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Designing and Implementing National Program of Health Electronic Surveillance Network (HESN); Infection Control Module in Saudi Arabia

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Abstract Surveillance of health care associated infections is the keystone of Infection Prevention and Control program in any health care setting. Without a reliable surveillance system, it is difficult to monitor the health care associated infections (device associated as well as non-device associated infections). The Infection Control Practitioners (ICPs) in the Kingdom of Saudi Arabia used to collect the Surveillance data manually almost more than a decade back, and then shifted to an electronic Surveillance System few years back, International Nosocomial Infection Control Consortium (INICC). As conventional manual surveillance requires resources and standardization of definitions. Finally, a national, web based, semi-automated system of Health Electronic Surveillance Network (HESN) was developed in the year 2012, but the Surveillance module of Health care associated infections was started in late 2016. Pilot study was done initially for the period of few months in five MOH Hospitals and later 96 MOH Hospitals were added gradually by the end of year 2019. The system is first of its kind as it covers certain public health modules including surveillance, infectious diseases, immunizations of newborns, needle stick injuries, blood and body fluid exposures and dialysis events surveillance. The data is entered by the Infection control department in HESN, followed by Regional Coordinators and supervised by the office of General Directorate of Infection Prevention and Control. Data validation is done by the internal and external validation teams and surprise audit visits to the hospitals. In addition to advantages of being quick, safe and online data management, there are certain limitations as the system is new for most of the ICPs. Therefore, with the passage of time, almost all the Infection control practitioners will adopt it well.

Keywords: *surveillance, healthcare associated infections, intensive care unit, infection control practitioner*

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1. Introduction

Surveillance of healthcare-associated infections (HAI) is the foundation of infection control and prevention programs in a health care facility. All healthcare associated infections including central line associated blood stream infections (CLABSI), catheter associated urinary tract infections (CAUTI), ventilator associated pneumonia (VAP), ventilator associated events (VAE) and surgical site infections (SSI). These infections may result in a prolonged hospital stay, disability, increased resistance of microorganisms to antimicrobial drugs, increased risk of mortality, a psychosocial impact and an additional financial burden for the health system, for patients and their families. As Public health, reporting includes the data of HAIs, a vigilant and effective surveillance system is mandatory to monitor and control HAIs. Effective surveillance system delivers information that can be used to make decisions by the stakeholders. In general, the use of conventional manual data collection is difficult as it lacks the standardization; it is time-consuming, resource and labor intensive. It usually inhibits the ability of an organization to report, disseminate and validate data, practice changes and continuously measure the impact of these changes on patient outcomes. Sometimes, it results in underestimation, misunderstanding, and misclassification of infections due to person-to-person variability in perceptions of definitions. Recent advance information technology has led to develop some automated Surveillance methodology [1,2].

The manual collection of Surveillance data was started almost more than a decade ago in the Kingdom of Saudi Arabia (KSA). Initially, Intensive Care Unit (ICU) nurses

and ICPs in the Infection Control Department used to collect the data on paper forms. Several sources (History from ICU Physicians, Nurses, and Microbiology Laboratory) were utilized and data was saved on paper forms including medical record number, age, gender, date of admission in the hospital, date of admission in ICU, dates insertion and removal of each of the devices, brief history, signs and symptoms, diagnosis, microbiology results and radiological findings [3].

There was shortage of infection control experts at that time in Saudi Arabia and had no unified national electronic infection control surveillance system. Neither National benchmarking nor valid surveillance data at the hospital, regional or Ministry of Health level were available until 2016. So transferring from manual to electronic data collection was the requirement of time. The Hospitals with at least 100 beds, an ICU, a Microbiology Lab and a full time Microbiologist were included in the study. The data is entered in electronic system by the Infection control practitioners at the hospital, followed by Regional Coordinators and supervised by the Office of General Directorate of Infection Prevention and Control.

1.1. Approaching Electronic Surveillance

Electronic Surveillance System had been evolving rapidly all over the world since more than a decade. The aim of electronic Surveillance is to provide quality improvement programs inside the hospitals to monitor the healthcare associated infections and enhance their control and prevention [4, 5].

Saudi Arabia was using electronic INICC Surveillance System from September 2013 to September 2016.

The surveillance was active, patient-based, prospective targeted surveillance that was done in specific ICUs for specific durations after a local infection risk assessment.

1.2. Implementation of National Health Electronic Surveillance Network (HESN)

The first National Health Electronic Surveillance Network was established in the year 2012 by HESN department in coordination with Institute of Business Management (IBM) in KSA. It was used for Hajj and Umrah preparations by Mass gathering medicine department in official reporting of MERS CoV cases in March 2014 and health care associated infections Module was made operational in the year 2016 [6,7].

It is a web based, semi-automated, comprehensive and flexible, electronic health solution, capable of accommodating national Public Health programs and integrating Public Health information system. It includes all public health aspects, which enables public health professionals to detect, respond, prevent and control diseases in a better way. The rationale was prevention and effective management of communicable, non-communicable diseases and infection prevention and control based on the data registered in the electronic surveillance system [8].

Before that, the definitions, assisting tools and timely reports were not available for data collection as well. There was bias and errors in entering and calculating the rates. Archiving, retrieving data and follow up was also difficult [9].

