

# Automated Surveillance System for Infection Control

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**Abstract**— Most of the health care facilities are having strict policies for controlling the transmission of harmful microorganisms within its premises that include education and awareness, immunization, standard hygiene practices etc. Even after enforcing such stringent policies and guidelines the spread of health care associated infections are common. If such transmissions are not timely identified, monitored and contained then it can lead to widespread outbreaks within the facility further resulting in deterioration of the healthcare standards. But most of the conventional methods used for such surveillance are time consuming and labor expensive. An automated surveillance system will help in yielding better results by providing timely and accurate results which will ensure that the adequate precautionary measures are taken as and when indicated by the system.

**Keywords**—HAI, Infection Control, Automated Surveillance

## I. INTRODUCTION

Nosocomial Infections are commonly used to denote infections that are acquired or contracted from a hospital or healthcare facility [1]. The term Healthcare Associated Infections (HAI) is also used for nosocomial infections. The transmission of such an infection can occur from patient to patient, from patient to staff, from staff to patient or from staff to staff. According to the reports of World Health Organization a huge number of patients are getting affected by such HAIs all over the world which results in high mortality rate and also leads to financial losses for health systems. Of every 100 hospitalized patients at any given time, 7 in developed and 10 in developing countries will acquire at least one health care-associated infection [2]. Such infections can

create many adverse effects such as acquiring a new illness, prolonged hospital stay and may be death. It can also lead to a huge outbreak if not properly contained resulting in further complications. HAIs are one of the leading causes of deaths in the U.S., the fourth leading cause of death in Canada, and cost the industry billions of dollars a year [3]. It is extremely important to maintain a consistent standard of infection control practices at the health care facility. Apart from the conventional techniques used, automated surveillance measures are shown to effectively increase the reliability and quality of the existing practices [4].

## II. BACKGROUND

There will be usually a set of practices that are defined and followed by the healthcare facility in order to minimize the spread of infections within the premises. The infection control department or the Infection control practitioner (ICP) will be responsible for ensuring that the policy guidelines are being followed throughout. The standard practices that are followed are education and awareness, immunization programs and other safety and hygiene measures. The infection control team provides the necessary training to the healthcare personnel especially those who will be in direct contact with the patients. Awareness programs also helps in equipping the personnel with the required knowledge and skills for enabling good infection control practices. The training and awareness programs are conducted periodically so as to include new policies if any and also to assess the quality and effect of the same.

Immunization program for the healthcare personnel is required in order to reduce the risk of acquiring and spreading HAIs. The ICPs need to identify the common HAIs and schedule the immunization program accordingly. It is found

that a good immunization program can substantially reduce the number of healthcare personnel who get affected by the HAIs and thereby further reducing the risk of transmission by them. The ICPs also chart out the set of standard hygiene practices that needs to be followed. The common practices include: hand washing, proper waste management, and usage of safety and protection gear such as masks, gloves, goggles when necessary etc. There are automated techniques with computerized performance indicators for measuring improvement in health care workers adherence to hand hygiene protocols [5]. Health care workers like nurses, support staff, attendants, laboratory personnel and even family members are advised to strictly follow these practices so as to reduce the risk of acquiring an infection.

Even with such strict policies in place, the transmission of HAIs cannot be completely prevented. Therefore it is very essential to constantly monitor the level of presence of such HAIs. Continuous monitoring can ensure that the infections are not spreading beyond a certain limit and if it occurs it will also help in taking the adequate measures as soon as possible. In most of the health care facilities conventional techniques are used for monitoring and surveillance. This includes manually going through the laboratory results and also analyzing and interpreting the results. This needs to be done on a daily basis and in a healthcare facility this task becomes very time consuming and tedious. Also because of human errors accurate and timely results may not become available, which may hinder the process of containing the infection effectively.

Modern hospitals are equipped with state of the art Hospital Information Systems (HIS) that accumulate day to day data within the hospital. This data can be effectively utilized for gaining important information related to various aspects of healthcare. Various analysis techniques can be deployed to extract meaning from the data. For example the average length of stay can be determined from the data available. There are many such practical applications and an automated method for monitoring the infection levels within a hospital facility is one such example.

III. PROPOSAL

Instead of using manual techniques for monitoring, an automated surveillance system for infection control (ASSIC) can be used for the same. This improves the efficiency and accuracy of the surveillance. The system takes input from the laboratory Information Subsystem (LIS) which is a part of the Hospital Information System (HIS). There will be a predefined set of scenarios that can be considered as a potential outbreak. However this can also be configured. When such a scenario is identified by the system it generates an alert to the infection control practitioner (ICP) so that the necessary control measures can be implemented. This system is being developed as interface that can be plugged into the existing HIS so that there is no need for additional data entry into this system.

