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Electronic Surveillance systems for healthcare-associated infections (HAIs): Prerequisite in healthcare

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Review Article

Electronic Surveillance systems for healthcare-associated infections (HAIs): Prerequisite in healthcare

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Abstract

Abstract:
The surveillance of HAI involves the systematic collation of HAI data, analysis and transformation into information and disseminating to those related who can take necessary action to combat HAI. HAIs pose a major problem today within healthcare. Detecting HAI poses the main challenge in healthcare. In the face of limited resources, surveillance in its traditional format is labour intensive. During the last few decades, healthcare-related infections impose a major burden on healthcare seekers. Conversely, with the use of information technology, substantial efforts have been made to improve the efficacy of HAI surveillance. This review highlights the progress made in the electronic surveillance for HAIs and its importance to limit HAI in healthcare. In summary, E- HAI surveillance has not reached a mature stage, and it is yet to be utilized routinely in most healthcare settings across the world.

Keywords: Electronic surveillance system, healthcare-associated infections, healthcare, quality, infection control, conventional system.

Introduction

Healthcare-associated infections (HAIs) are infections that an individual acquired during the specified period of medical treatment. HAIs are indicators of flaws in health care quality. HAIs have serious consequences, which is affecting the patient, their relatives/family and community altogether. HAI control and prevention can only begin with systematic and sound baseline data. Hence, surveillance of infections has become obligatory in many parts of the world. Active surveillance of infection helps to identify problems and evaluates the effectiveness of infection control activities. The conventional paper-based manual surveillance approach is labour-intensive, cumbersome, time-consuming, and usually insensitive. With advances in the healthcare system, surveillance needs to strengthen. Medical informatics has promoted proficiency by computerizing surveillance activities including compilation, analysis and dissemination of data. E-surveillance is now recognized as a potential driver of quality improvement in healthcare.

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HAI Surveillance through electronic surveillance system:

Electronic HAI detection systems are increasing across healthcare as patient data and health records are electronically available in many healthcare settings. This further allows additional time for specialists to employ on prevention of infection, and less on infection detection.

An effective E-surveillance system is often the outcome of online medical records and different databases like admission, laboratory, clinical, transfer, discharge. The electronic surveillance system monitors and provides real-time data on infection rates which helps to

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organize subsequent preventive activities. Ultimately, it also enables the appropriate utilization of infection control nurses (ICNs), as more time can be dedicated to educating health care professionals and the implementation of innovative interventions to combat infections at healthcare (Mathur, 2014).

A systematic review of literature from January 2001 to December 2011 uncovered the trends in the utilization of electronic patient information by electronic HAI surveillance system and identified significances for system effectiveness. Trend analysis of 26 publications showed that systems utilize multiple data sources. There was limited usage of physician narratives and clinical data. Assessment of system effectiveness demonstrated that, the usage of data from varied sources resulted in greater system sensitivity at the cost of specificity (Bruin, 2014).

A systematic review of publications from 1980 to 2007 in Medline and another bibliographic review compared the efficacy of conventional and electronic methods of surveillance. Of the 24 literatures identified, six conveyed that HAI may be identified utilizing microbiology data with the sensitivity (63% to 91%) and specificity (87% to >99%). The administrative data, including discharge coding and pharmacy databases, had a sensitivity (59% to 96%) and specificity (95% to >99%) was studied in seven studies. A combination of lab and administrative data had overall higher sensitivity (71% to 94%) and lower specificity (47% to >99%). Electronic surveillance showed exceptional efficacy when compared with the traditional methods for HAIs surveillance (Leal, 2008).

A systematic review of 44 literatures (January 2000 and December 2011) which assessed the utility of electronic surveillance system (ESS) for monitoring and detection of HAIs exhibited a linkage of electronic databases for automated monitoring of infections in specific clinical settings was given more stress in the majority of the studies. It was found feasible to implement electronic surveillance in many settings as they were fully integrated into hospital information systems and therefore, suggesting electronic surveillance system development to utilize the existing electronic data sources within the healthcare (Freeman, 2013).

