Using Predictive Analytics and Effective Tools to Drive Down Infections

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Learning Objectives

• Recognize the role of leadership and multidisciplinary collaboration in promoting patient safety.

• State the key elements of an effective patient safety initiative designed to lower central line-associated blood stream infections (CLABSI) in the hospital.

• Indicate how to use a predictive risk model based on predictive analytics to lower the incidence of CLABSI and reduce costs in the inpatient setting.
Poll Question #1

How effective is your organization’s program to reduce CLABSIs?

1) Not at all effective  
2) Somewhat effective  
3) Moderately effective  
4) Very effective  
5) We don’t have one  
6) Unsure or not applicable
Indiana University Health believes its primary mission is to prevent serious safety events, including CLABSIs.
One in 20 patients.

41,000 inpatients and 37,000 hemodialysis patients (cost $3,700 to $36,000 per case).

One in four die.
Organization Background

Indiana University Health (IU Health):

- 17-hospital system.
- 130,000 patient admissions annually.
- Indiana’s most comprehensive healthcare system.
- One of only 38 hospitals in the U.S. to be ranked in eight or more specialties by *U.S. News & World Report*.
- Unique partnership with Indiana University School of Medicine, one of the nation’s leading medical schools.
- Composed of:
  - Hospitals, physicians, and allied services dedicated to providing pre-eminent care throughout Indiana and beyond.
  - More than 1,500 board-certified or board-eligible physicians.
  - More than 200 locations statewide and approximately 1,800 team members, including more than 250 advanced practice providers.
Necessary Intervention Not Without Risk

A central line is an intravascular catheter that terminates at or close to the heart, or in one of the great vessels, used for infusion, withdrawal of blood, or hemodynamic monitoring.

When not placed correctly or kept clean, central lines can cause serious bloodstream infections that can be deadly.

CLABSIs are most prevalent in patients in the intensive care unit (ICU) and patients receiving dialysis.

Driven by the need to reduce harm and save costs, all hospitals are seeking to reduce the incidence of healthcare associated infections (HAIs).
Identifying the Opportunity for Improvement

Despite evidence-based national guidelines for preventing CLABSI, the various factors that increase the risk of CLABSI, and the relative weight of each of those factors on the overall risk for infection, are not well understood.

Ensuring evidenced-based interventions have been completed, and evaluating the effectiveness of prevention activities can be challenging.

Historically, ICUs, where the largest number of critically ill patients with central lines receive care, have been the focus of CLABSI improvement initiatives. Today, patients with central lines are in inpatient units throughout the hospital, as well as in outpatient facilities. Confirming that CLABSI prevention activities have been provided to every single patient, every single time, can be even more difficult.
IU Health leaders are dedicated to improving the efficiency, quality, and cost-effectiveness of care, including continuous improvement of its rate of HAIs.

**IU Health:**

- Has invested significant resources to determine the factors associated with developing CLABSIs and the preventive interventions that can be performed to reduce the risk of CLABSIs.
- Recognized the need for striving for high compliance with infection prevention guidelines.
- Embarked on a mission to achieve zero CLABSIs.
Results

IU Health developed and implemented a **CLABSI predictive risk model** to identify which patients with a central line are at greatest risk for developing a CLABSI.

The CLABSI predictive risk model **predicts which patients with a central line will develop a CLABSI with an estimated 87% accuracy**.

- CLABSI risk model AU_ROC performance = 0.871.
- The CLABSI predictive risk model’s true-positive rate = 0.81.
- CLABSI predictive risk model’s false-positive rate = 0.16.

Informed by its risk factor analysis, as well as using education and focused interventions with staff caring for patients with central lines, IU Health **decreased the CLABSI rate by 35% over 8 months**.
Predicting Risk of Infection

IU Health wondered, for patients with a central line, what is their risk of developing a CLABSI over their entire hospital encounter?

Could the information in the enterprise data warehouse (EDW) be used to predict which patients are at highest risk for CLABSI or identify when the risk factors occur that put a patient at risk for harm?

If a predictive risk model was developed, could it be effectively integrated into the CLABSI analytics application?

Could they reliably predict which patients would develop an infection?

Could it update dynamically, in real-time, as the patient’s risk factors changed?
IU Health set out to develop and **integrate predictive analytics** into its CLABSI analytics application to predict which patients with a central line are at the highest risk of CLABSI over the entire encounter.

A **work team comprised of clinical experts**—including physicians, infection preventionists, analysts, statistician, and decision support team—embarked on a process to create such a model including the variables thought to contribute to increased risk of CLABSI, and the required source data.
Clinical experts conducted a thorough analysis of research and literature about CLABSI, identifying intrinsic and extrinsic CLABSI risk factors, and identifying patient populations that are the most susceptible to developing a CLABSI.

