Strategies to Address Healthcare Associated Infections in India

Master of Public Health Integrating Experience Project

Problem Solving Framework

by

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Executive Summary

Healthcare Associated Infections (HAI), commonly known as nosocomial infections, is a global public health problem. Most frequently occurring HAI are surgical site infection, urinary tract infection, bloodstream infection and hospital acquired pneumonia. It is caused by bacterial, viral and fungal microorganisms. In addition to this, the Multi-Drug Resistant (MDR) or antibiotic resistant strains contribute to the increase in the HAI related mortality and morbidity.

Every year, hundreds of millions of patients are affected worldwide by HAI, and it leads to significant increase in mortality and financial cost for the healthcare system. According to World Health Organization (WHO), no country has yet solved the issue of HAI completely. The burden of this HAI problem is higher in the lower and middle-income countries when compared to high income countries. According to a 2011-2012 point-prevalence survey, the prevalence of HAI (at least one infection) in hospitalized patients was 6.0% in Europe. According to WHO report from 1995-2010, the prevalence rate of HAI was 8.8% and 12.5% in Iran and Turkey, respectively. According to WHO estimates, the annual financial losses in Europe due to HAI's was approximately €7 billion and, in the USA, approximately US$6.5 billion in 2004. For, India an overall HAI rate is not available, but according to a study done in seven cities of India from 2004-2007 ventilator-associated pneumonia (VAP) was 29.6% of all HAI's (10.46 per 1000 device-days) and CAUTI was 9.0% of all HAI's (1.41 per 1000 device-days).

The key risk factors that are related to HAI are "inadequate environmental hygienic conditions, poor infrastructure, insufficient equipment, understaffing, overcrowding, little knowledge and application of basic infection-control measures, prolonged and inappropriate use of invasive devices and antibiotics, lack of local and national policies, low hygiene compliance, and reuse of

equipment (including needles and gloves)." Being admitted in the intensive care unit (ICU) itself serves as a major risk factor for contracting HAI.

The intervention strategies that are used to address this HAI problem are key infection control guidelines and their implementation, education of Healthcare Workers (HCW), use of financial incentives, surveillance, reducing hospital overcrowding and tackling nursing shortage. These strategies were assessed for their strengths and weaknesses based on the following eligibility criteria such as intervention effectiveness, intervention feasibility, financial resources available, intervention sustainability and political feasibility. Based on the priority setting, compliance with the guidelines and education of HCW were found to be most effective in the prevention of HAI.

These chosen strategies, will be implemented through an infection control program in all health facilities. To see the effectiveness of the chosen strategies, a two-staged evaluation will be conducted, observation of HCW and before/after comparison of HAI rates. The observation of HCW will be done to see the HCW compliance with guidelines and then the HAI rates of the health facility will be compared before and after the implementation of the infection control program to see whether the implemented strategies where effective in reducing the HAI.

Introduction

Healthcare Associated Infections (HAI) also known as Nosocomial infections are defined by the World Health Organization (WHO) as "An infection occurring in a patient in a hospital or other health care facility in whom the infection was not present or incubating at the time of admission. This includes infections acquired in the hospital but appearing after discharge, and also occupational infections among staff of the facility".[1] Other authors defined HAI as the infection acquired during receiving a treatment/care for another disease or even after the discharge from the hospitals/ healthcare facility, but not presented before the admission in the care.[2,3]

Frequently encountered HAI are classified based on the infection sites they occur, infection at surgical wound site, urinary tract infection, bloodstream infection and hospital acquired pneumonia.[1,4] The US Center for Disease Control and Prevention (CDC) classifies the HAI types in the following way: "Central Line-Associated Bloodstream Infections (CLABSI), Catheter-Associated Urinary Tract Infection (CAUTI), Ventilator-Associated Pneumonia (VAP) and Surgical Site Infection (SSI)."[5] The pathogens responsible for HAI can be bacterial, viral and fungal microorganisms. There are Multi-Drug Resistant (MDR) strains which have become a major issue and contribute to increasing HAI related mortality and morbidity.[6]

