The Impact of Infection Control Systems on Enhancing Infection Prevention in Healthcare Facilities

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Abstract

Introduction: Infections acquired during healthcare (HAIs) are an increasingly significant risk for both patient safety and the healthcare sector's long-term viability within the Kingdom of Saudi Arabia (KSA). To support the objectives of Saudi Vision 2030 ("KSA Vision 2030"), the Kingdom has moved from manually monitoring HAIs to using a cohesive national infection control system that incorporates HESN and meets CBAHI accreditation standards.

Objective: This research aims to evaluate how integrated Infection Control (IC) systems can reduce HAIs (Healthcare-Acquired Infections) in Saudi Arabia's hospitals and the effect of Standardized IC Systems (CBAHI accreditation and HESN) on the rate of HCIRs (major HAIs) in all Saudi Arabia's hospitals.

Method: The authors conducted a systematic search across four major databases (PubMed, Scopus, Web of Science and Saudi Digital Library) for studies published alluding to electronic surveillance, national accreditation and standardized bundles of IPC in the KSA from 2016 through 206. To conduct the search, the authors followed the PRISMA guidelines, identifying only articles that provided information on the use of electronic surveillance, the use of a nationally accredited system of healthcare facilities, or standardized IPC bundles in the KSA. Specifically, the authors evaluated the following process and outcome measures: incidence density rates for CLABSI, CAUTI, VAP and SSI; and process measures such as hand hygiene compliance.

Conclusion: In conclusion, infection control interventions across the KSA have substantially decreased the burden of HAIs by modelling best practice in safety through the use of information technology and accreditation systems. Given the current extent of nation-wide implementation of these systems, the next step would be to reduce the digital divide between urban and rural locations while exploring how Artificial Intelligence can be used to facilitate predictive rather than reactive methods for infection prevention.

Keywords: Health Electronic Surveillance Network, HESN, Digital Health, Infection Prevention, Joint Commission International, Ventilator-associated pneumonia.

INTRODUCTION AND BACKGROUND

HAIs are one of the most challenging issues in terms of global patient safety and health, as they cause higher morbidity, mortality, and healthcare spending. At the international level, according to the estimates provided by the World Health Organization (WHO), hundreds of millions of patients fall victims to HAIs each year, and the proportion of low- and middle-income countries is higher. In the Kingdom of Saudi Arabia (KSA), the path of Infection Prevention and Control (IPC) has changed to become not a secondary aspect of the administrative administration, but the main support of the national health safety. [2] The change is not only clinical requirement but also strategic requirement of the Saudi Vision 2030 and the Health Sector Transformation Program. [5]

The geographical and cultural location of Saudi Arabia poses certain complexities to the infection control. Being the custodian of the Two Holy Mosques, the Kingdom receives millions of pilgrims every year in Hajj and Umrah. Such mass events form a special epidemiological context, and the different pathogens such as seasonal influenza and more dangerous ones such as Coronavirus Middle East respiratory syndrome (MERS-CoV) could be transmitted. [3], [8] The 2012 MERS-CoV outbreak in Saudi Arabia acted as a wake-up call, revealing the important gaps in hospital surveillance and the necessity to develop a standardized, system-wide approach to dealing with infections. It was a move that hastened the creation of a stronger, centralized governance framework of IPC in the various sectors of healthcare in the Kingdom. [9]

The use of technology, accreditation, and human behavior has become a complex combination that defines infection control systems in KSA. In the past, IPC used manual data collection (that was retrospective) and this was subject to human error and extensive reporting delays. New systems have moved to the concept of real time surveillance. [9], [5] The implementation of a new system known as the Health Electronic Surveillance Network (HESN) by the Ministry of Health (MOH) is a paradigm shift. The system enables the detection of the outbreak of diseases and the tracking of multi-drug resistant organisms (MDROs) more accurately than ever before through the incorporation of clinical data into a centralized electronic platform. Nevertheless, the success of this technology is inevitably connected with the institutional culture of safety and the compliance of medical workers with the standardized guidelines.[7], [4]