As the level of coordination and integration of any Surveillance system could easily affect its performance, cost and being tenable with electronic detailed data entry. Infection Preventionists (IPs) can minimize the difference between manual and electronic entries of device days and patient days and find real numbers and rates of infection. [10]

2. Methods

2.1. Hospital Selection

The Ministry of Health Hospitals (MOH) with more than 100 beds, a Microbiology lab with a full time Microbiologist and at least one critical care unit were included. Initially only five hospitals were registered for the pilot study. After the successful implementation, 96 MOH Hospitals were added gradually to HESN making 101 hospitals, by the end of 2019.

The use of an electronic surveillance system has been suggested as more efficient method for quality assurance and the Ministry of Health, KSA along with 67 other countries of the world, temporarily adopted an electronic surveillance system of healthcare associated infections [11]. Before launching HESN, in 2012, an electronic system INICC, (developed by Dr. Victor in Argentine in the year 1998) was being used for Surveillance purposes. From the Kingdom of Saudi Arabia, 29 hospitals in various cities were involved [12].

It was continued for 4 years until the end of year 2016 when a web-based multidisciplinary platform, national Health electronic surveillance network (HESN) was developed by the combined effort of General Directorate of Infection Prevention and Control, Ministry of Health (MOH), Health Electronic Surveillance Network (HESN) Department and Institute of Business Management (IBM) [13,14]. It has replaced the conventional manual data collection of Surveillance. Now all the information is collected and uploaded in the system by the ICPs in included Health Care Facilities. Automated and semi-automated systems enable time saving, consistent application of surveillance definitions and significantly reduce the burden of data management, as earlier the ICPs used to spend most of their time is data collection manually. [15,16].

The infection control module was started in the year 2016, with 5 MOH Hospitals and by the year 2019; it was expanded to almost 101 hospitals of 20 different geographical regions in the Kingdom. The primitive objective of HESN was to describe the epidemiology of HAIs, develop Benchmark and encourage a unified national, electronic Kingdom wide surveillance [17].

2.2. Data Collection and Management

The data were collected and entered by infection control practitioners (ICPs) at respective hospitals, in electronic system after identifying the events based on the definitions. They were informed by the laboratory about any of the positive cultures in the ICUs and they follow

these cases in the respective ICUs. The data were directly entered into the HESN program at two levels; device bundle forms and event forms. The number of device days were counted daily at a fixed time (usually in the morning around 8:00 or 10:00 AM), for all patients with a device. A difference of +/- 5% of the manually collected daily count and electronic count was acceptable for the validation purposes, to avoid the possibility of human error. It has decreased the complexity of work, burden of manual data collection and entries and improved the accuracy. The data is collected at three levels; National, Regional and healthcare facility level. The focus in the first phase is on the Intensive care units of the hospitals only. It was started in 16 different types of ICUs (including all adult, pediatric, neonatal, medical, surgical, trauma, burn, cardiothoracic and cardiac ICUs).

The data collected includes about non-device associated as well as device-associated infections in all the critical care units. Central line associated blood stream infections (CLABSI), Catheter associated urinary tract infections (CAUTI), Ventilator associated Pneumonia (VAP) rates, SSI (Surgical site infections), device utilizations ratios (DUR) for central line, Foley's catheter and ventilator.

The workflow is illustrated in Figure 1, Figure 2 and Figure 3, if the patient is admitted in ICU, transferred from ICU to non-critical unit and if re admitted to the critical unit respectively. It depends on the accuracy and timeliness of data entries and knowledge of ICPs about the definitions of Healthcare-associated infections [18,19].

The reports and dashboards were in the form of Data quality tables, ICU admissions, infection (events) rates, devices descriptive information, daily and monthly device reports, device bundle compliance, antibiograms, dialysis events information, national and international benchmarking, as depicted in Table 1 were added in the system.

Study objectives and key outcome measures are illustrated in Table 2.