Nosocomial Respiratory Infections or Hospital Acquired Pneumonia

Hospital Acquired Pneumonia (HAP)/ Nosocomial Pneumonia, which is acquired in a hospital setting during the stay in hospitals, is a lower respiratory infection which is not there at the time of admission in the hospital but it should be clinically manifested two or more days after the hospitalization.[7] Nosocomial Pneumonia itself consists of three subcategories: non-intubated

patients' pneumonia, ventilator-associated pneumonia (VAP) and health care–associated pneumonia (HCAP). Where non-intubated patients' means those who did not have intubation but acquired the infection in hospital settings, ventilator-associated pneumonia (VAP) is pneumonia that acquired after 48 hours of insertion of the endotracheal tube and develops among patients who are on ventilators. HCAP includes patients who have been hospitalized within 90 days of the infection; this can happen to patients who receive care other than hospital settings such as nursing residents, those who are residing in a nursing home or long-term care facility; or attended a hemodialysis clinic. HCAP includes VAP and non-intubated patients pneumonia, since most features overlap.[8,9,10] However, in this paper I will use the term Nosocomial Pneumonia.

The most common pathogenic microorganisms for nosocomial pneumonia is Pseudomonas aeruginosa, Staphylococcus aureus and methicillin-resistant S aureus (MRSA), Klebsiella pneumonia, Escherichia coli, Legionella, and Acinetobacter.[7,11]

Catheter-Associated Urinary Tract Infection

According to the CDC, "a urinary tract infection (UTI) is an infection involving any part of the urinary system, including urethra, bladder, ureters, and kidney."[12] One of the common ways to acquire UTI in health care facility is through the use of indwelling catheter. About 70% to 80% of catheter associated UTI (CAUTI) is attributable to the use of indwelling catheter.[13] There are two types of UTIs distinguished according to the UTI definition criteria to identify CAUTI: Symptomatic UTI (SUTI) and Asymptomatic Bacteremic UTI (ABUTI).[14]

According to the US Center for Disease Control and Prevention National Healthcare Safety Network (NHSN), SUTI 1a is a CAUTI; SUTI 1b is a Non-Catheter Associated Urinary Tract Infection (Non-CAUTI).[14]

If a Patient meets the following criteria he/she is to be confirmed as SUTI 1a or CAUTI:

1. "Patient had an indwelling urinary catheter that had been in place for > 2 days on the date of event (day of device placement = Day 1) and was either still present for any portion of the calendar day on the date of event or was removed the day before the date of the event.
2. Patient has at least one of the following signs or symptoms: fever (>38.0°C), suprapubic tenderness, costovertebral angle pain or tenderness, urinary urgency, urinary frequency, and dysuria.
3. Patient has an urine culture with no more than two species of organisms, at least one of which is a bacterium of ≥105 CFU/ml."[14]

If a Patient meets the following criteria he/she is to be confirmed as SUTI 1b or Non-CAUTI:

1. "One of the following is true: a) the patient has/had an indwelling urinary catheter but it has/had not been in place >2 calendar days, or b) the patient did not have a urinary catheter in place on the date of event nor the day before the date of the event.
2. The patient has at least one of the following signs or symptoms: fever (>38°C) in a patient that is ≤ 65 years of age, suprapubic tenderness, costovertebral angle pain or tenderness, urinary frequency, urinary urgency, and dysuria.
3. The patient has a urine culture with no more than two species of organisms, at least one of which is a bacterium of ≥105 CFU/ml."[14]

All elements of the SUTI must occur during the Infection Window Period.[14]

ABUTI is confirmed if the patient meets the following criteria:

1. "The patient with or without an indwelling urinary catheter has no signs or symptoms of SUTI 1 or 2 according to age (Note: Patients > 65 years of age with a non-catheter-associated ABUTI may have a fever and still meet the ABUTI criteria)
2. The patient has an urine culture with no more than two species of organisms, at least one of which is a bacterium of ≥105 CFU/ml.
3. The patient has a positive blood culture with at least one matching bacterium to the urine culture or meets Laboratory-Confirmed Bloodstream Infection (LCBI) criterion 2 (without fever) and matching common commensal(s) in the urine."[14]

All elements of the ABUTI must occur during the Infection Window Period.[14] The most common pathogenic microorganism that causes CAUTI are Staphylococcus aureus (S. aureus), Pseudomonas aeruginosa (P. aeruginosa), Escherichia coli (E. coli) and Klebsiella pneumoniae (K. spp), and Candida albicans (Candida spp).[13,15,16]

Objectives

The main goals of the paper are:

- To identify strategies that can help to reduce the HAI rates in India.
- To provide specific recommendations for addressing this issue in India.
- To develop an evaluation plan for the selected HAI recommendation in India.