In order to compare the data components and its validation systems with acclaimed standards of HAIs, a systematic review of published literature from 2009 January to 2014 August which describes the ESS for identification of HAIs and surveillance was carried out. The majority (83%) of the literature used data sources that are recommended and validated the numerator (80%). Internal and external validation was executed only in 10% of the studies. Further, due to the lack of extensive internal and denominator data with external validation, in the ESS, the reliability of the finding was decreased. Hence, mandates for advanced programming skills to construct, implement and sustain ESS and to lessen the inconsistency in the data formats (Kenrick & Cato, 2015).

A systematic review of the published literature (January 1972 - September 2012) carried out among 33 selected studies to evaluate, classify and analyse the diagnostic performance, strengths and limitations of ESS systems identified that the performance was fluctuating, with sensitivity (from 21% to 100%) and specificity (from 5% to 100%). The computed positive likelihood ratios were from 1.04 to 929.12, while the negative likelihood ratio was from 0.83 to zero. There was substantial variance in the functioning of the existing ESS in acute care, curtailing due to the variety of diverse clinical entities and ESS systems (Kashiouris, 2013).

Comparison of the conventional system with an electronic system for surveillance of HAIs:

HAIs are a universal issue concerning healthcare and HAI surveillance has developed into an important tool in getting rid of HAI. As requirements for HAI surveillance have increased, less laborious surveillance methods have become necessary. Surveillance is considered as an indispensable segment of an efficient infection control and prevention program. The infection control team and clinicians spend too much time in surveillance and hence lacking time for teaching and quality enhancement actions in healthcare. The electronic surveillance has made a keynote in many of the literatures from several developed countries. The literature indicates that electronic surveillance improves validity, minimizes the time spent on compilation and dissemination of surveillance data, to provide space for improvement in infection prevention activities along with taking prompt actions on matters arising from HAI surveillance. Robust information technology is necessary for the successful implementation of electronic surveillance of HAI (Reilly, 2015).

Table 1:

Comparison of the Conventional System with an Electronic System for Surveillance of HAIs.