The alerts can be defined in 3 different categories:

- 1) When a particular infection level (number of patients being affected) over a period of days (which is predefined) goes beyond the allowable threshold.
- 2) When the number of patients identified with a particular infection from a specific location goes beyond the allowable threshold.
- 3) When the number of patients identified with a particular diagnostic code goes beyond the allowable threshold.

These alerts when timely produced will effectively help to contain the spread of an infection and also to spread awareness about the possibility of an outbreak at a specific location also.

The healthcare facility aided with these alerts can be better equipped for handling the situation there by improving the standards.

IV. SYSTEM ARCHITECTURE

The Automated Surveillance System for Infection Control depends on the data obtained from the Hospital Information Systems and Laboratory Information Subsystems. The key inputs required for the system is the laboratory data of every incident being reported in the hospital thereby using and analyzing real time information to give the alerts at the earliest to control any infection being identified.

The architecture of the system given in Figure 1 gives a high level interpretation of the various systems included in the system environment. The main components within the system are: the Data Sources, the Surveillance Engine and the Alert Mechanism.

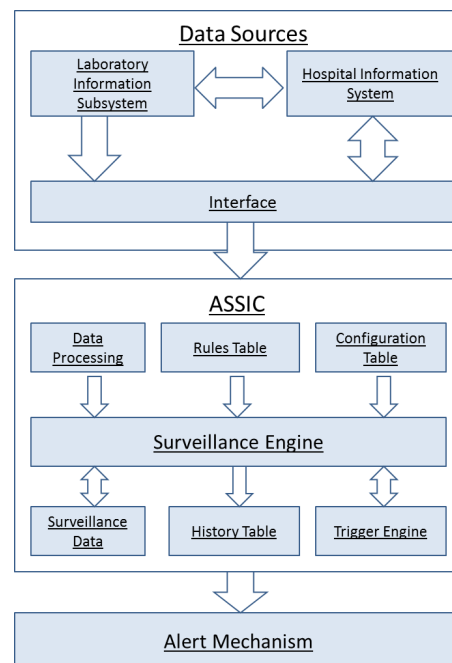


Figure1 . System Architecture

### Data Sources

The availability of timely information is extremely important for the ASSIC system to effectively identify the infective outbreaks and give alerts at the right time to aid the prevention activities. The Hospital Information System (HIS) is expected to have all the patient related information including patient history, treatment & medical history.

#### A) Laboratory Information Subsystem

The Laboratory Information Subsystem (LIS) is the main system that records all procedures and investigations done at the Laboratory. It is expected that every incident reported at the laboratory will have a transaction which records patient id, sample details, investigations done and the results of the investigation. It is also assumed that the LIS is updated on a real time basis. The LIS should integrate with the HIS to send results of the tests done to the patient record to aid the diagnosis and also to be maintained as part of the medical history of the patient.

#### B) Hospital Information System

The HIS should provide necessary patient related information including diagnosis and history, if required. The ASSIC system will report back to HIS incase any flagged result is identified from the results. Possible outbreaks identified by the ASSIC system may have to be reported back to the HIS to flag the patients as having high risk and needs extra care while treatment.

### ASSIC- Automated Surveillance System for Infection Control

ASSIC is the core system for analyzing the data to identify and alert any potential outbreaks.

#### A) Configuration System & Table

The parameters and their threshold values for each incident to be identified as an epidemic are configured in the configuration system. The system has a master set of parameters which covers the entire list of parameters being considered for the infections. The system can be used to create subsets, each representing particular infection criteria with varying parameters and varying values. Each subset shall form the base rule for validating the input received to assess the outbreak. The parameters may include medical investigation parameters, demographic information etc. A selected subsystem based on the ICD codes can also be developed to monitor based on the disease diagnosed.

#### B) Rules Database

Rules are a set of events that identifies an alert scenario. The rules database will have the entire set of criteria developed from the configuration system. The surveillance system depends on the Rules Database to classify the incidents to various categories of outbreak, which shall be consolidated to identify repeat occurrence of the pattern. These rules can be aligned with the norms that are suggested by health care

advisory boards or government regulations. This ensures that the hospital is following the standards set by the respective regulatory bodies. Whenever there is a change in the norms the configuration system will be changed to reflect this and the rules are subsequently updated.