Magnitude of the Healthcare Associated Infections

According to WHO, no country has yet solved the issue of HAI completely, moreover in low- and middle-income countries the burden of this problem is higher compared to high income countries.[17,18] Hundreds of millions of patients worldwide are affected by the HAI every year leading to higher mortality.[19] According to systematic literature review conducted by WHO from 1995-2008, high-income countries reported the overall prevalence rate between 5.1% and 11.6% and data on low- and middle-income countries (LMIC) have been scarce; the reported prevalence rate varies between 5% to 19%.[17] According to 2011-2012 point-prevalence survey, the prevalence of HAI (at least one infection) in hospitalized patients was 6.0% in Europe.[20] According to the European Centre for Disease prevention and Control (ECDC) (2010) point prevalence survey study conducted in 23 European countries with a total of 19,888 patients in 66 acute care hospitals reported that overall, 7.1% of patients had at least one type of HAI, with the intensive care departments having the highest rate of 28.1%.[21] According to the ECDC point prevalence survey in (2013) the crude prevalence rate of HAI among residents in long-term care facilities (LTCFs) in Europe was 3.4%.[22]

According to the systematic literature review conducted by WHO from 1995-2010, the prevalence rate of HAI was 8.8% and 12.5% in Iran and Turkey, respectively. The crude excess mortality, which is the difference between the crude mortality of patients with and without HAI during the same time period and among adult patients with HAI in South America, Asia, and Africa was estimated to be 18.5%, 23.6%, and 29.3% (pooled crude excess mortality for 95% CI) for urinary tract infection, blood stream infection and ventilator associated pneumonia, respectively for 2003-2008.[23,24] HAI rates are predominantly high in neonatal and pediatric intensive care units (ICU).[24] These HAI, in addition to the burden of disease, also bring in the

burden of financial costs on the health system such as costs associated with prolonged hospitals stays, long-term disability of the patient due to infections and increase in the resistance to the antimicrobials. According to WHO estimates, the annual financial losses in Europe due to HAI's was approximately €7 billion and in the USA approximately US$ 6.5 billion in 2004.[24]

Situation in India

According to the WHO, the total population of India was 1.3 billion in 2015.[25] According to the Economic Survey 2015-2016, India spends around 1.3% of its Gross Domestic Product (GDP) for health care purposes.[26] Hospital overcrowding is one of the major issues in India and since the healthcare system of the country is inadequate for people, affordability and accessibility remain as important challenges.[27] Similar to other countries, in India the intensive care units (ICU) possess the most threat for acquiring HAI.[11,28,29,30,31] The overall HAI rate was not reported for India, but some studies provided an approximate estimate "an overall rate of 4.4%, and 9.06 HCAIs per 1000 ICU-days."[32] According to the International Nosocomial Infection Control Consortium (INICC) report on device-associated nosocomial infections in intensive care units from seven cities in India the rates were the following: VAP was 29.6% of all HAI's (10.46 per 1000 device-days) and CAUTI was 9.0% of all HAI's (1.41 per 1000 device-days).[32] The excess mortality of patients affected by VAP was 19.0%, 11.6% by CAUTI and 4.0% by CLABSI with the excess length of stay for VAP of 11 days, CAUTI of 8 days and CLABSI of 5 days, respectively.[24] By benchmarking against the regional and international standards the overall HAI rate per 100 patients was 4.4% and was lower than in Thailand (23.1%) and in eight developing countries (14.7%).[32] In case of Surgical Site Infections (SSI) in India, the overall incidence rate ranged from 2% to 21% in 2014.[31] According to a study done in India, the UTI

was the most common type of HAI (71%) in 2013-2015, then CLABSI (19%), VAP (8%), and SSI (2%) and mortality analysis revealed that CLABSI was the reason for the maximum number of deaths "contributing to 27.22% as case fatality rate and 60.12% proportional mortality rate."[33] According to a study published by INICC on SSI rates in India, the SSI rates were higher in India compared with regional and international standards of INICC and CDC-NHSN.[34]

Hospital Infection Society India (HISI) is an association of medical professionals in the field of HAI providing numerous services for prevention and control of the infections.[35] The National Center for Disease Control (NCDC) is an administrative sector under the control of the Director General of Health Services, Ministry of Health and Family Welfare, Government of India pertaining to the communicable disease control of the country.[36]