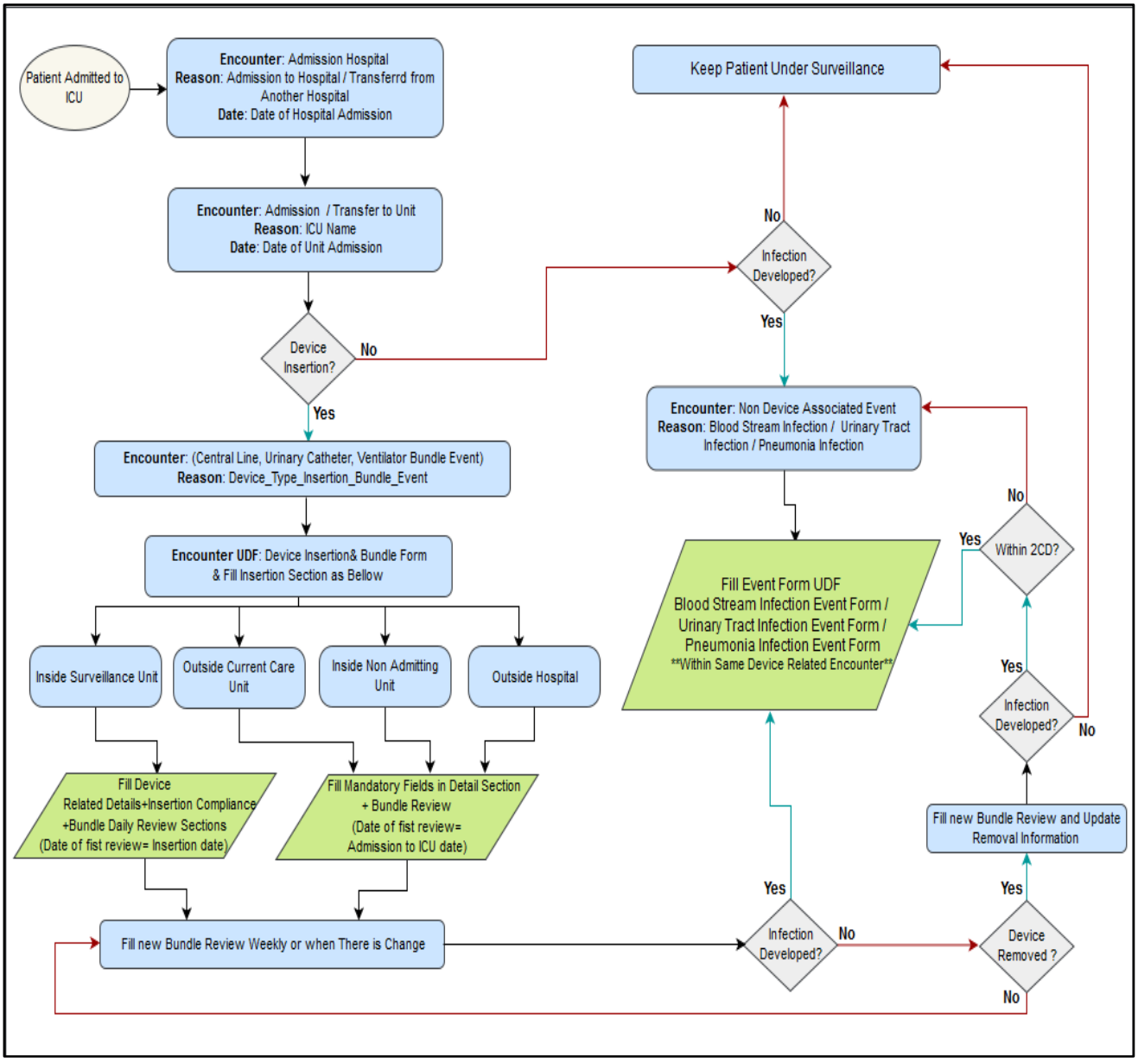

Figure 1. Algorithm for Health Care Associated Infections Surveillance in ICU; Intensive Care Unit (CD: Calendar day; a full day beginning and ending at 12 midnight, ICU: Intensive Care Unit, UDF: User defined function/form)

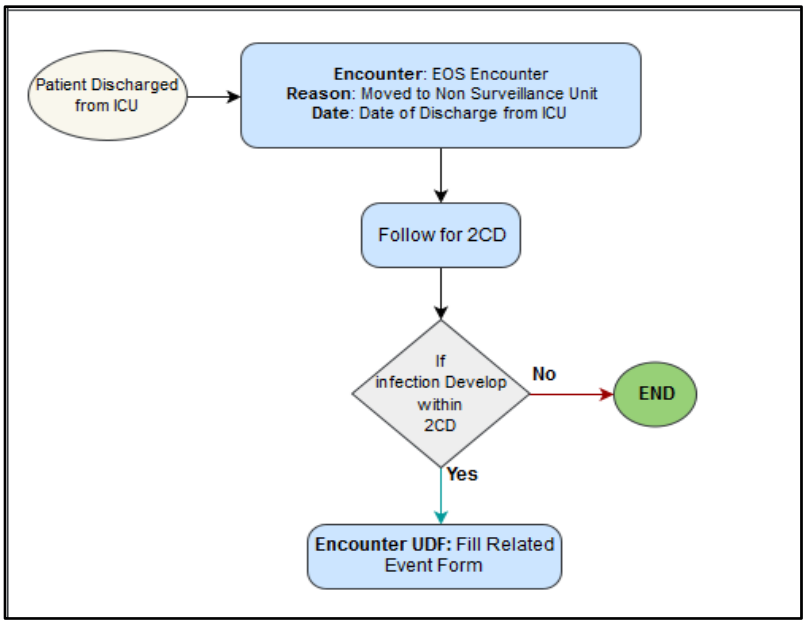

Figure 2. In case, the patient is transferred from an ICU to Non-ICU (Non-Surveillance Unit) (CD: Calendar day; a full day beginning and ending at 12 midnight. ICU: Intensive Care Unit. Non-ICU: Non Intensive Care Unit.)

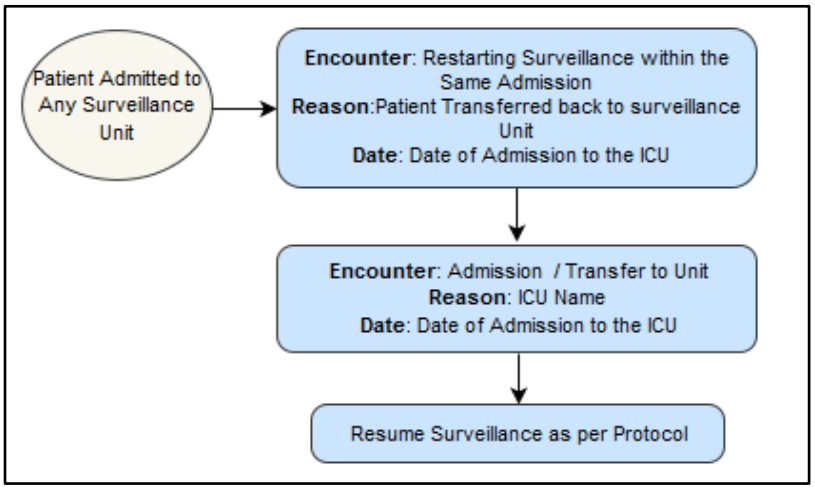

Figure 3. In case the patient is, re admitted to any ICU (Surveillance Unit)

Table 1. Available Reports and Dashboards of Infection Control Module in HESN.

