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Developing Information Model of Central Line-Associated Bloodstream Infection (CLABSI) Prevention

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Abstract. CLABSIs are one of the most lethal and costly types of healthcare associated infections (HAIs). Regulatory organizations have mandated hospitals to submit monthly surveillance reports. However, there is an inaccuracy of presenting this report because of the lack of data standardization. This descriptive qualitative study aimed to develop a CLABSI prevention Information Model (IM) so the CLABSI prevention guidelines can be incorporated into structured nursing documentations. The flowsheet metadata stored in the Clinical Decision Repository was analyzed using an advanced analytics tool. The CLABSI prevention flowsheet data were mapped to 25 concepts, 45 data attributes and over 200 data value sets after organizing hierarchical structures. Seven domains of CLABSI prevention were identified in a CLABSI prevention IM. It would provide tangible benefits to create a practice reminder of the high risk for CLABSIs based on the nursing flowsheet data sets and multidisciplinary Electronic Health Record (EHR).

Keywords. Central-line associated blood stream infection, information model, concept mapping

1. Introduction

CLABSI is defined as "*a laboratory confirmed bloodstream infection where an eligible bloodstream infection organism is identified and an eligible central line is present on the date of event or the day before*" [1]. Although preventable, CLABSI is one of the deadliest types of HAIs, with a mortality rate of 12% to 25% [2,3]. By increasing adherence to recommended practices, data monitoring and feedback, and collaborative prevention efforts, there was an approximately 50% reduction in CLABSI rates between 2008 and 2014 in acute hospitals [3]. Yet, CLABSI is causing thousands of deaths in America every year, prolonged hospital stays and billions of dollars in hospital costs [1,4]. To prevent CLABSIs, multiple government and professional organizations have provided evidence-based practice guidelines, protocols, checklists and toolkits [1,2,4-5]. Therefore, it is critical to implement the knowledge, information, and recommendations into practice at the point of patient care.

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To reduce the rate of CLABSIs, the regulatory organizations mandates hospitals to track CLABSI surveillance, validate data, and submit monthly reports to the National Healthcare Safety Network (NHSN) [6]. However, generating CLABSI reports from various clinical documentations is a tedious and time-consuming process because of the complex rules and data collection methods [1]. One of the challenges is the definition of the CLABSIs and Central Lines (CLs). After analyzing NHSN reports, Bagchi et al. [7] identified an issue with the NHSN data validation and underreported CLABSI rates. The report validation showed low sensitivity (82.9%) as well as a 4.4% pooled error rate. Major reasons for this error indicated misapplication of the CLABSI definitions, missed case finding, and applying clinical or subjective judgement over surveillance definitions [4,7]. Moreover, there is a gap between nursing practice and clinical documentations. Various sources and datasets of clinical documentations are using non-standardized, incomplete, and semi-structured data [8]. As a result, it is difficult to associate nursing interventions with patient outcomes on the CL care.

The purpose of study was to organize complex data-driven flowsheet documentation, mostly semi-structured data. The goal of this project was to investigate how CDC recommended practice guidelines were being incorporated into CLABSI prevention nursing documentation. It will address strategic plans and recommendations for nurses to collect accurate data, to apply evidence-based knowledge into practice and to share the information to reduce CLABSI events and improve patient outcomes.

2. Methods

2.1. Sample and Setting

This project was a retrospective descriptive qualitative study using concept analysis of secondary data. The flowsheet metadata was extracted, stored and analyzed through the University of Minnesota (UMN) Clinical Data Repository (CDR). The CDR includes de-identified patients' flowsheet data between October 2010 and December 2016, generated from a major health care system in Minnesota. The Institutional Review Board (IRB) was exempted for this project as was did not use human subjects. Extracted files include 1.6 billion rows of data, 34,114 unique flowsheet identifiers, flowsheet observation names, display names, types of flowsheet rows and values, lists of value choices, total number of observations, patients and encounters, and the first and last date of flowsheet usages.