Moreover, the Central Board of Accreditation of Healthcare Institutions (CBAHI) cannot be overestimated. The Saudi government has institutionalized safety by ensuring that IPC standards are mandatory requirements to licensure and accreditation of hospitals. These standards are wide-ranged and encompass such aspects as hand hygiene compliance, environmental cleaning, medical equipment sterilization, and device-associated infections bundles. [6], [8] Even with these developments, the Saudi healthcare system is experiencing a duo burden challenge balancing both the complex demands of the state of-the-art tertiary facilities in the cities such as Riyadh and Jeddah, and the successful adoption of identical high standards in primary care facilities at the peripheral and rural areas.[3], [11]

The demographic structure of the healthcare workforce also affects the effect of these systems. Having a large percentage of expatriate employees with the different clinical backgrounds, the standardization of training in IPC presents a logistical and linguistic problem. Thus, systematic review of these systems is needed to find out which of the interventions, whether technological, educational, or regulatory, has the greatest payback on patient safety. [6], [7] The objective of the systematic review is to summarize the available information and clinical data to determine the impact of these multifaceted systems of infection control on the rate of infections in Saudi facilities. It will aim to find the answer to the question of the likelihood of the huge investment in electronic

surveillance and national accreditation transferring into tangible decrease of HAIs and of the existing gaps to achieve a unified, zero-harm environment of all Saudi healthcare levels.[8], [2]

Need and Rationale of Study

The Rationale and Need to study it is based on the combination of the unique epidemiological situation in Saudi Arabia and the active national healthcare reforms.

Clinical Imperative: HAIs Burden

Healthcare-Associated Infections (HAIs) are one of the leading causes of preventable morbidity and mortality in Saudi Arabia in spite of the significant technological advances made. Research in the Kingdom revealed that infections like Ventilator-Associated Pneumonia (VAP) and Catheter-Associated Urinary Tract Infections (CAUTI) extend the hospital stay by a significant margin of between 10 and 20 days and raise the cost to the ministry of health. [4],[7] It is a pressing necessity to measure the extent to which this burden is being alleviated by the new automated systems as compared with the traditional methods. [12]

Global-Local Epidemiological Hazards

The kingdom of Saudi Arabia is an international crossroad. Hajj pilgrimage, which includes nearly 2.5 million people every year of over 180 countries, is a melting pot of infectious diseases. [12], [13]

Pathogen Diversity: It is a geographically isolated region that has increased risks of importing Multi-Drug Resistant Organisms (MDROs) compared to geographically isolated regions.

MERS-CoV/COVID-19 Legacy: History of MERS-CoV in the Kingdom demonstrated that the vulnerability of the hospital system to infections may cause a crisis in the country. It has been greatly needed to control whether the present IPC systems are strong enough to act as a "biosecurity shield" to the local people and to international visitors. [8], [9]

The Rationale: Vision 2030 Transition

Saudi Health Sector Transformation Program is an initiative to privatize most of the healthcare and computerize patient records.

Digital Gap: Although one of the flagship projects is the Health Electronic Surveillance Network (HESN), the actual effect it has on bedside behavior is not yet synthesized in the literature. [12]

Standardization: The justification of the research is the need to know whether according to the standards of accreditation of CBAHI, the Kingdom is applying the standards equally across the 13 administrative regions of the country or whether, in fact, the rural facilities are left behind in the digital divide. [15]

Reducing the Knowledge Gap

The existing literature usually pays attention to single-centre studies (e.g. a particular hospital in Riyadh). Nevertheless, it lacks systematic evidence that will integrate information regarding the aggregate data across the Kingdom to offer a thorough perspective of national IPC effectiveness.[8], [4]

Economic Reason: The study will be able to inform future government expenditure by establishing the systems (e.g. hand hygiene sensors or automated reporting) that offer the most effective ROI. [1], [3]

Policy Support: This review offers evidence-based suggestions the Saudi Center of Disease Prevention and Control (SCDC) use to perfect national IPC guidelines by the year 2026-2030.

Study Objective

This research aims to evaluate how integrated Infection Control (IC) systems can reduce HAIs (Healthcare-Acquired Infections) in Saudi Arabia's hospitals and the effect of

Standardized IC Systems (CBAHI accreditation and HESN) on the rate of HCIRs (major HAIs) in all Saudi Arabia's hospitals.