Available Report	Detail
Data Quality	Data Quality Tables; Central line, Foley's Catheter, Ventilator
	SSI Data Quality
ICU Admissions	Patient under Surveillance
Device & Non device associated Infections	Device associated Event Reports; CLABSI, CAUTI, VAP
	Non-Device associated Events Reports; BSI, UTI, Pneumonia
Device & Denominator Reports	Device Reports; Central line, Foley's Catheter, Ventilator
	Denominator Report; Patient days, Device days
Bundle Compliance	Devices Overall Bundle Compliance; Central line, Foley's Catheter, Ventilator
	SSI Bundle Compliance
SSI	SSI Report
	SSI Event Report
Susceptibility Pattern of Pathogens	Antibiogram
Blood & Body fluids exposure	Needle Stick & Sharp Injuries
Dialysis Module	Dialysis Denominator Report; Patient months.
	Dialysis Event Report
Benchmark	National Benchmark
	International Benchmark

CLABSI: Central line associated bloodstream infection; CAUTI: Catheter associated urinary tract infection; HESN: Health Electronic Surveillance Network; SSI: Surgical site infection; VAP: Ventilator associated pneumonia

Table 2. Objectives and Key outcome measures

Objective	Outcome measure
To estimate the rate of HAIs among all of critical care units in MOH Hospitals of KSA	Total number of patients classified as having a HAI. • Device associated HAIs (CLABSI, CAUTI, VAP) • Non-device associated Infections (BSI, UTI, Pneumonia) • Hospital Acquired • Community Acquired
To describe the HAIs by the site, type of patient, type of ICU, geographical region	The patients with a HAI • Site of infection • Gender • Age • Type of device • Type of critical care unit • Healthcare facility type
To estimate the rate of Neonatal Infections (CLABSI, VAP)	Per birth weight group of the newborn (in grams) • ≤ 750 • 751-1000 • 1001-1500 • 1501-2500 • >2500
To estimate the rate of Surgical Site Infections	Type of Infection • Superficial • Deep • Organ/Space Type of Surveillance Period • 30 days Surveillance • 90 days Surveillance
Patients under Surveillance	• Length of Hospital stay • Length of ICU stay • Type of infection
Patients with devices	• Types of devices • Duration of device insertion • Types of HAIs associated with devices • Microorganism associated with devices
Patients with multi drug resistant organisms	• Type of MDRO • Gram positive bacteria • Gram negative bacteria • Infection or colonization • Healthcare onset or Community onset
Dialysis Event	• Type of vascular Access (Fistula, Graft, Central line) • Positive blood culture • IV Antimicrobial start • Pus, redness and swelling
Antimicrobial Sensitivity	• Sensitive • Resistant • Intermediate
Care Bundle Compliance	• Central line • Foley's Catheter • Ventilator • SSI Bundle

BSI: Blood stream infection; CLABSI: Central line associated bloodstream infection; CAUTI: Catheter associated urinary tract infection; SSI: Surgical site infection; UTI: Urinary tract infection; VAP: Ventilator associated pneumonia

2.3. Moving Ahead

Accordingly, a training plan was designed after the surveillance program needs and desired information was assessed (Real-time and automatic data). Training of infection control practitioners from each hospital involved in IC-HESN was started.

HESN training manual, PowerPoint Presentations, case scenarios, and training schedules were designed and finalized. Twenty training workshops were conducted and more than 200 infection control practitioners and more than 20 Regional Coordinators were trained. The workshops were conducted for 3 days each using a training HESN system that does not affect the real data. The training included both hospital Infection Control Practitioners as surveillance data collectors and regional Coordinators as trainers and validators. Training was about an introduction to Healthcare associated infections surveillance, based on CDC-NHSN definitions 2016 for central line-associated bloodstream infections (CLABSI), catheter-associated urinary tract infections (CAUTI) and surgical site infections (SSI). CDC-NHSN guidelines for 2013 for ventilator-associated pneumonia (VAP) were followed [20,21]. Bundles of care (Central line, Foley's catheter, Ventilator, and Surgical site infection) were started according to Institute for Healthcare Improvement (IHI) guidelines [22,23].

Introduction to health electronic surveillance network (HESN), case scenarios, and practical data entry sessions with the training usernames, basic calculation of rates and ratios and open discussions was done. After training, a period of data entry in the training module was allowed before actual real-time data entry in HESN system. Their performance was monitored for a period of 3 months and retraining was conducted for those who had shown inefficient performance.

2.4. Implementation of the Surveillance Module in HESN

In the beginning, CLABSI, CAUTI, SSI determinations were established on the CDC/NHSN definitions of 2016 and VAP according to CDC 2013 guidelines [21,22,24,25]. Surveillance Manual, as well as paper forms were prepared to facilitate the data entry in the system according to IHI and Ministry of Health in Saudi Arabia (MOH) guidelines. Certain assisting tools were embedded in the system to assist the ICPs in their data entry, demographic information; risk factors of clinical data were collected from medical records and direct observation of the patients. User-defined forms (UDFs), device and event reports were created on the HESN production website (different from the initial HESN Training site). Dashboards (HESN Web Portal) were created to facilitate the generation of surveillance reports that included benchmark with national and CDC/NHSN (International) values, tables, charts, graphs, pie diagrams and bar graphs at three levels (Hospital level, Regional directorate level and General Directorate, Ministry of health level). Data quality check tables were designed as tools to assist ICPs in identifying and diagnosing healthcare-associated infections accurately and validating entered data. It has helped to reduce the bias and errors. In addition, data quality tables are available for users at all levels to check their data. Automatic calculation of healthcare-associated infection, rates and device utilization ratios were done in a timely manner. There is consistency in data collection and application of HAI definitions and prevents any subjective influences that may occur at a hospital level [26,27].