2.2. Process

Concept mapping [9] was used to organize concepts. Extracted flowsheet data was analyzed into unique rows, hierarchical terminologies and relationships in a structured way to develop a CLABSI prevention IM. These flowsheet documents were accessed via secured UNM virtual private network, extracted and organized using advanced analytics tools, *FloMap.* From 34,114 flowsheet unique observations (rows), 1,740 were selected, remaining 417 flowsheet rows after excluding irrelevant observations. Additional 242 duplicated rows were removed, leaving 192 flowsheet observations as related to the CLABSI prevention concepts. To include up-to-date flowsheet information as well as frequency of use, a manual search was conducted in the *Sherlook*, an electronic look-up

tool and 50 new rows were added. Finally, 242 flowsheet observations were selected and analyzed (Figure 1).

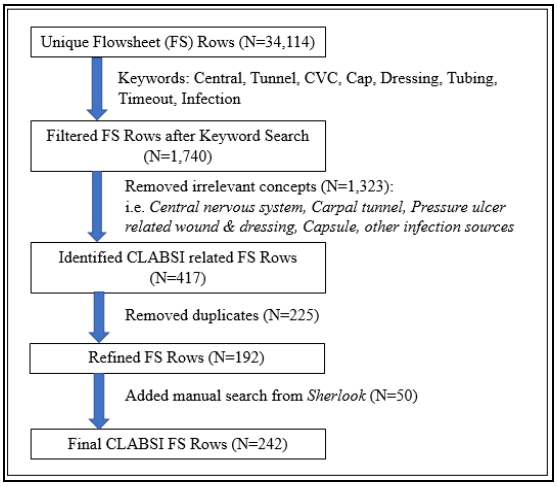

Figure 1. Selection process of the CLABSI Flowsheet Observations.

2.3. Analysis

During analysis, 33 rows were excluded because the flowsheet rows were discontinued before Dec. 2015 and used less than 100 times. Of 209 flowsheet observations, concept mapping and analysis were completed based on definitions and evidence-based literature or CDC guidelines. CLABSI prevention flowsheet data were extracted and mapped to 25 concepts, 45 data attributes and 200 value sets. Final concept mapping table is organized by hierarchical conceptual categories. Each concept was defined and referenced based on the literature review to support the flowsheet data-mapping concepts. A mock-up IM of CLABSI prevention was presented to experts in the IM subgroup of the Nursing Knowledge Big Data Science Conference (NKBDSC). Based on the experts' feedback, the conceptual model was revised and organized in a CLABSI prevention IM. The CLABSI prevention concept mapping, IM and gaps between the clinical documentation and the CDC guidelines were presented to the NKBDSC group to build consensus and validation of CLABSI prevention IM.

3. Results

A gap analysis was performed between flowsheet CDR and the CDC recommended Central Venous Catheter (CVC) insertion and maintenance bundles. Flowsheet CDR data includes only a subset of the CDC's CLABSI precaution guidelines and checklist. The use of full barrier precaution were documented in flowsheet under the procedure timeout section. In the CVC maintenance bundles, most of the protocols and guidelines were identified in the flowsheet data sets. However, similar to the CVC insertion bundles, aseptic technique, health care personnel training and daily review of line necessity were not documented in flowsheet observations. In the IM, any concepts recommended by the

NHSN but not documented in flowsheet data sets were indicated in the white sections, so it can be easily differentiated from the data entries that are available in flowsheet.

Seven domains of CLABSI prevention were identified and the final IM for CLABSI was built (Figure 2).