Key Determinants

Multiple factors account for the development of HAI in patients admitted to hospitals or other healthcare facilities. Most of the factors are common or similar in many countries; but some factors are unique to specific countries or regions.[28,30,37,38,39]

Being in ICU itself serves as one of the major risk factor for acquiring/contracting HAI.[11,37,40] According to a report published on HAI in LMIC, key determinants included: "inadequate environmental hygienic conditions, poor infrastructure, insufficient equipment, understaffing, overcrowding, little knowledge and application of basic infection-control measures, prolonged and inappropriate use of invasive devices and antibiotics, lack of local and national policies, low hygiene compliance, and reuse of equipment (including needles and gloves)."[41]

Hospital overcrowding / high bed occupancy has a greater risk and is significantly associated with the development of HAI and decrease in hand hygiene compliance among the Healthcare Workers (HCW) as there is increase in indication for hand hygiene when there is understaffing and high workload noted among them.[42,43] In addition, according to a study in India on hospital overcrowding, which shows that in India adherence to infection control guidelines is irregular, accreditation of hospitals is not mandatory, and the use of some resources and equipment were different from high income countries.[44] Moreover, this situation is aggravated by inadequate human and financial resources for infection control programs in public hospitals. Which as a result, leads to low nurse to patient ratio that is highly connected to increase in HAI rates and hospital overcrowding.[44,45]

In India, nursing shortage is one of the major issues and the lack of adequate nursing staff has significance in the increase of HAI among patients, since nursing shortage leads to decrease in the nurse to patient ratio, which in turn leads to increase in the workload of the nurses and providing less time for adherence to hand hygiene compliance.[43,46,47,48] A nursing shortage occurs due to the existing imbalance in the supply and demand factors of the healthcare workforce, which includes poor recruitment of nurses, inappropriate use of the available nursing resource, inadequate workforce planning and allocation mechanisms.[49] The causes of nursing shortage in India are due to multiple factors such as poor working conditions, poor salary and incentives, lack of education and career opportunities, social stigma and religious norms, degradation and undervaluation of the profession.[50] There is bigger undersupply or lack of nursing population in rural regions than in the urban regions mainly due to lack of infrastructure, poor career prospective, lack of proper accommodation and living conditions, smaller amount of salary, so nurses prefer to work in urban areas than in rural areas. Moreover, a huge number of

nurses migrate to high income countries (the UK, the US, Australia, New Zealand and Gulf countries) for high salary, good living conditions, better education and career prospective, and professional autonomy.[50,51] In addition to these factors contributing to the shortage of nurses, admission in nursing colleges is increasingly falling in India. Despite the increase in the number of nursing institutions and training facilities in India during the last decade, the increase in the number of vacancy in the nursing positions is because the nursing profession itself has become unattractive to the people in India. As a result, annual supply of nurses is diminishing, which has caused increase in the burden of nursing shortage in India.[48,51,52]

Different countries and regions have different variations of nursing workforce with different level of nursing skills and different service needs to be met. High income countries like the UK and the US have large older age population and technological advances require them to have a more specialized workforce, including nurses, in order to meet the basic geriatric needs; while in LMIC (including countries in Africa and South East Asia region) the nurse to population ratio is even smaller.[49]

According to some studies that evaluated risk factors associated with HAI in India showed that urinary catheterization, length of ICU stay, prior antimicrobial therapy and days of intervention were all found to be potential risk factors associated with HAI.[37,38] Other risk factors include being an immunocompromised individual who is more susceptible to HAI than a non-immunocompromised patient.[53,54] A person with more than eight days of hospital stay is at a risk to get a device-related infection of bladder catheter or mechanically ventilated HAI.[55]

According to other studies, the main risks for HAI were central vascular line, urinary catheter, nasogastric tube, drainage catheter, mechanical ventilation, enteral nutrition, total parenteral nutrition (TPN), major preexisting chronic conditions (such as diabetes, malnutrition, anemia and

renal insufficiency), thoracic surgery, hemodialysis, histamine-2 (H2) receptor antagonist/proton pump inhibitor (PPI) exposure during hospitalization, and prolonged hospitalization for more than 10 days.[56,57]