2.5. Data Validation

Surveillance Validation Tool (SVT) was created to validate the collected data in HESN; comparison was done for numerators and denominators, by internal and external validation method. Internal validation was done by the Infection Control Department by visiting the ICUs. Manual and electronic data were compared on daily and weekly basis. A difference of +/- 5% of the manually collected daily count and electronic count was acceptable for the validation purposes, to avoid any human error. Validation team was separate from the original data collection team and they cross check the data. Data was assessed for its completeness, validity and accuracy. The purpose of validation was to assure high quality surveillance data by identifying the health care associated infections timely and act accordingly to prevent them. External validation was done by Regional Coordinators in the Regions monthly and Surveillance GDIPC Team at the General Directorate by surprise visits and audits [28,41].

2.6. Statistical Analysis

The data from all regions was extracted from HESN program and analyzed using SPSS. Data extraction, management, analysis and interpretations were done centrally at the GDIPC. Event rates (expressed per 1,000 device days) and device utilization ratios were calculated. Confidence intervals (CIs) and standard percentiles were calculated for both event rates and device utilization ratios. Percentiles were not calculated for ICU types with less than 20 data points (hospital year of surveillance). To benchmark current event rates and device utilization ratios with international benchmarks, standardized infection ratios (SIR) and standardized utilization ratio (SUR) were calculated (respectively) after adjusting for differences in ICU types (all ICUs). SIR and SUR were calculated by dividing the number of observed events and device days (respectively) by their expected values. The expected values were calculated using the published reports of NHSN [20,21], GCC [29,34,35,36] and International Nosocomial Infection Control Consortium (INICC) [12]. P-value <0.05 was considered as significant. SPSS software (release 25.0, Armonk, NY: IBM Corp) was used for all statistical analyses [41].

2.7. Data Dissemination

All the collected data is available to the Stakeholders as well as Critical care units, Infection Control departments, Hospital administration immediately. The confidentiality of the data is maintained as the facility data is available to the ICP and Hospital administration only, Regional data is available to the ICPs and Regional Coordinator only and complete access is available to the office of General Directorate of Infection Prevention Control. Accordingly, the action plans are developed and followed.

3. Discussion

3.1. Benchmarking

Benchmarking of HAI is the process of comparing the surveillance outcomes on well-defined definitions and procedures in one healthcare facility to other healthcare facilities performing similar types of procedures [29].

HAIs benchmarking can be divided into internal and external. Internal benchmarking typically involves comparing current processes and/or outcomes to baseline data or comparing different departments in the same healthcare facility. External benchmarking, on the other hand, usually involves comparing processes and/or outcomes in one healthcare facility to other facilities performing similar activities, often with higher standards. Benchmarks are typically public reports that apply a standard methodology and estimate risk-stratified or risk-adjusted HAIs and/or their preventive processes across a large network of healthcare facilities [30].

Internal and External Benchmarking were available in the Dashboards.

3.2. National Healthcare Safety Network (NHSN)

NHSN is an internet-based surveillance system at the US Center for Disease Control and Prevention (CDC), established in 2005 for the integration and the replacement of three different surveillance systems at the CDC. It is the most important and well-established surveillance system worldwide. One of its main stated purposes is to provide enrolled facilities with risk-adjusted metrics that can be used for inter-facility comparisons as well as local quality improvement activities. Starting from 2007, NHSN published a yearly report to estimate the magnitude of HAIs, mainly in regards to risk-stratified pooled means and percentiles of device-associated and procedure-associated HAIs. Data of NHSN reports is preferred "because the case definitions and methodologies are similar and differences in HAIs rates will likely encourage improvements [31].

3.3. International Nosocomial Infection Control Consortium (INICC)

The INICC is an international collaborative HAI surveillance system that uses a methodology largely similar to that of the NHSN, founded in Argentina in the year 1998. 36 countries in South America, Asia, Africa, and Europe were covered in 2009. The Kingdom adopted this system for a period of 4 years as a trial involving 29 Hospitals in different cities [32]. Actually, it was not the national system of the Kingdom. ICPs used to identify the HAIs in this system while HESN is the first national electronic system and the HAIs could be identified automatically once they have entered the data.

3.4. Gulf Cooperation Council (GCC)

GCC Center for Infection Control has set a standard surveillance methodology for GCC countries. Methodology almost similar to NHSN was adopted with aims (a) publishing surveillance manual and (b) unique data collection forms [33].

The activities of the GCC Center for Infection Control have recently been crowned with the first official regional (Gulf Countries) HAI benchmarking reports on ventilator-associated pneumonia (VAP), catheter-associated urinary tract infections (CAUTIs) and central line-associated bloodstream infections (CLABSI) [34,35,36].

Current reports of GCC countries point to the huge potential for improving HAI surveillance and prevention in the region. Such improvement depends on the collaborative efforts and data sharing.

