Capstone Project Report Draft

Primary BSI in PICU

The most frequent hospital-acquired (nosocomial) infection in PICU patients is nosocomial primary bloodstream infection (BSI), which accounts for roughly one-third of all nosocomial infections in this patient population according to the National Nosocomial Infections Surveillance System publication in 1999 (Richards et al.), A bloodstream infection (BSI) is characterized as one or more positive blood cultures that are accompanied by systemic symptoms of infection such as fevers, chills, and/or hypotension. There are two types of BSIs: primary and secondary. Primary BSIs arise when there is no other known source of infection.(*Central Line Associated Bloodstream Infections - Guide to Infection Control - ISID*).

CLABSI problem in PICU patients and potential risk factors

When a treatment for more than a week is needed, a central line is commonly utilized instead of a conventional IV (intravenous) line. The line can deliver medicine or nutrients directly into the bloodstream. It can also be used to monitor blood flow (hemodynamic monitoring), draw blood, and for other purposes, one type of central lines is the central venous catheter (Figure 1) which is a tube that runs into a vein in your arm or chest and ends in the right atrium of your heart. If the catheter is in your chest, it may be connected to a device called a port that is placed beneath your skin. In a small procedure, the port and catheter are implanted (*Central Venous Catheters - Ports: MedlinePlus Medical Encyclopedia*).

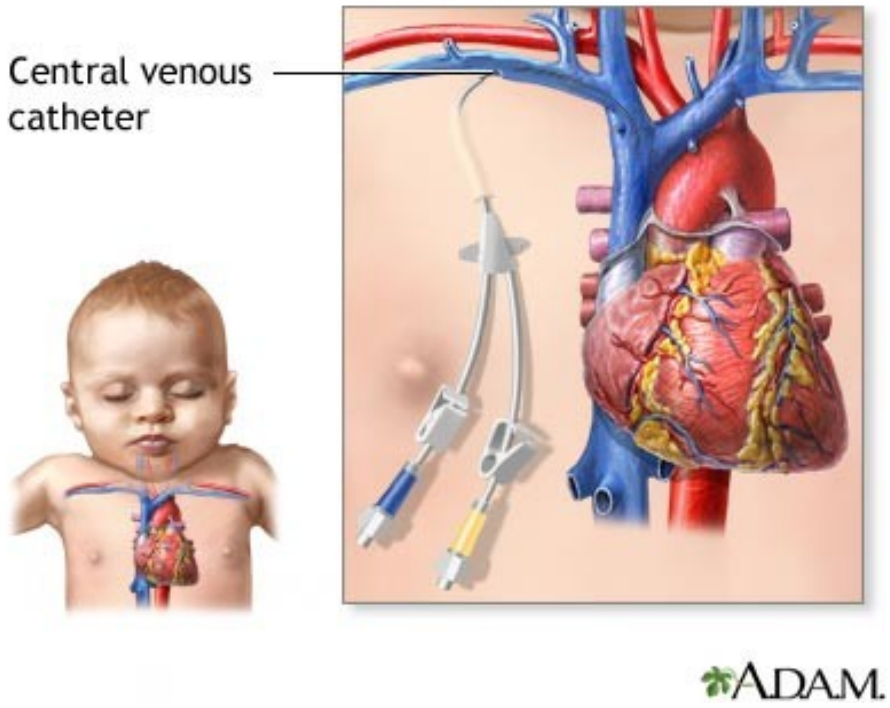

Figure 1: A central venous catheter (*Central Venous Catheters - Ports: MedlinePlus Medical Encyclopedia*)

The National Healthcare Safety Network (NHSN) of the CDC defines central line associated blood stream infection (CLABSI) as a primary BSI in a patient who had a central vascular catheter within the 48-hour period preceding the BSI and is not directly tied to an infection at another site (*Central Line Associated Bloodstream Infections - Guide to Infection Control - ISID*), The Centers for Disease Control and Prevention state that although (CLABSI) are preventable, they are responsible for thousands of mortalities each year, and billions of dollars in rising expenses to the U.S. healthcare system, To minimize CLABSI, it is critical to assess the effectiveness of preventative actions using data from evidence-based surveillance (Moriyama et al.).