According to a study done in India, being a female, older age, having a valve surgery, duration of central venous catheter, duration of mechanical ventilation, duration of intra-aortic balloon counter pulsation, duration of urinary catheter, total number of antibiotics used before the resistance developed, duration of antibiotics used before the resistance developed were risk factors related to development of HAI in patients with antibiotic resistance.[6,57,58]

Several factors are similar for both nosocomial pneumonia and CAUTI and a few factors are specific to each infection type. The risk factors that are specific for nosocomial pneumonia are intubation and bronchoscopy in ICU, the number of days the patients are kept on ventilation, reintubation due to failed weaning, use of paralytics, sedative and male gender.[6,54,59]

The risk factors that are specific for CAUTI are prolonged urinary catheterization, insertion of urinary catheter outside the operating room, improper placement of the drainage tube and collecting bag and it is more often found in female patients.[55,60,61]

Prevention/Intervention strategies

Prevention of HAI is a duty of all health care providers. Everyone should be cooperative in the reduction of risk of infection for both patients and staff working in health facilities, including personnel providing direct patient care and the hospital/healthcare facility management.[62] For prevention of HAI, an effective infection control program and policies should be implemented. An infection control program is said to be effective when it restricts and contains the

transmission of infection in both patients and HCW (physicians, nurses, and particularly ICU staff), when it significantly reduces the morbidity and mortality of patients, length of the stay in hospitals and the cost of hospital stay.[63] However, insufficient funding and human resources, hospital overcrowding and low nurse-to-patient ratios are still important challenges for implementing infection prevention and control programs in India.[64]

The following current and possible prevention/intervention strategies that are recommended, most of them are based on the multidimensional approach developed by INICC [65,66,67,68] which is similar for both nosocomial pneumonia and CAUTI.

Current Intervention Strategies

Key infection control guidelines and their implementation

A comprehensive approach is vital to prevent HAIs. HCW practice should be based on the guidelines on proper hand hygiene, appropriate use of antibiotics, and on the prevention of specific HAI's (e.g., guidelines on prevention of nosocomial pneumonia and CAUTI prevention).

The Indian Government (NCDC and Indian Council of Medical Research (ICMR)) has developed guideline for prevention and control of hospital infections.[63,69] Enforcement mechanisms are needed for each health facility in India to implement the existing guidelines. Adherence to hand hygiene guideline is the first step on HAI control in healthcare facilities for HCW, which is based on the WHO recommended five moments for hand hygiene.[63,70] Optimization on the use of antibiotics should be done with regulations such that healthcare facilities should have guidelines on prescription of antibiotics to patients. The guidelines for prevention of antibiotic resistance should include: the appropriate use of antibiotics, by

restricting the unnecessary use of them in healthcare facilities. For those patients who have a potential risk to develop HAI, should be treated by adhering to specific protocols on the use of antibiotics for controlling the HAI.[6,71,72]

Another group of guidelines included under this strategy would be: the positioning and weaning of the patient during mechanical and noninvasive ventilation, the appropriate gastrointestinal care, appropriate oropharyngeal care and appropriate usage of urinary catheter.[67,68,73,74] The above mentioned medical procedures will be implemented according to the guidelines.

Possible Intervention Strategies

Education of Healthcare Workers

For effective implementation of guidelines on infection control, educating the healthcare workers is necessary. Training of healthcare workers should be done periodically by a specialized team consisting of infection control professionals called Infection Control Team (ICT). This ICT will conduct education and training sessions for HCW on hand hygiene, antibiotic resistance, nosocomial pneumonia and CAUTI prevention based on standard guidelines and recommendations. Training sessions should be carried out when all the necessary guidelines are developed and implemented and an instruction manual is prepared.[66]

Use of Financial Incentives

The use of financial incentives will serve as an encouragement for good performers of a healthcare facility. This will be given as a facility's performance-based incentive, which will check for compliance with guidelines and infection control practices. The financial incentives shall be of subsidies and quality improvement payments, these incentives shall be awarded to

facilities which reach a HAI reduction targets and benchmark rates. Non-financial incentive such as 'peer pressure' can also be a motivating factor for the HCW to comply with infection control practices, which will eventually result in better performance of the facility and high reduction in HAI rates. The better performers can publicize their data through public reporting as it shows the quality of service offered by the facility. This will serve as an incentivizing factor for HCW in other facilities to perform better.[75]

The use of financial disincentives such as fines and penalty funds can also be a secondary approach for HCW to comply with the standard guidelines and decrease the HAI rates.[75]