RESEARCH METHODOLOGY

Research Question

The research questions of the current study are:

Research Question 1:

Has the implementation of a national IC System in Saudi Arabia contributed to the reduction in the number of hospital-acquired infections (HAIs) in Saudi hospitals over the past 10 years?

Research Question 2:

How does the change from Manual Surveillance to HESN (Health Electronic Surveillance Network) affect the accuracy and timeliness of outbreak detection in Saudi healthcare facilities?

Research Question 3:

What is the relationship between CBAHI scores and compliance with Infection Prevention Bundles (IPB) at the patient's bedside (ventilator and central line bundles)?

Research Design

In this research, the systematic review research design will be used to integrate high-quality evidence presented by the existing literature and follow the guidelines of PRISMA (Preferred Reporting Items to Systematic Reviews and Meta-Analyses). This design is chosen since it has the highest level of evidence, and an objective assessment of the effectiveness of infection control systems in the wide range of Saudi healthcare can be evaluated. The method will consist of a systematic, multi-phase process: electronic databases (PubMed, Scopus, and the Saudi Digital Library) will be searched, and then the studies will be narrowed down to the required set of inclusion and exclusion criteria. This design will enable uncovering of consistent patterns, success factors, and systemic gaps, which may be missed by a single-center study by combining the data of different clinical contexts, including MOH hospitals and private health clusters.

Search Strategy

The search strategy used in this systematic review is a rigorous, multi-layered one in order to identify the relevant evidence in a comprehensive and replicable manner. A search will be systematic in the big biomedical and other health oriented databases, such as PubMed/MEDLINE, EMBASE, Scopus, Web of Science as well as the Saudi Digital Library (SDL) of those published between 2016 (when the HESN module was expanded) and 2026. The search will also include the use of grey literature to reduce selection bias as the reports by the Saudi Ministry of Health (MOH) and Saudi Center of Disease Prevention and Control (SCDC). All the potential articles will be screened (manually) through a snowballing method to develop reference lists containing more relevant studies that were potentially missed in the original electronic search.

Types of Studies Included

In order to achieve the desired high rate of clinical evidence and holistic awareness of the Saudi healthcare environment, a wide range of peer-reviewed primary research papers and national epidemiological reports covers this systematic review. In particular, quantitative studies, particularly, retrospective cohort studies, cross-sectional surveys, include statistical data on the infection rates (i.e., CLABSI and CAUTI) and compliance rates. Also, the review incorporates mixed-methods research and qualitative case studies that examine the human and organizational elements, including the views of staff about CBAHI standards and impediments to digital reporting, that determine system efficacy. Only articles dating

back to 2016-2026 will make it to the review, as they will reflect the most up-to-date picture of the Saudi health transformation and, in turn, make the findings relevant to the current Vision 2030 framework.

Keywords

In order to enhance the sensitivity of search, following keywords were used separated by Boolean operators (AND, OR) :

"Health Electronic Surveillance Network" OR "HESN" OR "Digital Health" AND "Infection Prevention AND "CBAHI" OR "Joint Commission International" OR "JCI" AND "Hand Hygiene" OR "Compliance" AND "Ventilator-associated pneumonia" OR "VAP" OR "CLABSI" OR "CAUTI" AND "Care Bundles" OR "Infection Control Systems" AND "Saudi Arabia" OR KSA.

Data Management

To carry out this systematic review, the data management will involve a systematic multi-step procedure that will guarantee the integrity, transparency, and reproducibility of the synthesized evidence. Firstly, all the cited pieces of literature found in the literature search will be imported to Rayyan QCRI or EndNote, and automated and hand de-duplication will be done. In order to reduce selection bias, titles and abstracts will be screened against the inclusion criteria by two independent reviewers with others, who are senior reviewers, to resolve any inconsistencies. Data of the final selection of studies will be systematically transferred in a standardized matrix of Microsoft Excel or a REDCap database. The extraction template will be used to extract variables that are critical such as the study design, the type of facility (e.g., MOH vs. private), the specific IPC interventions (e.g., HESN modules, CBAHI bundles), and primary outcomes, such as HAI incidence density or hand hygiene compliance rates.