The Presence of gastrostomy tube, nonoperative cardiovascular disease, ICU placement of central venous catheter, duration of central access, receipt of parenteral nutrition, and receipt of blood transfusion were confirmed as risk factors for CLABSI among children in the ICU (Wylie et al.)

The main Issue discussed by the three provided papers.

The three provided papers started their introduction with why CLABSI is an important issue, they all agree that the CLABSI problem should be solved as it is one of the main healthcare-associated infections.

Paper 1 (Elward et al.), Started by trying to determine the attributable cost of nosocomial primary bloodstream infections (BSIs) in PICU patients and found that it would be cost-effective to apply preventative measures to reduce CLABSIs, then Paper 2 (Wylie et al.), Identified risk factors for CLABSI to describe children who might benefit from adjunctive interventions, what they are trying to do is to know what factors increase the risk of getting CLABSI, and they used a statistical approach to estimate the factors, however, in Paper 3 (Parreco et al., "Predicting Central Line-Associated Bloodstream Infections and Mortality Using Supervised Machine Learning"), the researchers are trying to implement machine learning models in order to predict CLABSI before it happens, and they have concluded that the used models (logistic regression, gradient boosted trees, and deep learning) can practically predict CLABSI before it happens which will give an upper edge for the health providers to identify the patients with high probability of developing CLABSI and apply the best practises accordingly.

The three papers kind of build on each other as the first one establish the importance of being able to solve the CLABSI problem and paper 2 identified some of the risk factors that paper 3 (which establishes a ground to solving this problem using ML) can add to their model in the future, we can see that paper 2 used a lot more input variables than paper 3 and including those variables in the models of paper 3 would likely increase the predictability of the ML models as these variables were proven to statistically identify risk factors associated with CLABSI.

"A machine learning model using common features in the electronic medical records can predict the onset of serious infections in children with central venous lines at least 8 h prior to when a clinical team drew a blood culture." (Tabaie et al.)

On the other hand, a study with low statistical power has a lower chance of finding an actual effect, and it is also less likely that a statistically significant result reflects a true effect (Button et al.). With that said, we see that in all the three papers the sample sizes were relatively small due to the difficulty in finding cases and because the outcomes are rare, for example (Blanco et al.) found that for CLABSI, 60 clusters (30 clusters as a control) needs to be included in the Cluster-Randomized Trials (defined Below) in order to get a 30% decrease in daily rates, such large amount of clusters requires collaboration between healthcare providers in sharing data, resources and efforts in order to reach a conclusive causal relation to mitigate CLABSI.

"A cluster randomized trial (CRT) is a trial in which individuals are randomized in groups—the group as a whole is randomized and not the individual. Physicians, group practices, health plans, or even geographic regions (counties or states) can be defined as clusters." - (Harris)

Paper 2 vs. Paper 3 analysis

	Paper 2 (Wylie et al.)	**Paper 3** (Parreco et al.)
Objective	Identify risk factors for central line–associated bloodstream infection (CLABSI) to describe children who might benefit from adjunctive interventions.	Compare machine learning techniques for predicting central line associated bloodstream infection (CLABSI).
Data Source	Active surveillance by the Children's Hospital Boston Infection Prevention and Control Program	The Multiparameter Intelligent Monitoring in Intensive Care III database
Hospital	Children's Hospital Boston	Beth Israel Deaconess Medical Center from 2001 to 2012
Population	Patients admitted to the medical-surgical ICU or cardiac ICU from January 1, 2004, through December 31, 2007, who had a CVC and who developed a CLABSI	All hospital (Beth Israel Deaconess Medical Center) admissions
Model	Multivariate conditional logistic regression models	1. Logistic regression 2. Gradient boosted trees 3. Deep learning
Outcome	Risk Factors	1. In-hospital mortality 2. central line placement 3. CLABSI
Similar Features Used	• Age • Vital signs and laboratory values Medical History	• Age • Vital signs and laboratory values Medical History

Different Features Used	• Admission date • Weight • Characteristics of illness PRISM III score • Interventions during Admission • CVC characteristics • Type of CVC • Placement site • Location of CVC placement	None
Results	Risk factors for preventing CLABSI	Prediction of : • In-hospital mortality • Central line placement • CLABSI

Paper 2 used more features because the papers have different objectives, while paper 2 is trying to predict the risk factors that lead to CLABSI, paper 3 is trying to predict if CLABSI will happen.

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