Author Year / Study duration	Clinical area/ Setting	Surveillance systems		Sources of Surveillance data		Outcome
Blacky (2011). November 2006 to February 2007	12 adult ICUs / 2,200 bedded Vienna General Hospital (teaching and tertiary care)	Monitoring of nosocomial infections ICUs - MONI-ICU	Trained surveillance staff and attending clinical experts	Automatic access by the data interface between the hospital's information system providing patients' administrative data and laboratory information system (LIS)	Review of patients chart and other prevailing data	**MONI – ICU:** - HAI - 28/31 cases (sensitivity 90.3%) - Non - HAI - 68/68 cases (specificity 100%) - Negative predictive value - 95.7% - Positive predictive value - 100% **Time spent:** *Conventional:* 82.5 hrs. (100%) *MONI – ICU:* 12.5 hrs. (15.2%)
Bruin, (2014) November 13, 2006, and February 7, 2007	2 ICUs / 2135 bedded tertiary care teaching Vienna General Hospital	MONI-ICU	Manual Surveillance by IP	MONI-ICU (gathers data from the Philips CareVue patient data management systems (PDMSs))	Visit to ICU by IP two times a week Discuss with ICU physicians, review patient charts and PDMS data with microbiology and radiology reports.	*Manual Surveillance* / *Electronic Surveillance* *Sensitivity (%)* 40.0 (23.2 – 59.3) / 86.7 (68.4 – 95.6) *Specificity (%)* 93.6 (85.0 – 97.6) / 98.7 (91.9 – 99.9) *PPV (%)* 70.6 (44.0 – 88.6) / 96.3 (79.1 – 99.8) *NPV (%)* 80.2 (70.3 –87.6) / 94.9 (86.9 – 98.4) *Accuracy (%)* 78.7 (69.6 – 85.6) / 95.3 (88.8 – 98.3)
Kaiser (2014) October 2009 to October 2010	24 bedded ICU of V U University Medical Center Amsterdam	Semi -automated Electronic Surveillance System (ESS) (trigger –based)	Semi-automated ESS (without trigger)	Patient data management system (PDMS) with microbiology and chest X-ray with positive trigger signals	Patient data management system (PDMS) with Chest X-rays and culture reports from microbiology	Total number of patients screened - 553. **Trigger-based ESS-** VAP: Incidence 3.3/1000 ventilator days; Sensitivity 92.3%; Specificity 100%; Negative predictive value 99.8% CLABSI: Incidence 1.7/ 1000 central line days; Sensitivity 91.3%; Specificity 100%; Negative predictive value 99.6% The time spent on screening and identification of infection was lowered by 90% (i.e., 4.4 hrs./ week to 26 min/week)
Heather et al., (2015) January 10 to June 30, 2012	8 adult ICUs with 166 beds / Massachusetts General Hospital (MGH) teaching hospital in Boston	Traditional surveillance (TS) Augmented electronic surveillance (AES)	Electronic surveillance (ES) tool Reference standard (RS)	TS - Manual review of register by ICPs AES - ES with review of register on a subset of cases	ES - Multiple hospital databases and further chart review RS- a subset of case is initially established by TS or ES and confirmed by review.	Compared with RS, the sensitivity and specificity of other tools were as follows: Sensitivity / Specificity TS: 43.8% (95% CI, 26.4% -62.3%) / 82.5% (95% CI, 75.3%-88.4%) ES: 100.0% (95% CI, 89.1% -100.0%) / 2.8% (95% CI, 0.8% - 7.0%) AES: 100.0% (95% CI, 89.1%-100.0%) / 100% (95% CI, 97.5% -100.0%)

Author Year / Study duration	Clinical area/ Setting	Surveillance systems		Sources of Surveillance data		Outcome
Heidi et al., (2014) August 2010 to June 2011	25 Non-ICU / Nurses Improving Care for Health System Elders (NICHE) hospitals, US	Electronic Surveillance of CAUTI	Manual	Merging data from electronic systems	Data from infection prevention practitioner	Fully automation was successful at 15 sites electronic health records. It was practicable and sustainable to have centralized electronic surveillance strategy for CAUTI.
Kenrick et al., (2015) 2009 through 2012	Four hospitals in Manhattan, NY	Computer algorithms using Strict National Healthcare Safety Network (NHSN) based SSI algorithm	Computer algorithms for NHSN-defined SSI procedures	Electronic medical record and charting system Clinical data warehouse storing information Clinical laboratory records Admission discharge transfer (ADT) system.		Strict SSI algorithm – classified 27.3% of discharges with a raised indeterminate case. Modified, less strict model- classified 97.2% of discharges.
Phuong (2018) 2013 through 2017	Oxford University Hospitals	Web-based, HCAI Data Capture System (HCAI-DCS) by Infection control (IC) team	Web-based, HCAI Data Capture System (HCAI-DCS) by linked-EHR	HCAI-DCS by IC team	Linked-EHR (automation)	IC team / linked - EHR MRSA: 428 / 432 MSSA: 795 / 816 E. Coli: 2454 / 2450 C. difficile: 3365 / 3393
Puhto (2015) 2011 January to 2013 December	Internal medicine, surgical and haematology-oncology wards / Oulu University Hospital, Finland	The automated electronic incidence surveillance program	Traditional manual review method	Link to all electronic databases in the hospital	Manual review	Sensitivity: both methods were identical. The HAI incident declined from 16.1 [95% CI 15.4-16.9] to 15.4 [95% CI 14.6- 16.1]
Claridge et al., (2009)	Two surgical and trauma ICUs/ Level I trauma center, Ohio	Medical informatics application and Surgical Intensive Care -Infection Registry (SIC-IR)	Prospective and retrospective analysis by trained IC teams	The SIC-IR combined with the laboratory information system, medication administration record and input from a multidisciplinary team	Monitoring of all patients' records with positive microbiology culture results, and daily data examination.	***VAP Rate:*** SIC-IR / IC Incidence: 14.8/1,000 ventilator days / 8.4/1,000 ventilator days Sensitivity: 97% / 56% Specificity: 100% / 99% ***CRBSI -*** No differences were found with the CRBSI rate from both the systems.
Elham et al., (2016) March 2012 to September 2013 (19 months)	NICU with 28 incubators / Kasr Al-Aini Hospital, Faculty of Medicine, Cairo University, Egypt	Personal digital assistants (PDA) based, HP iPad [PDAs and QM software (Questionnaire Mobile) model 210] developed by NAMRU-3	Paper-based Surveillance	Data entry to PDAs NICU nurses	Paper-based case report form by a screening/ case report log book, and denominator sheet.	A total number of neonates enrolled -1,053. Number of suspected episodes of HAIs recorded in PDAs- 124 The overall HAI density – - 7.4/1,000 patient days - 2.72/1000 patient days in the NICU. PDAs detected HAI episodes, save personnel resources and generating fewer false-positive and false negative results.
Sanger et al., (2017) (training set - February 2010 - July 2011) (validation set -August 2011-August 2012)	University of Washington Medical Center	CAUTI surveillance tool	IP's semi-automated manual chart review	EHR - Cerner ORCA EHR, hospital administrative / billing database, microbiology lab system	IP received a monthly report of patients with urinary catheters with positive culture results, and then conducted a manual chart review on these patients	Among semi-automated manual review in 346 urinary catheterized, CAUTI surveillance tool had a sensitivity (97.1%), specificity (94.5%) PPV- 66.7% NPV- 99.6%.