Surveillance

The WHO defines "Public health surveillance is the continuous, systematic collection, analysis and interpretation of health-related data needed for the planning, implementation, and evaluation of public health practice".[76] The surveillance program that will serve as an intervention to control the HAI will include both outcome surveillance and process surveillance. The ICT should organize surveillance efforts at the facility level. Outcome surveillance will monitor the rates of HAIs per 1,000 device days, microorganism profile, antimicrobial resistance, length of stay and mortality rates in the hospital units. The methods and definitions used for the surveillance measurement will be based on the CDC-NHSN.[66,67]

Process surveillance should be done to ensure whether the interventions are carried out consistently and regularly in the patient care. It also assesses and monitors the compliance with hand hygiene and measurable specific infection control practices of HCW that are associated with HAI prevention.[73,74]

ICT will be comprised of an infection control personnel (principle investigator with an internal medicine and epidemiology background) and other infection control professionals including a

medical doctor and a microbiologist in order for conducting surveillance in the healthcare facilities. The surveillance will be conducted by the ICT, and the infection control professionals will be extracting patients' data such as (age, sex, underlying diseases and other variables) from the medical records (including results of laboratory and radiographic tests). The surveillance data collected by the ICT will be used for analyses and reporting. The strategy that could be used for improving the surveillance system can be the use of electronic health records. Integrated healthcare information technology across the healthcare setting could be implemented which will be a system for reporting HAI data on local, state and nation levels.[75]

Additional surveillance activities should include conducting surveillance for nosocomial pneumonia in ICU patients for those who are at high risk for contracting nosocomial pneumonia (patients with mechanically assisted ventilation or selected postoperative patients) to find out outbreaks and control the infection rates, as well other potential infection control problems. The collected data will be used in rates (for example number of infected patients or infections per 100 ICU days or per 1,000 ventilator days) to be helpful for intra-hospital comparisons and the trend determination. This model of conducting surveillance is also suitable for CAUTI in ICU patients; e.g., among patients with urinary catheter and to express the data as infections per 1,000 UC-days.[77]

Monthly, the surveillance forms will be completed and sent to the principle investigator for reviewing accuracy of the recorded data, then the data will be entered into the database and analyzed. The results will be compared with the results of the next consecutive monthly surveillance of HAI in the healthcare facility.[66,68,78]

The ICT will assess and give feedback on the performance of the HCW based on the results that were obtained. The ICT will communicate with the HCW regarding the incidence rates of HAI,

microorganism profile, antimicrobial resistance, length of stay, mortality rates related to HAI, and compliance with the ICT protocol on hand hygiene, HAI preventive measures in infection control practices of process surveillance. This method is used to interact with HCW to increase their awareness about HAI and take specific control measures to reduce the HAI rates or its adverse consequences.[73,74]

The strategy to improve the awareness of the HCW would be posting the HAI rates on the nosocomial pneumonia and CAUTI; and also the rates of compliance with infection control practices using charts, graphs and statistical analyses in prominent locations in hospital units in order to be visible to the HCW.[66]

Hospital Overcrowding

The strategy for reducing hospital overcrowding could include use of target bed occupancy rate, which is used as a tool to measure the ability of healthcare facilities functioning and performance in terms of delivery of healthcare to its patients. The target bed occupancy rate of 85% is considered as the optimal level (especially in the UK and Australia), above that level it will lead to negative impact in health care such as lower quality care, increased risk of infections and overcrowded wards.[42] The target bed occupancy rate varies in different countries and in different healthcare settings as it is specific for every healthcare settings depending upon its size and capacity, the number of units and the healthcare facility.[42,79] In India, there is not much data available on the current bed occupancy rate in the healthcare facilities and there are only few studies has been conducted on it. According to a study done in India in 2013, it found out that only the private teaching hospitals that participated in the study has a bed occupancy rate of 80%, other hospitals such as district hospitals, tertiary care hospitals, private hospitals and charitable hospitals that participated in the study all have bed occupancy rate below 80%.[80]

Increase in the number of outpatient care and home health care facilities, which include a wide range of healthcare services being provided in the patient's home for those who are recovering after a hospital or facility stay, as it would reduce unnecessary hospitalization.[81,82] It would be a good strategy to reduce the hospital overcrowding. Moreover, the length of the stay and extra cost of the stay in the acute care settings is higher when compared to the outpatient care and home health care facilities. Improving (renovating) the existing facilities and increasing the number of new outpatient facilities will be helpful.[83]

