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Major article

Data elements and validation methods used for electronic surveillance of health care-associated infections: A systematic review

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Automated surveillance
Automation/methods
Electronic Health Records

Background: We describe the primary data sources, data elements, and validation methods currently used in electronic surveillance systems (ESS) for identification and surveillance of health care-associated infections (HAIs), and compares these data elements and validation methods with recommended standards.

Methods: Using Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, a PubMed and manual search was conducted to identify research articles describing ESS for identification and surveillance of HAIs published January 1, 2009–August 31, 2014. Selected articles were evaluated to determine what data elements and validation methods were included.

Results: Among the 509 articles identified in the original literature search, 30 met the inclusion criteria. Whereas the majority of studies (83%) used recommended data sources and validated the numerator (80%), only 10% of studies performed external and internal validation. In addition, there was variation in the ESS data formats used.

Conclusions: Our findings suggest that the majority of ESS for HAI surveillance use standard definitions, but the lack of widespread internal data, denominator, and external validation in these systems reduces the reliability of their findings. Additionally, advanced programming skills are required to create, implement, and maintain these systems and to reduce the variability in data formats.

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For the past 3 decades, surveillance has been recognized as the cornerstone of effective infection prevention and control programs,¹ but traditional manual surveillance methods are labor intensive and limited by interobserver variability.² To address these issues, the infection prevention community has pursued the development of automated electronic surveillance systems (ESS). Whereas ESS using electronically available patient data have been found to be accurate and potentially save time,^{3–5} their performance is not consistent across settings.⁶ The performance of ESS often depends on implementation issues related to data sources and data capture.⁷ This review uses an adapted framework⁸ to describe primary data sources, data elements, and validation methods currently used in ESS for the identification and surveillance of health care-associated

infections (HAIs), and compare these data elements and validation methods with recommended standards.

METHODS

Search strategies and information sources

Using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement (<http://www.prisma-statement.org/>) as a guide, we conducted a systematic search of published literature that evaluated ESS for HAIs. The PubMed system was used to search for publications indexed by Medline from January 1, 2009, through August 31, 2014. Manual searches were also performed by scanning the bibliographies of eligible original research papers and systematic reviews.

Eligibility criteria and study selection

Selected articles had to describe an automated system that performed electronic HAI surveillance, relevant data sources used in the system, and any system validation performed. Studies that

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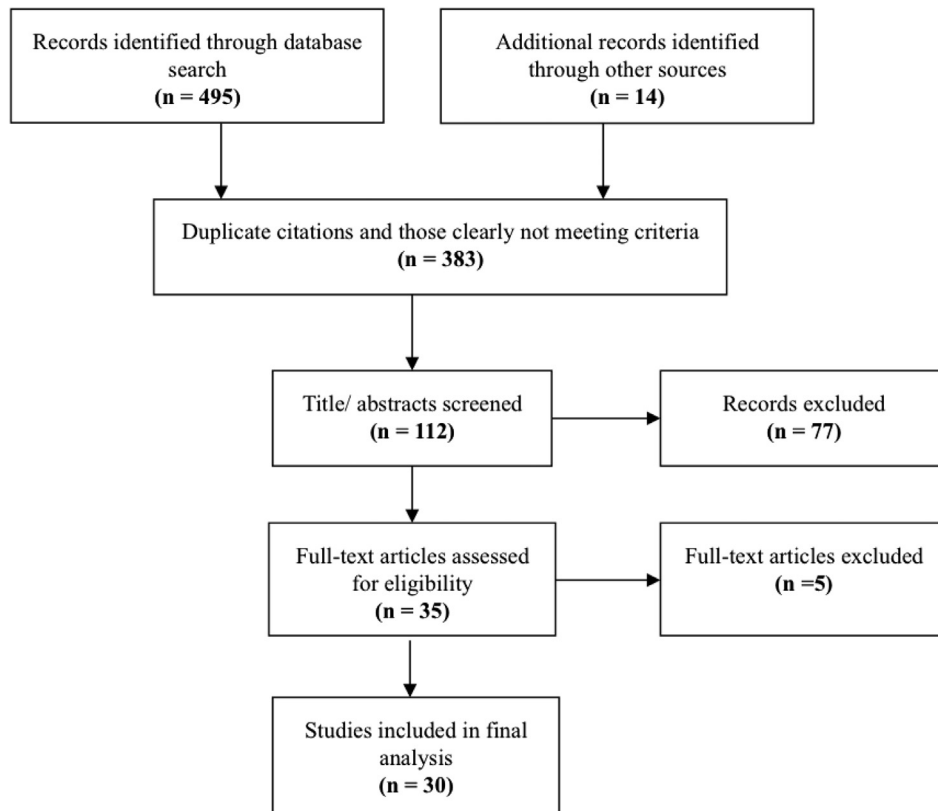
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Conflicts of interest: None to report.