3.5. Surveillance System Comparison

Since its start, HESN has become the operational healthcare-associated infections (HAIs) surveillance system almost 101 MOH hospitals of Saudi Arabia replacing the previously used manual and electronic systems (like INICC). Both HESN and INICC used the same definitions and methodologies of CDC/NHSN for surveillance of healthcare-associated infections. However, there are differences between the two systems. INICC collects and analyzes the data of healthcare-associated infections (HAIs) at an international level on a voluntary basis by a number of hospitals, in many countries. It does not provide the data quality tables, no bundle compliance and no contact information of the responsible ICP. HESN, on the other hand, has been established solely for the national HAIs surveillance in the Kingdom of Saudi Arabia and the reporting of infections is mandatory in the healthcare facilities where it is implemented. In addition, data quality tables for central line, Foley's catheter, ventilator, surgical site infections, bundle compliance and contact information of ICP is easily accessible [37].

3.6. Data Quality Improvement

Implementation of HESN was crucial for Surveillance data quality improvement in the hospitals of the Kingdom. Utilizing the data saved by the system, hospitals can prioritize their prevention interventions. As HAIs surveillance activities are gradually expanded to include more patient care areas, collected data becomes more representative to reflect the HAIs of the entire facility. Healthcare facilities can use HESN data to increase prevention efforts by setting priorities and maximizing the use of available resources. In addition to the services that HESN can provide at the level of a healthcare facility, its data could be used at the regional (20 geographical regions of the Kingdom) and national level for identifying the health care associated infections and prioritizing efforts aimed at reducing HAIs and tracking progress over time. Multiple educational and training activities were organized in the participating hospitals to enhance the experience of the infection control staff in surveillance and to assist with data entry and analysis.

Public reporting of HAIs is expected to increase transparency, encourage Healthcare facilities to standardize practices and to facilitate training. It also encourages healthy competitiveness between facilities and increases healthcare and public awareness of HAIs; while at the same time improve patient outcomes.

3.7. Strengths of HESN

This study has a number of strengths. It is based on the well-established CDC guidelines and validated methodology.

HESN is a system of its own type to generate information about HAIs Surveillance. Real-time semi-automated data and recognition are available. Dashboards, device and event reports are available at any time. It is less time consuming than manual/ traditional data entries of Surveillance, reduces the time and efforts of ICPs and has included performance indicators (e.g. completeness and timeliness). An easy comparison is available between NHSN values, national and regional data. As well-trained staff collected the data, it greatly increases the likelihood of consistency in data collection and application of standardized HAI definitions and prevents any subjective influences that may occur at a hospital level. A care bundle compliance rate is available. Contact detail of the ICP who has entered the data is available all the time. The information/ reports generated can be disseminated to higher authorities at any time. Updates clinicians and

public health authorities about the current rates and ratios for immediate action to be taken. A big burden on infection control practitioners has been reduced. A huge amount of patient data is available electronically. The confidentiality of the patient data is maintained strictly. Involvement of multiple departments in the Surveillance system like ICU, (Operation room) OR, pharmacy and (Emergency room) ER at the same time electronically. Accurate and efficient calculations of rates and ratios are available immediately. It is cost saving and user-friendly. Data can be exported to excel very easily. The electronic system once established; its software needs to be updated only. The semi-automated system can be implemented in any hospital with well-trained Infection Control staff and efficient information technology department [38].

3.8. Limitations and Challenges

Data collection is limited to all critical care units only in the first phase. Data from other inpatient units is not collected in the first phase. As it is completely new to all the ICPs in Saudi Arabia, they might take time to understand and follow the electronic system completely. Underreporting of infections has been identified through certain internal and external validation reports. Currently, surveillance activities must be reviewed and gaps in the system should be identified. Although most of the data is reported by HESN still data quality is a big concern. Electronic data entries might be affected by a number of factors like disrupted internet connection, lack of trained and experienced staff, missing data, overcrowding of patients and understaffing. The system needs regular updates. Sometimes the system has missing or duplicated data or error shown in the system. Generally, it is limited by resource constraints and some practical clinical challenges.

An integrated approach of the surveillance system within existing patient record management system is compulsory to address all the above-mentioned issues. It is important that personals involved in surveillance activities trained for their assigned tasks and a need for ongoing in-service training at all levels, through workshops followed by closed supervision in the field.

Complete and continuous evaluation and feedback from the health care professionals is expected to make the system more efficient. Electronic data entry may have multiple advantages over traditional manual systems; studies for reliability and validation of the data are still required.

The basic requirement is to build an interface between hospital administration, critical care units, and laboratories. Limited resources and several local challenges for standardized surveillance are still there to be fixed for example there is a need for more training and certifications, transferring from routine data collection to patient-safety oriented surveillance, emphasizing data validation and encouraging public reporting.

4. Conclusions

Vigilant surveillance system is essential to improve the quality of patient care provided. Measuring the burden of HAIs in improving the infection control practices in the critical care units is important to be integrated to the professional development of clinical staff. The standardized surveillance of HAIs is important to ensure the reliability and quality of the data, so appropriate strategies can be developed to prevent and control infections.

This paper presented a new National web based, semi-automated surveillance system. It helped to decrease the time of HAIs identification and to reduce the number of infections. The output of the system is in the form of different tables, graphs and charts. It has helped the stakeholders and decision makers to make new policies and procedures for surveillance plans [39]. The plan is to expand this electronic system in all hospitals around the Kingdom in the next 5 years and to include the rest of components of infection control surveillance [Ventilator associated Event (VAE), Occupational Health Module, antimicrobial resistance and utilization, and risk-stratified surgical site infections)]. Moreover, all units (inpatient units other than ICUs) in all the MOH hospitals would be added to monitor and reduce the number of all healthcare associated infections [40,41].

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Conflict of Interest

The authors declare that there is no conflict of interest.

