons also emerged from those sessions. One is to ensure getting the technical work right. The Michigan study began with paper-based data collection because of the limited resources. Future collaborative studies should be designed so that, from the outset, a centralized research group with the capability to design and conduct studies and summarize evidence is established, eg, a hospital association, large health system, or another organized group to develop and maintain a data management system. In addition, a data quality control plan is imperative to reduce missing data; enlisting support from hospital leaders can help in this regard.

Table 1. Comprehensive, sustained approach to reducing CR-BSIs[3]

• Implemented unit-based safety culture and daily goal sheet—3 months
• CR-BSI intervention—3 months
Handwashing
Full barrier precaution during line insertion
Chlorhexidine cleaning of the skin
Avoiding the femoral site
Removing unnecessary catheters
Education on infection control practices
Facilitators—central-line carts, checklists, ability to stop the procedure if practices not adhered to

Table 2. Mitigating risks of CR-BSIs—Keystone ICU Project

18-Month study with 103 of 108 ICUs reporting[3]
Total of 375,757 catheter-days[3]
Median rate of CR-BSI/1000 catheter-days decreased from 2.7 at baseline to 0 at 3 months after implementation of intervention ($P \leq .002$)[3]
Mean rate of CR-BSI/1000 catheter-days decreased from 7.7 at baseline to 1.4 at 16-18 months ($P < .002$)[3]
66% Decrease in CR-BSI at 16-18 months after implementation[3]
Improvements in CR-BSI rates sustained at 5 years after implementation

Fox example, in this study missing data were very high and we were able to lower it to about 12% by enlisting the help of chief executive officers at each hospital. The CEO was sent a letter informing them of percent of missing data coming from their hospital and the need to submit the required data or they would have to be dropped from the collaborative. This simple letter led to dramatic decreases in missing data, and their collaboration raised the bar on the ability to collect quality data for quality improvement efforts.

There should continue to be a focus on the adaptive aspects. Having staff tell their own stories and having baseline data to challenge their current view of reality is important. In addition, using the 4E model to target key microsystems (senior leaders, team leaders, and front-line staff) is important to translate evidence into practice. It was harder for local leaders at large hospitals to reach all staff. Technology such as Webinars or e-learning tools that front-line nurses and doctors could access materials online on their own time should be considered.

A more structured approach to engage senior leaders who do not actively participate in the 5 interventions would probably be beneficial. The involvement of these individuals would demonstrate why they need to commit resources and sometimes remove barriers that staff encounter when attempting to implement the program. If they have no feedback on the results of improvement initiatives, they are often overly optimistic about the impact.

At the end of the Keystone ICU project, a ''team checkup tool'' was pilot tested. Each month, teams completed a survey that asked, ''What is slowing your progress—senior leader support, physician support, time to do this, knowledge of the evidence, knowledge of quality improvement, or politics at the hospital?'' The ''scorecards'' were provided to the chief executive officers (CEOs). The impact was revealing. In subsequent surveys we received the following types of responses: ''I don't know what happened, but my CEO just came down and said he was sorry for not giving me enough time and now I can focus 20% of my time on this project.'' It showed that senior leaders were really committed to patient safety improvement and engaged but did not necessarily know what to do. This made it easy for them to assess their roles as senior leaders. In future projects, this tool will be used right from the start.

FUTURE DIRECTIONS

The QSRG research team is embarking on a national program to eliminate CR-BSIs across the United States. This is a large task and will require many partners. The team seeks to achieve this by replicating the collaborative undertaken in Michigan in other states. The Agency for Healthcare Research Quality has awarded the Heath Research and Educational Trust, and QSRG researchers at Johns Hopkins a grant to replicate this collaborative program in 10 states. In addition, the QSRG has received philanthropic support to implement the collabrative in another 20 states.

CONCLUSION

Targeted, evidence-based safety improvement efforts that have a centralized research group to manage the technical work and a culture program to adapt it to local units can eradicate CR-BSIs as effectively as polio.[4] In the mid-1980s, polio was killing approximately 350,000 people worldwide every year. Today, the death toll is less than a thousand, with almost all originating in one small region in Africa. Successful eradication happened because there was a focused effort on one problem.

Safety and quality efforts typically go ''an inch deep and a mile wide.'' They are focused on trying to solve many real problems to some small degree. Our model focuses on a specific outcome, eliminting CR-BSIs. Working to eliminate these infections throughout the United States, we will prevent 30,000 to 60,000 deaths and $2 to $3 billion annually. The challenge now is to implement this model on a large scale in the United States or the world so that we can build capacity and develop ways for clinicians to work together no matter where they are and really solve the problem of CR-BSIs. We look forward to everyone joining this effort.

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