Nursing shortage

The strategy to address the nursing shortage issue would be balancing both supply and demand factors that are influencing nursing workforce, those factors are improving recruitment of nurses by developing a good work-related environment as it is a crucial factor making them to participate in decision making, allowing them to gain autonomy; retention of the nursing staff can be done by providing them incentives such as increase in salary, increase opportunities for further education. And also, to make policy level interventions to use the available nursing resources effectively, as nursing shortage is not only about less number of nurses, but also about the functioning of the health care system on workforce planning and allocation mechanisms. It could be done by identifying the skills and roles of nursing population and developing skill mix with physicians, registered nurses and other healthcare professionals in providing better clarity and balance in roles that is necessary to meet the service needs which will be effective.[48,49] In India the distribution of nurses in urban and rural areas is uneven. A potential strategy that the Government can implement is to employ nurses in rural areas on contractual (agreement) basis maybe for about 2-3 years with providing them incentives such as increase in the amount of salary, good accommodation and living conditions, incentivizing promotion in their job on the

basis of performance.[50,51] There is also a huge number of nurses migrating to high income countries for better pay and better career prospects. The Government should give incentives such as increase in the salary, should increase professional recognition in the healthcare field and community level recognition of the nursing profession among the public and development for better educational and career prospects in order to retain the well trained and qualified nurses those who migrate to other countries.[48,51] Even though, in the last decade there were increase in the number of nursing schools and training facilities in India, there is increasing vacancies in the nursing schools and teaching facilities. The potential strategy to address this would be to give special subsidies, scholarships and educational loans to encourage students to take the nursing profession; especially for students from poor socio-economic status and discriminated societies who cannot afford to join the nursing education. The use of "Float Nurses" or "Agency Nurses" strategies could be a temporary short-term solution, where a float nurse is –trained to work in different wards/units within hospitals, especially to assist in times of heavy workloads and to substitute when a nursing staff is absent. Similar is the role of agency nurses, who are employed by an agency. When hospitals/healthcare facilities are in need, especially in case of shortage of nurses, the facilities can pay agencies to hire nurses for delivering temporary care. However, there are some shortcomings in this such as nurses being unfamiliar and inexperienced to work in specific units of a hospital, especially in ICU's, which can increase the potential to increase the HAI rates. But this issue can be solved, by maintaining consistency in the units, that is training the float nurses to work only for limited number of units, which will be helpful. This approach could help to address the issue of nursing shortage in hospital/healthcare facilities without increasing the risk for HAI.[84]

Policy and Priority settings

The above-mentioned prevention/intervention strategies' strengths and weaknesses are assessed based on the following eligibility criteria: intervention effectiveness, intervention feasibility, financial resource needed, intervention sustainability and political feasibility. The rating score for each criterion is classified from very low to high. Priority scale for each intervention was allotted based on the evaluation of the eligibility criteria. Table 1 shows the assessment of the intervention strategies.

Compliance with the Guidelines

The NCDC and ICMR have released the guidelines to healthcare facilities in the country regarding hand hygiene use, antibiotic use, prevention of nosocomial pneumonia and CAUTI.[63,69,70] As, the Ministry of Health and Family Welfare being the responsible body for carrying out health reforms and policies in the Indian health sector, it will regulate and mandate all healthcare facilities to comply and adhere to the respective recommended guidelines.[85] This regulation on compliance with the guidelines is highly feasible to implement in the healthcare setting. Financial resources are not a big concern in implementing the guidelines. The sustainability of this intervention is dependent on having proper monitoring and enforcement mechanisms. The enforcing and implementing the guidelines will be time-consuming process, but it will be politically feasible as there will not be big opposition to implementing guidelines that can save resources for the health system and for health facilities. There is a need for developing regulations for enforcing the guidelines throughout health facilities in India.

Education of HCW

Education of HCW through the ICT could be a very effective approach and is necessary for improving awareness and understanding of this issue.[66] However, the educational intervention for HCW can be done only with adequate financial and human resources. For the intervention to be sustainable in the long term, periodical trainings and education sessions for HCW are needed. This needs to be mandated through internal mechanisms and facility accreditation requirements. It would be politically feasible, as having guidelines and regulations requires training the HCW on the new guidelines and its enforcement mechanisms.