Abbreviations

CDC: Center of Disease Control
CLABSI: Central line associated blood stream infection
CAUTI: Cather associated urinary tract infection
GCC: Gulf Cooperation Council
HAI; Healthcare associated infections
HESN: Health Electronic Surveillance Network
ICP: Infection Control Practitioner
ICU: Intensive Care Unit
INICC: International Nosocomial Infection Control Consortium
MOH: Ministry of Health
NHSN: National Healthcare Safety Network
SSI: Surgical Site Infection
VAP: Ventilator associated Pneumonia

References

[1] Van Mourik MSM, Perencevich EN, Gastmeier P, Bonten MJM. *Designing Surveillance of Healthcare-Associated Infections in the Era of Automation and Reporting Mandates.* Clin Infect Dis. 2018 Mar 5; 66 (6): 970-976.

[2] Humayun T, Qureshi A, Al Roweily SF, Carig J, Humayun F. *Efficacy Of Hydrogen Peroxide Fumigation In Improving*

Disinfection Of Hospital Rooms And Reducing The Number Of Microorganisms. J Ayub Med Coll Abbottabad. 2019 Oct-Dec; 31 (Suppl 1) (4):S646-S650. PMID: 31965767.

[3] Saajida Mahomed, Ozayr Mahomed, A. Willem Sturm, Stephen Knight, Prashini Moodley. "*Challenges with Surveillance of Healthcare-Associated Infections in Intensive Care Units in South Africa*". Critical Care Research and Practice, vol. 2017, Article ID 7296317, 7 pages, 2017.

[4] Newgard CD, Zive D, Jui J *et al. Electronic versus manual data processing: evaluating the use of electronic health records in out-of-hospital clinical research.* Acad Emerg Med. 2012; 19 (2): 217-227.

[5] Talaat M, El-Shokry M, El-Kholy J *et al. National surveillance of health care-associated infections in Egypt: Developing a sustainable program in a resource-limited country*. Am J Infect Control. 2016; 44 (11): 1296-1301.

[6] Al-Tawfiq, Jaffar & Memish, Ziad. *Mass gathering medicine: 2014 Hajj and Umra preparation as a leading example.* International Journal of Infectious Diseases. 27.

[7] Alotaibi BM, Yezli S, Bin Saeed AA *et al. Strengthening health security at the Hajj mass gatherings: characteristics of the infectious diseases surveillance systems operational during the 2015 Hajj*. J Travel Med. 2017; 24(3): taw 087.

[8] Saeed AA, Abedi GR, Alzahrani AG, et al. Surveillance and Testing for Middle East Respiratory Syndrome Coronavirus, Saudi Arabia, April 2015-February 2016. *Emerg Infect Dis*. 2017; 23 (4): 682-685.

[9] Alzahrani A, Kujawski SA, Abedi GR, et al. Surveillance and Testing for Middle East Respiratory Syndrome Coronavirus, Saudi Arabia, March 2016-March 2019. Emerging Infectious Diseases. 2020 Jul; 26 (7):1571-1574.

[10] Hernández-Gómez C, Motoa G, Vallejo M *et al. Introduction of software tools for epidemiological surveillance in infection control in Colombia.* Colomb Med (Cali). 2015; 46 (2): 60-65. Published 2015 Jun 30.

[11] Hearn, P., Miliya, T., Seng, S. *et al. Prospective surveillance of healthcare associated infections in a Cambodian pediatric hospital.* Antimicrob Resist Infect Control. 6, 16 (2017).

[12] Rosenthal VD. *International Nosocomial Infection Control Consortium (INICC) resources: INICC multidimensional approach and INICC surveillance online system*. Am J Infect Control. 2016; 44 (6): e 81-e 90.

[13] Hansen, S., Sohr, D., Geffers, C. *et al.* Concordance between European and US case definitions of healthcare-associated infections. *Antimicrob Resist Infect Control.* 1, 28 (2012).

[14] Ferreira, J., Bouzada, M. C. F., de Jesus, L. A., Cortes, M. da C. W., Armond, G. A., Clemente, W. T., … Romanelli, R. M. C. *Evaluation of national health‐care related infection criteria for epidemiological surveillance in neonatology. Jornal de Pediatria, 90(4),* 389-395.

[15] Russo PL, Cheng AC, Richards M, Graves N, Hall L. Healthcare-associated infections in Australia: time for national surveillance. Aust Health Rev. 2015 Feb; 39 (1): 37-43.

[16] Russo PL, Stewardson A, Cheng AC, *et al. Establishing the prevalence of healthcare-associated infections in Australian hospitals: protocol for the Comprehensive Healthcare Associated Infection National Surveillance (CHAINS) study.* BMJ Open 2018; 8: e 024924.

[17] Noaman, AY, Ragab, AHM, Al‐ Abdullah N *et al. Predicting and reducing "hospital‐ acquired infections" using a knowledge-based e-surveillance system*. Expert Systems. 2020; 37: e12402.

[18] Rochefort, C.M., Buckeridge, D.L. & Forster, A.J. Accuracy of using automated methods for detecting adverse events from electronic health record data: a research protocol. *Implementation Sci.* 10, 5 (2015).

[19] Streefkerk H Roel A, Verkooijen Roel PAJ, Bramer Wichor M, Verbrugh Henri A. *Electronically assisted surveillance systems of healthcare-associated infections: a systematic review*. Euro Surveill. 2020; 25(2): pii=1900321.

[20] CDC/NHSN. (2013) *CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting*. Atlanta, GA: CDC; Available at: http://www.cdc.gov/nhsn/. January 2013.