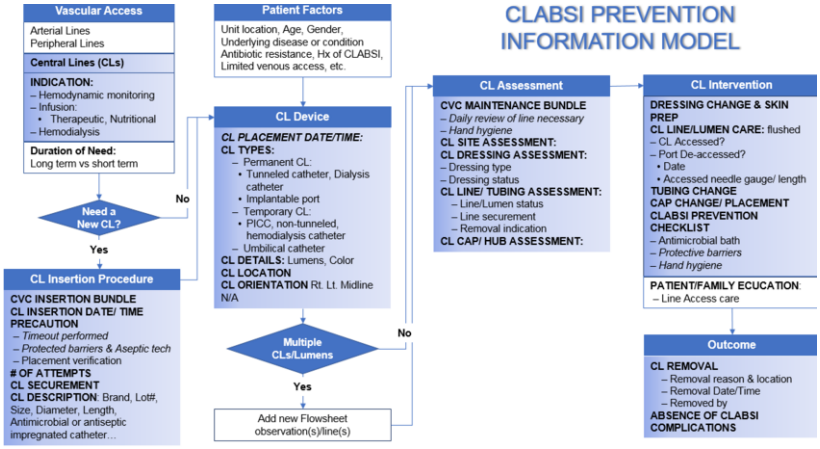

Figure 2. Information model of the CLABSI Prevention.

4. Discussion

In the flowsheet datasets, the CLABSI prevention data entries were mainly recorded in the Lines, Drains and Catheter flowsheets in a specific vendor application. Based on the result of Statewide Health Department validation studies [7], inadequate documentation of CLs in the patient chart is one of the challenges finding CLABSI cases. The CDC mandates strict to adhere the NHSN CLABSI definition without being overruled by clinical judgement. As suggested in the hierarchical IM, *Vascular Access* should consist of peripheral intravenous lines, arterial lines and CLs. This is an efficient method of calculating CL days from retrieved flowsheet data. However, nursing assessment and interventions were documented as a single entity, which makes it difficult distinguish one from another. It is important to standardize definitions of the CLs and associated CLABSI prevention concepts in order to adhere to evidence-based nursing practices and CDC guidelines. The CLABSI prevention IM will allow data analysts to retrieve complex and time-consuming NHSN CLABSI reporting processes efficiently. The CDC guidelines and toolkits on the CLABSI prevention were broader than the IM in the nursing dataset. CLABSI insertion bundles and patient risk factors were indicated in MD procedure notes whereas general infection prevention and patient/ family education were documented in nursing care plans.

Nurses use sophisticated, massive, rich clinical data and information derived from electronic nursing records, to build more precise and predictive knowledge for patient care using the clinical decision support system [10]. When new evidence-based practice guidelines are added, the CLABSI prevention IM data sets can be continuously modified. For example, a nurse-led vascular access preservation program using ultrasound is a new technology for reducing the use of nonessential PICC. Nurses can develop wisdom in a more meaningful way of delivering patient outcomes, safety and cost reduction via

innovative big data technologies such as HAIs including CLABSIs and surgical site infections [10].

Some limitations include generalization of the CLABSI prevention model. The CDR is based on one health system so the concept mapping and IMs need to be validated by other health organizations in other states. Furthermore, data sets can be mapped to coded values such as Logical Observation Identifiers Names and Codes (LOINC) or Systematized Nomenclature of Medicine – Clinical Terms (SNOMED-CT) to achieve interoperability by standardizing and sharing nursing knowledge with other disciplines.

5. Conclusion

It would be beneficial to create a practice reminder of the CLABSI prevention nursing interventions based on the nursing flowsheet data as well as a system generated alert to flag high risk CLABSI patients based on the multidisciplinary EHR. Developing a clinical decision support system from complex EHR documentation will enhance meaningful usage of nursing knowledge and wisdom while reducing the documentation burden on nurses. The CLABSI prevention IM can both identify patients who are vulnerable to CLABSIs and provide a practical nursing intervention strategy. Evidence-based nursing education will ultimately enhance patient outcomes and quality improvement by reducing the presence of CLABSIs, and therefore reduce unnecessary hospital costs associated with preventable CLABSIs in acute settings.

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