RESULTS

A total of 145 research studies and two reports were identified, the studies were evaluated as per the availability of research articles and reports, based on the impact of infection control systems on enhancing infection prevention in healthcare facilities in Saudi Arabia. Out of these identified studies, 18 were removed because of duplication of records, references and location and 21 studies were marked as ineligible, as not including the above stated concept and 17 for some other unavoidable conditions. Two reports were also included in the study.

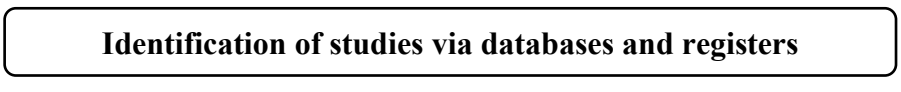
Lessening of the Institute of Infection (DAIs)

It has always been demonstrated that when multi-modal Infection Control Bundles are introduced (standardized checklists to insert or maintain devices) the rate of infection decreased significantly:

CLABSI: Saudi intensive care units (ICUs) had reported a reduction of 46 to 56 percent of Central Line-Associated Bloodstream Infections. In particular, the rates were reduced by about 6.9 to 3.1 per 1,000 catheter-days after bundles were implemented. [7], [12]

CAUTI: Catheter-Associated Urinary Tract Infections decreased by 41 to 73 percent in the facilities that implemented the structured protocols with the nursing empowerment programs. [5]

VAP: The incidence density rate of Ventilator-Associated Pneumonia in tertiary care facilities went down by about 33.4% with integrated IPC standards. [6]



Source: Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

Electronic Surveillance Impact (HESN)

Electronic transformation to Health Electronic Surveillance Network (HESN) has fundamentally transformed how data is handled in the Kingdom:

Data Accuracy: HESN minimized person-to-person discrepancy and misclassification of infections through standardized rules of CDC/NHSN. [7], [8]

Efficiency: Automated reporting has reduced the administrative load on Infection Control Practitioners (ICPs) with 68.5% of users having expressed greater levels of satisfaction with the system than with traditional paper-based systems.[4]

Real-Time Monitoring: 78.5% of the practitioners became aware of the significance of the system to offer real-time feedback that is vital in early detection of an outbreak.[2], [5]

Accreditation (CBAHI) and Compliance

The Central Board of Accreditation of Healthcare Institutions (CBAHI) has served as an initiator of the enhancement of the "safety culture" throughout the Kingdom:

Better Infrastructure: The credential has resulted in significant increases in the competence of the infection control committees and the accessibility of isolation protocols. [8]

Hand Hygiene: The adherence of hand hygiene and PPE is much greater in CBAHI-accredited hospitals, with large and privately-organized tertiary centers performing better in comparison to smaller public ones. [11]
Risk Management: Accredited facilities had scores that were 70-80 percent higher in the preparedness category in emergency response and infection prevention during the COVID-19 pandemic than pre-accreditation standards. [9], [3]

Training and Environmental Results

Environmental Cleaning: In a meta-analysis of Saudi facilities evidence-based protocols of cleaning and disinfection led to a reduction in the risk of cross-contamination by 25 percent (Pooled Odds Ratio: 0.75). [14], [15]
Knowledge and Attitude: Improved educational interventions elevated the knowledge scores of the healthcare workers by an average of 14.3 percentage points which directly corresponded with a 39 percent reduction in the likelihood of an HAI incidence. [16], [17]