[21] Centers for Disease Control and Prevention (CDC). *CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting.* http://www.cdc.gov/nhsn/. Date: 2016. (Accessed March 3, 2016).

[22] Borgert M, Binnekade J, Paulus F. *et al. A flowchart for building evidence-based care bundles in intensive care: based on a systematic review.* International Journal for Quality in Health Care, Volume 29, Issue 2, April 2017, Pages 163-175.

[23] Tseng YJ, Wu JH, Lin HC, Chen MY, Ping XO, Sun CC, Shang RJ, Sheng WH, Chen YC, Lai F, Chang SC. *A Web-Based, Hospital-Wide Health Care-Associated Bloodstream Infection Surveillance and Classification System: Development and Evaluation.* JMIR Med Inform 2015; 3(3): e31.

[24] Dudeck MA, Weiner LM, Allen-Bridson K *et al. National Healthcare Safety Network (NHSN) report, data summary for 2012, Device-associated module.* Am J Infect Control. 2013; 41 (12): 1148-1166.

[25] Dudeck MA, Edwards JR, Allen-Bridson K, et al. *National Healthcare Safety Network report, data summary for 2013, Device-associated Module.* Am J Infect Control. 2015; 43(3): 206-221.

[26] Woeltje KF, Lin MY, Klompas M *et al. Data requirements for electronic surveillance of healthcare-associated infections*. Infect Control Hosp Epidemiol. 2014; 35 (9):1083-1091.

[27] Arefian H, Hagel S, Fischer D *et al*. (2019) *Estimating extra length of stay due to healthcare-associated infections before and after implementation of a hospital-wide infection control program.* PLoS ONE 14 (5): e0217159.

[28] Cato KD, Cohen B, Larson E. *Data elements and validation methods used for electronic surveillance of health care-associated infections: a systematic review*. Am J Infect Control. 2015; 43 (6): 600-605.

[29] El-Saed A, Balkhy HH. *Setting a benchmark for healthcare-associated infections in gulf cooperation council (GCC) states: achievements and ongoing efforts.* Arch Gen Intern Med. 2018; 2(2): 27-28.

[30] Kołpa, M.; Wałaszek, M.; Różańska *et al. Hospital-Wide Surveillance of Healthcare-Associated Infections as a Source of Information about Specific Hospital Needs. A 5-Year Observation in a Multiprofile Provincial Hospital in the South of Poland*. Int. J. Environ. Res. Public Health 2018, *15*, 1956.

[31] Dudeck MA, Horan TC, Peterson KD *et al. National Healthcare Safety Network report, data summary for 2011, device-associated module.* Am J Infect Control. 2013; 41(4): 286-300.

[32] Al-Abdely HM, Alshehri AD, Rosenthal VD et al. *Prospective multicenter study in intensive care units in five cities from the Kingdom of Saudi Arabia: Impact of the International Nosocomial Infection Control Consortium (INICC) multidimensional approach on rates of central line-associated bloodstream infection.* J Infect Prev. 2017; 18 (1): 25-34.

[33] Balkhy H, El-Saed A. *Health care associated Infections Surveillance Manual. Third Edition. Kingdom of Saudi Arabia, Ministry of National Guards Health Affairs in collaboration with the Gulf Cooperation Council (GCC) Center for Health Control.* Updated January 2018.

[34] Balkhy HH, El-Saed A, Al-Abri SS *et al. Rates of central line-associated bloodstream infection in tertiary care hospitals in 3 Arabian Gulf countries: 6-year surveillance study.* Am J Infect Control. 2017; 45(5): e49-e51.

[35] Al Nasser W, El-Saed A, Al-Jardani A *et al. Rates of catheter-associated urinary tract infection in tertiary care hospitals in 3 Arabian Gulf countries: A 6-year surveillance study*. Am J Infect Control. 2016; 44(12): 1589-1594.

[36] El-Saed A, Al-Jardani A, Althaqafi A *et al. Ventilator-associated pneumonia rates in critical care units in 3 Arabian Gulf countries: A 6-year surveillance study.*-Am J Infect Control. 2016; 44(7): 794-798.

[37] Rosenthal V, Bat-Erdene I, Gupta D. *International Nosocomial Infection Control Consortium (INICC) report, data summary of 45 countries for 2012-2017: Device-associated module.* American Journal of Infection Control, Volume 48, Issue 4, 2020, 423-432, ISSN 0196-6553.

[38] Al Mayahi Z, Alswaidi F, Alzahrani A. *Perception of the Health Surveillance Users on the Health Electronic Surveillance Network (HESN) of Saudi Ministry of Health.* iproc 2018; 4 (1): e10551. URL: https://www.iproc.org/2018/1/e10551.

[39] Noaman, A. Y., Ragab, A. H. M., Al-Abdullah, N., Jamjoom, A., Nadeem, F., & Ali, A. G. (2018). *WMSS: A Web-Based*

Multitiered Surveillance System for Predicting CLABSI. BioMed Research International, 2018, 1-11.

[40] Grota PG, Stone PW, Jordan S, Pogorzelska M, Larson E. Electronic surveillance systems in infection prevention: organizational support, program characteristics, and user satisfaction. Am J Infect Control. 2010 Sep; 38(7): 509-14.

[41] Humayun T, Alshanbari N, Alanazi A *et al*. *Rates of Ventilator Associated Pneumonia in Saudi Ministry of Health Hospitals; A Two-year Multi-Center Study.* American Journal of Infectious Diseases and Microbiology. 2021; 9(1): 25-31.