**Intrinsic risk factors:** non-modifiable characteristics like age, gender, and underlying diseases or conditions.

**Extrinsic risk factors:** potentially modifiable factors associated with central line insertion or maintenance, such as prolonged hospitalization, or multiple central lines.
Variables Identified

| Relatively simple approach—using total count of risk factors to identify those at higher risk. |
|---|---|---|---|
| Patient age in days | Total hospital days since admission | Total line days port | Total line days all lines (patients with more than one line) |
| Gender | Previous history CLABSI | Total line days internal jugular | Total line days tunneled |
| Chlorhexidine gluconate (CHG) Bathing (Yes/No) | Number line days each line | Total line days non-tunneled | Received parenteral nutrition (Yes/No) |
| Total hospital days prior to insertion | Total line days femoral | Total line days peripherally inserted catheter | Routine bathing (Yes/No) |
What Is Machine Learning?

- The “machine” is the computer and statistical software.
- The “learning” is the process involved when an algorithm, embedded in the software, learns from historical data (the values associated with specific input features) and then applies that learning on new data to predict an outcome…
- And, then cycles through that process iteratively.
Applying Machine Learning

Understanding it is the combination and interaction of risk factors that ultimately determines overall risk, the team leveraged machine learning to build a model based on retrospective data in the EDW.

This approach was used to train models on the previously identified 16 variables on 70,218 retrospective CLABSI cases.

Considering the mortality risk of patients with CLABSI, the IU Health team decided to err on the side of having more false positives and the threshold between a “yes case” versus a “no case” was adjusted accordingly in the application.
Poll Question #2

Does your organization use machine learning and predictive analytics to assess risk and to guide/drive improvement efforts?

a) Yes
b) No
c) Unsure or not applicable
CLABSI Predictive Risk Model Probability Visualization

Data, which can viewed in real-time, is accessible in an easy-to-use visualization that has filters for hospital/unit of interest, time period of interest, and patient probability of infection, high, medium, or low.

1. Top three risk factors for each patient.
2. Trended percentage of active patients by probability of infection.
3. Filters (e.g., patient, location, department).
Kristen would like to find some additional visuals. Will do this later…

**Compliance**

**Current Selections**
- Facility: IUH Methodist Hosp, IUH Univ Hospital

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**Bundle Compliance Over Time**

- Chart showing compliance over time from 2015-01 to 2017-06.

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**Question Compliance**

- All Bundle Measures Met?: 78.3%
- Dressing Occlusive?: 97.5%
- Documentation: Caps Current?: 93.3%
- Documentation: Daily Assessment for Continued Need of Line?: 97.6%
- Dressing Clean/Dry?: 93.7%
- Dressing Current?: 96.0%
- Unused Tubing Capped with Dead Ender?: 97.1%
- Daily Linen Changed?: 100.0%
- Tubing Current?: 92.0%
- Scrub the Hub of all Access Ports Prior to any Access?: 0.0%
- TPN Tubing Current?: 91.7%
Application to Clinical Care

With the dashboard, nurse unit managers and bedside nurses can determine which units have missed central line maintenance activities and/or did not complete prevention bundles for CLABSIs.

Providers also can use the tool to track how long a patient has had a central line—a key predictor of infection.
Kirsten… A visualization to support the previous slide would be great.

John
Driving Engagement

How did IU Health gain engagement for the model?

1. Grassroots effort.
2. Informal team structure so that this effort did not appear top down but rather bottom up.
4. Strong relationships! The power of the people. Leverage the ideas of the frontline staff.

During model development, small cohorts were built as a means to refine issues.
Workflow Integration

How is IU Health using it in its workflow?

Teams use the dashboard daily to identify central lines to come out and watch process measures.

Nursing units use huddle form on CLABSIs to identify gaps in real-time without manual chart review.

Pilot project in place regarding high risk patients for CLABSI: daily monitoring to understand opportunities for intervention.
Governance

How did IU Health organize and get the work done?

Used a “small and nimble approach” rather than a big, systemwide rollout—not big governance—too top down.

Partnered with the innovators to “dream big,” move fast, and reduce political hang-ups.

Leveraged aid from decision support as a crucial component. Communicated the clinical impact regularly—frontline staff likes to know how they make a difference too!

Cast a big vision. To do big things it takes a big, hairy, audacious plan.

Listened to the naysayers, but did not let them stop or discourage the team. If the naysayers had a point, it was considered and incorporated into the plan.
Using machine learning algorithms, IU Health developed an effective CLABSI risk prediction model that is built into a unit-level dashboard used by clinicians to identify the patients’ CLABSI risk score, patient-level care gaps, and the top three risk factors for each high-risk patient—providing immediate insight into specific actions that can reduce the CLABSI risk for these patients.
Lessons Learned

1. Strong leadership and a clear vision are essential.

2. A multidisciplinary, highly collaborative approach, and education are required to increase adoption and drive improvement.

3. Machine learning and predictive analytics can be effective in identifying patients at high risk of CLABSI.

4. Timely access to reliable, actionable data facilitates the ability to prevent CLABSI and improve care.

5. Timely and effective communication to increase understanding and engagement.
Future Plans

Integrate the risk scores into the clinician daily workflow.

Use the information to identify patients at highest risk of CLABSI and guide the decision of whether to put in or take out a central line.

Apply the risk model to other patient populations and determine if the predictive risk model can lower the overall rate of inpatient infection.
Thank You