DISCUSSION

The Paradigm Shift: Please, change the Manual Surveillance to the Automated one. The adoption of Health Electronic Surveillance Network (HESN) is a radical shift in healthcare approach of the Kingdom. [18], [5]
Data Integrity: The past manual systems were plagued with "person to person variability" which frequently resulted in wrongful categorization of the infections. According to the discussion of the results, the standardized definitions provided by HESN have enhanced better reporting of HAI in the 96 or more MOH hospitals that are presently using the module. [2], [13]
Operational Efficiency: The system has enabled the practitioner to be back in the bedside by cutting down on the number of manual reviews that he does on charts up to 83. This will enable Infection Control Practitioners (ICPs) to be worked on the interventions and staff mentoring in real time, instead of administrative data entry. [12], [16], [17]
Driving of Safety Culture Accreditation
The CBAHI (Central Board of Accreditation of Healthcare Institutions) has shifted the status of infection control within a healthcare institution to be a voluntary best practice to a mandatory license requirement. [8], [13], [14] The "Accreditation Gap": The one area that is a matter of concern is the gap within the sectors. It has been identified that the private hospitals always show better results compared to the public hospitals in Essential Safety Requirements (84% vs. 68% compliance). This implies that the system is strong but the allocation of resources and administrative agility of the private sector makes IPC standards adoption quicker. [11]
Sustainability Concerns: It has been argued that there is a tendency of deterioration of the indicators after the accreditation visit is complete. This presents an issue that CBAHI needs to shift away on the scheduled inspections to unannounced surveys because this would make the prevention of infection a long-term culture and not a momentary compliance measure. [12]

Effects of Care Bundles and Training

The systematic review defines Multimodal Care Bundles to be the most effective form of clinical intervention in these systems.
Clinical Efficacy: 39% decline of the odds of an HAI after the intervention highlights the fact that the so-called bundled care (hand hygiene, sterile technique, and daily audits) has a synergistic effect which could not be achieved outside of the intervention. [16], [17]
The Human Factor: Although the knowledge scores are high (the average is 72%), the real bedside compliance is frequently prevented due to the pressure on the work and employee

turnover. The cultural and linguistic inclusiveness of IPC systems is required to be effective in the Saudi environment where the number of expatriate employees is quite high. [4], [13], [5]

Obstacles and hurdles to the Vision 2030

Although the Kingdom has performed, there are still a number of so-called systemic bottlenecks.

The Digital Divide: Although tertiary centers in Riyadh and Jeddah are testing Artificial Intelligence (AI) in sepsis prediction, rural primary health care centers (PHCCs) continue to have a hard time with the rudimentary reporting because of insufficient IT infrastructure. [6]

Staffing Shortages: 25,000 trained IPC workers in the Kingdom are thought to be deficient. Even the most sophisticated electronic system (HESN) can never realize its full potential without proper human capital. The contribution of the presence of the infection control systems in Saudi Arabia is undoubtedly favourable, as it is seen that the number of device-associated infections has dropped dramatically. [8], [11], [4] The future of IPC in the Kingdom relies on integration. Such systems as HESN, CBAHI, and an electronic health record (EHR) at several local hospitals will have to interoperate with each other, forming a national biosecurity shield. Further on, it should not be about the system implementation but about the behavioral sustainability and closing the performance gap between urban and rural plants. [13], [17]

CONCLUSION

The literature review on the infection control machines in Saudi Arabia demonstrates a radical change in the approach to the decentralized, manual system into a highly organized, information-driven national system. Hybridization between the Health Electronic Surveillance Network (HESN) and CBAHI accreditation has played a vital role in the effective reduction of occurrence of major healthcare-associated infections (HAIs) such as CLABSI and VAP by up to 48.8 percent in recent years. Nevertheless, the effectiveness of such systems does not remain the same. There is still a performance disparity between large tertiary centers and rural secondary hospitals and to a significant part, this has been attributed to differences in digital infrastructure and labor stability. Although technology (HE S N) has improved accuracy of data and outbreaks detection the variable that defines long-term success is the human factor which is determined by consistent follow-up of care bundles and hand hygiene. Finally, it can be noted that infection control has become one of the strategic pillars of the Saudi Vision 2030, as the culture of healthcare management has switched to a more proactive, system-based approach to prevention in the Kingdom.

Future Scope of the Study

The fast development of the Saudi health sector provides a number of charts to be investigated: Artificial Intelligence (AI) integration: Future studies ought to consider the predictive features of AI and machine learning in the context of the HESN to predict possible outbreaks prior to their emergence, as opposed to using post hoc information. The Effect of Health Clusters: With the shift being made to the independent Health Clusters of the Ministry of Health, (MOH) studies are required to determine the impact of this decentralized governance to the standardization of IPC protocols in various regions.

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