Table 1

Search term used for the PubMed query

Search term
((cross infection [All Fields] OR Algorithms [All Fields] OR automated surveillance [All Fields] OR Automatic Data Processing [All Fields] OR Bacteremia/classification [All Fields] OR Infection Control [All Fields] OR Sentinel Surveillance [All Fields] OR Electronic Surveillance System [All Fields] OR Surgical Wound Infection [All Fields] OR Surgical site infection [All Fields] OR Population Surveillance/methods [All Fields] OR Hospital Information Systems [All Fields] OR Diagnosis, Computer-Assisted [All Fields] OR Data Collection/methods [All Fields] OR hospital acquired infection [All Fields] OR hospital associated infection [All Fields] OR healthcare associated infection [All Fields] OR Fields [All Fields] OR patient to patient infection [All Fields] OR nosocomial infection [All Fields] OR catheter related infection [All Fields] OR CLABSI [All Fields] OR BSI [All Fields] OR Urinary Tract Infections [All Fields] OR central line associated bloodstream infection [All Fields]) AND electronic health record [All Fields] OR EHR [All Fields] OR EMR [All Fields] OR electronic medical record [All Fields] OR computerized medical record [All Fields]) AND 2009/01/01 [PDAT]: 2014/09/01 [PDAT]))

**Fig 1.** Flow chart used to identify articles examining automated health care-associated infection surveillance systems to ultimately select articles for inclusion in our analysis.

used the electronic health record as solely a means for conducting chart review were excluded, as were those that investigated predictive risk modeling for HAI. We used the filters *human*, *abstract*, and *English language* on all searches. [Table 1](#) summarizes the PubMed search query.

Assessment of studies

To ensure articles matched the eligibility criteria, titles and abstracts were evaluated independently by each author and discrepant cases were settled by consensus. Full texts of the remaining articles were then reviewed independently by each author to verify that they met the inclusion criteria. After articles that met the inclusion criteria were identified, they were assessed using a modified framework originally developed by Woeltje et al.⁸ The first 3 articles were independently assessed and then discussed by all 3 authors, and any discrepancies were resolved by consensus. The remaining articles were abstracted by 1 of the 3 authors using an assessment framework.

The assessment framework developed by Woeltje et al.⁸ has 2 main components. First, for each of 5 types of infection, recommended data elements for ESS were outlined based on National Healthcare Safety Network definitions for HAI surveillance (http://www.cdc.gov/nhsn/pdfs/pscmanual/17pscnosinfdef_current.pdf). These included central line-associated bloodstream infection, catheter-associated urinary tract infection, surgical site infection, ventilator-associated event, multidrug-resistant organism module, and *Clostridium difficile* module. We added bloodstream infection, urinary tract infection, ventilator-associated pneumonia, and pneumonia to the list of HAIs because these were also investigated in the articles we reviewed. Second, 4 key concepts for describing data validation were recommended: internal and external validation and validation of numerator and denominator.⁸ Based on this framework, we evaluated each article to determine whether all recommended data elements were included and whether recommended validations were performed. The Woeltje et al.⁸ framework was modified only for surgical site infections, for which it was decided that an ESS would not require both procedure and diagnostic codes because there is considerable overlap between

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