Measuring Surgical Site Infections in Children: Comparing Clinical, Electronic, and Administrative Data

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BACKGROUND: Surgical site infections (SSIs) are an important end point and measure of quality of care. Surgical site infections can be identified using clinical registries, electronic surveillance, and administrative claims data. This study compared measurements of SSIs using these 3 different methods and estimated their implication for health care costs.

STUDY DESIGN: Data were obtained from 5,476 surgical patients treated at a single academic children's hospital (January 1, 2010 through August 31, 2014). Surgical site infections within 30 days were identified using a clinical registry in the NSQIP Pediatric, an electronic surveillance method (Nosocomial Infection Marker; MedMined), and billing claims. Infection rates, diagnostic characteristics, and attributable costs were estimated for each of the 3 measures of SSI.

RESULTS: Surgical site infections were observed in 2.24% of patients per NSQIP Pediatric definitions, 0.99% of patients per the Nosocomial Infection Marker, and 2.34% per billing claims definitions. Using NSQIP Pediatric as the clinical reference, Nosocomial Infection Marker had a sensitivity of 31.7% and positive predictive value of 72.2%, and billing claims had a sensitivity of 48.0% and positive predictive value of 46.1% for detection of an SSI. Nosocomial Infection Marker and billing claims overestimated the costs of SSIs by 108% and 41%, respectively.

CONCLUSIONS: There is poor correlation among SSIs measured using electronic surveillance, administrative claims, and clinically derived measures of SSI in the pediatric surgical population. Although these measures might be more convenient, clinically derived data, such as NSQIP Pediatric, may provide a more appropriate quality metric to estimate the postoperative burden of SSIs in children. (J Am Coll Surg 2016;222:823–830. © 2016 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

Clinical outcomes parameters extracted from documentation and administrative data, such as surgical site infections (SSI), are being used as the source of quality metrics for surgeon and hospital performance, as well as understanding health care costs.[1-5] However, for these clinical outcomes parameters to validly assess quality in health care delivery, it is important that they accurately and reliably measure the outcomes of interest. A number of different mechanisms exist to measure SSI, including administrative or billing claims data (derived from ICD-9), active electronic surveillance, and clinical registries.

Each method is characterized by advantages and disadvantages to the quality and nature of data, as well as costs and resource (eg personnel and labor) intensity. For example, ICD-9-based data allow for rapid data mining and are not resource intensive. However, their quality varies considerably based on the quality of documentation and the ability of coders to extract relevant information.[6] Active electronic surveillance systems are typically built around proprietary algorithms based on the electronic

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medical record (EMR) clinical data to flag potential SSI.[7] Finally, clinical registries involve clinician review of patient records with consideration of laboratory studies, imaging, and standardized definitions to assess for the occurrence of outcomes of interest. This source of data is generally considered to be more accurate and reliable, but is more labor intensive, and many require a large financial investment for participation in the registry.[4] Not only do these measures differ in quality, but they also result in different estimates of attributable costs in adults.[8]

Little is known about the measurement and surveillance of SSI in children. The recent emergence of the NSQIP Pediatric allows for the characterization of SSI in clinical registries compared with administrative and electronic methods.[9-11] Our aims were to compare administrative, electronic, and clinical methods for SSI surveillance to understand their implications on estimating rates of infection and assessing attributable costs of SSI in children.

METHODS

This study was reviewed by the Penn State Hershey College of Medicine IRB and determined to be exempt from formal review. Data were collected from our institution's NSQIP Pediatric database to identify pediatric patients who underwent surgery between January 2010 and August 2014. The NSQIP Pediatric was formed in 2005 through a partnership between the American College of Surgeons and American Pediatric Surgical Association.[11,12] Data are prospectively abstracted and collected by a dedicated trained clinical reviewer.[11,12] The NSQIP Pediatric does not include each surgical case performed at an institution, but uses a sampling method whereby cases are selected for inclusion based on CPT codes using an 8-day cycle based of approximately 35 procedures per cycle.[11]

Among the outcomes measures captured in NSQIP Pediatric is the development of an SSI. These are divided in the occurrence of a superficial, deep, or organ-space infection, with criteria based on the definitions outlined by the Centers for Disease Control and Prevention. Superficial SSI is characterized by involvement of the skin or subcutaneous tissue, deep SSI involves muscle or fascial layers, and organ-space SSI involves areas in and around body organs that had become infected. Per NSQIP Pediatric, an SSI can be assigned based on documentation of any of the following: purulent drainage, positive results of wound sample culturing, or diagnosis of SSI by the surgeon. Additionally, superficial SSI can be assigned in the presence of redness, swelling, or tenderness of the incision, and if the surgeon deliberately opened the wound. A deep or organ-space SSI can be assigned if radiologic studies or reoperation identified an abscess or evidence of infection at the fascia, muscle, or organ-space level.[8]

For the patient population captured by NSQIP Pediatric, outcomes measures of SSI were compared with 2 other sources for measuring SSI. The NSQIP Pediatric was linked to our institutions' electronic infection surveillance system, Nosocomial Infection Marker (NIM; MedMined). This system's algorithm uses electronic microbiology laboratory and patient census data in the EMR to identify nosocomial infections and has been validated in previous work.[7,13] Additionally, the data were linked to an administrative measure of SSI by examining patient billing claims data documenting the presence of a postoperative infection (ICD-9 code 998.59). We ensured that markers of SSI via NIM and ICD-9 were extended to 30 days postoperatively to allow for equitable comparisons with NSQIP Pediatric measures. The random sample generated from our institutional NSQIP database was the same patient population evaluated by the 3 assessed methods of SSI detection.

Cost data were obtained from the hospital's cost accounting database and represent fully loaded operating costs. These are estimated using a costs-to-charges ratio (CCR) methodology. This standard accounting technique establishes costs as a percentage of hospital charges to calculate a yearly CCR. The CCR is subsequently applied to the following year's departmental charges to estimate costs. This methodology has previously been validated as an acceptable approach for estimating costs across hospitals.[14] Costs were adjusted for inflation of 2014 US dollars using the medical care component of the Consumer Price Index.

Prevalence of infection using each of the different measures of SSI is estimated. The purpose of our statistical analysis was to compare the diagnostic performance of these different measures using NSQIP Pediatric as a clinical reference. Additionally, we modeled the implications of using different measures of SSI to estimate the attributable costs of SSI for the hospital. Total costs were fitted to a generalized linear regression model. The model assumed a gamma family of distributions and an identity link function. The linear regression model of attributable cost controlled for patient characteristics, including age, sex, race/ethnicity, comorbidity, wound class, and surgical specialty (eg general/thoracic, orthopaedic), and operative year. The estimated cost of SSIs reported is based on the population of patients within the total cohort that each method captured as developing an SSI and, therefore, reflects the variation in cost estimates obtained due to misclassification of disease state (eg postoperative complication). All analyses were performed using STATA