Author Year / Study duration	Clinical area/ Setting	Surveillance systems		Sources of Surveillance data		Outcome
Tseng et al., (2015) July 1, 2010-September 30, 2010 (14-week)	National Taiwan University Hospital (NTUH)	Web-based system, integrated into the medical information system	Conventional ICP based surveillance system	Linked to HIS and LIS data with established rule-based HABSI surveillance	For case identification, ICPs review microbiological data daily and visit inpatient units weekly	HABSI classification system: Sensitivity- 98.16% Specificity- 99.96% PPV- 95.81% NPV - 99.98% Delay in the validation of HABSI cases were declined, on average by 29 days.
Wright et al., (2009) 2002 to 2003	North Shore University Health System, Chicago	Automated device day calculation through electronic medical records.	Medical record review by infection preventionist	Automated system for all the documentations	Review of nursing documentation, radiology dictations, laboratory data, and interdisciplinary team notes.	Automated system *Urinary catheter*: *Sensitivity* 99%, *Specificity* 99%, *PPV* 0.99, *NPV* 0.98 *Ventilator patient days*: 100%, 96%, 0.96, 1.0 *Central venous catheters*: 95%, 98%, 0.99, 0.93
Woeltje et al., (2008) July 1, 2005 – June 30, 2006	Barnes – Jewish Hospital, Saint Louis, Missouri.	Computer algorithms with dichotomous prediction rules for electronic surveillance of CLABSI	Manual surveillance	Combinations of dichotomous prediction rules for CLABSI.	Review of the medical chart, physician summaries, microbiology and pharmacy data of blood culture positive patients in ICU	Algorithm with 2 rules had the highest NPV (99.4%) and the lowest specificity (44.2%). The augmented algorithm had NPV (99.2%) and specificity of 68 %

Several studies have established the performances of manual and electronic HAI surveillance. The following table outline the comparison of manual and electronic surveillance for HAI (Table 1).

Conclusion: The HAI surveillance is critical to any infection control program. It is one of the most important infection control measure. This review emphasizes the importance of active surveillance in healthcare highlighting more on advanced electronic surveillance system to comply for monitoring and controlling HAIs.

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