#### C) Data Process

The Data Processing module of the ASSIC system receives the incident data from the input sources (LIS, HIS) and processes the data. The Data Processing engine works as a first line filter classifying the incidents in to different patterns based on the rules set in the rules table. Each incident may get classified into various patterns depending on the rules which could be based on diagnosis, medical investigation parameters, demographics etc.

#### D) Surveillance Engine

The surveillance engine decides if the incidents being analyzed are to be classified as an infection outbreak or not. Each incident being classified and passed on to the surveillance engine is correlated with rules and the surveillance history of the incidents. If the particular incident crosses the threshold number of incidents to be declared as infectious outbreak, necessary directions are given to the alert system. It evaluates all the incidents in the surveillance database, flags the incidents within the interval and send necessary information to classify those patients as infected and recommending further attention and care.

For example, a rule will have the set of microorganisms being analyzed, the allowable threshold or count (number of affected cases), the number of days to be considered etc. If the data satisfies any of the rules criteria, it is being added into the surveillance table.

#### E) Surveillance Data

The single occurrence of any incident may not classify for infection outbreak. The role of the surveillance database is to store every incident in their respective classified conditions to be invoked by the Surveillance Engine to check the number occurrences. It also forms the base set of database to identify the medical records once the infection is identified.

Once an entry is made into the surveillance table a trigger is performed to check for an alert scenario. If an alert scenario is identified, then the Alert Mechanism will be notified. Also the identified alerts will be moved to the history table for future reference.

#### F) History Table

History Table records the details of every infection outbreak identified by the ASSIC System. It serves as a repository of past outbreaks, which can be used retrospectively to identify new patterns or parameters associated with such outbreaks, so as create new set of rules that will aid earlier identification of such outbreaks.

**Trigger Engine & Alert Mechanism**

The alert mechanism decides the various modes to inform the ICP and related departments about the outbreak. The communication channels can be configured. A notification to the Infection control practitioner is sent once the alert system is triggered. Based on the alerts received the ICP will be taking the appropriate measures –notifying the concerned department, steps for containing the infection, improving the hygiene standards, monitoring the situation etc. Also the past history can also be used for analyzing the current situation.

**Process flow**

The flow of the process in the system is as given in Figure 2. The inputs data received from the input sources (HIS, LIS) are fed to the data processing system. The data processing system processes and classifies the incident based on the rules provided from the rules database. The incident with the classifications is given to the surveillance engine which checks for the various parameters to decide whether the incident is an outbreak or not. The inputs of the recent past occurrences are provided from the Surveillance table and the current incident is also added to surveillance table. If the incidents are identified to be an outbreak it is reported to the trigger mechanism which in turn gives the details to the alert mechanism. The details are given to the history table for the future analysis and reference.

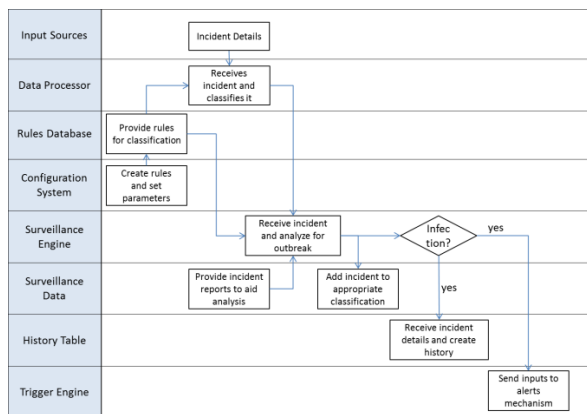


Figure2. Process Flow

**CONCLUSION**

This paper proposes a system for automatic surveillance for infection control in Health Care organizations. The data that is already available within a healthcare facility can be used for extracting useful information which can be very much beneficial. The automated surveillance system proposed in this paper is one such method that effectively utilizes the data that is available and utilizes it for monitoring the infection levels. The system collects the available data from the existing systems to identify any potential infectious outbreak, and alert the organization early enough to handle and bring the infection under control. The data collected by the system may be in future used to create newer data models for identification of infection which may go unnoticed. The system makes the identification and control much faster compared to manual mode of monitoring, and helps avoiding potential risks. The system and data may provide a great deal of further information for medical research. Also it is extremely helpful for medical officers to identify a potential outbreak in a specific location with respect to a particular epidemic and take the required proactive steps. Also data mining techniques can be applied to discover interesting patterns and relationships among the available data which can be used for prediction and classification. This will provide useful insights for the betterment of the available facilities.

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