Use of financial incentives

The use of incentives serves as a good strategy and is more feasible, for enforcing an infection control program. This will create a motivation for HCW to comply and adhere to the specific infection practices and guidelines, which will result in reduction of adverse events and decreased HAI rates.[75] The healthcare facilities administrative body will be responsible for the use and allocation of the incentives. This mechanism can help improving the quality of care in the facility and can serve as a funding for the infection control program. However, a significant amount of financial resources are required to incentivize better performers.

Surveillance

Surveillance is one of the major interventions in the control of HAI and a crucial component in an effectively functioning infection control program in healthcare facilities. An ICT should be setup as a responsible body to conduct and maintain the infection control program and the surveillance system. Some of the private hospitals and entities have established their own infection control programs by their own resourses.[64] Setting up an ICT and surveillance system

is a long term work and requires financial resources. However, based on the evidence it is a necessary and crucial tool in controlling the HAI.[65,66,85] It will have significant impact in the decrease of HAI rates, decrease in the length of stay and hospital costs related to HAI. The effectiveness of this intervention will be high if it is implemented and the political feasibility for implementing surveillance and mandating it on all healthcare facilities is also high. As, now the Ministry of Health and Family Welfare has focused and prioritized the infection control, the surveillance system comes as one of the important steps for carrying it out. However, it is setup as a longer-term goal in achieving and full functioning of the system at the national level.[85]

The use of integrated online surveillance system is of necessity and it requires huge financial investment, but it gives an overall pattern and necessary data on HAI. As of now, in India, there is not even a proper reporting data available on HAI, so this will be very much helpful in carrying out further policy changes and further steps in the future to combat HAI. [66,85]

Providing feedback to HCW regarding the HAI rates, HAI preventive measures and infection control practices can also be an effective method to raise awareness about HAI prevention. The use of charts, graphs and statistical data will help them to adhere and focus more on the infection control.[67,74] It is less time consuming, but might not be feasible to implement in the near future because of needed financial resources.

Reduction of hospital overcrowding

Hospital overcrowding can be controlled by some necessary measures. The first step would be by controlling the bed occupancy in the healthcare settings. Bed occupancy rate is the actual utilization of an inpatient health facility for a given time period. For addressing this issue we propose using the "Target bed occupancy rate" which will be helpful in providing an optimal level for the bed occupancy and showing the performance of the healthcare facility.[42] The

Ministry of Health and Family Welfare would need to develop a policy for improving the bed occupancy rate. That could be done by increasing and improving the outpatient care and home health care which will definitely help in the reduction of hospital overcrowding.[83] This is especially important in the rural areas where it needs to be increased as they lack proper healthcare facilities. This requires political will that is feasible to achieve in the long term and significant amount of financial resources will be needed for this strategy.

Tackling nursing shortage

The nursing shortage is not only a major issue in India, it is also a global level problem.[49,50] The potential strategies for reducing this crisis such as improving the recruitment of nurses by providing them good incentives would be the long term strategy. Allowing them to participate in decision making and to gain autonomy in work place might be challanging.[51] This is feasible politically in India but not at all levels of healthcare system. The Indian Nursing Council, administrative body that is responsible for nursing profession and Ministry of Health and Family Welfare, they should bring policy level changes in the effective use of workforce such as use of skill mix with physicians and allocating mechanism especially, employing nurses in rural areas. These level of policy changes are feasible in India as they are finding solutions to tackle the nursing shortage.[51,86] The huge number of well-qualified nurses migration to high income countries for better career, salary and living conditions is unavoidable, as increase of salary and opportunities for further education, which is a long-term goal to be achieved as it requires a lot of financial resources and infrastructure to be setup. It can also be done only in certain level of healthcare system, especially in primary care level.[49,50,86] The use of ‘‘float nurses’’ or “agency nurses” system will be a good strategy as a short term solution, which could be feasible in India along with proper regulations on staff recruitment and contractual based agreement.

Specific Recommendations

The prevention of HAI requires a comprehensive approach; based on the priority setting of the listed intervention strategies (Table 1), we recommend the following specific strategies for HAI control program in the health facilities of India:

- Compliance with the guidelines
- Education of HCW

The compliance with guidelines is the primary chosen strategy and a key infection control intervention for implementing an infection control program in the health facilities. This seems to be effective, sustainable and feasible politically and financially. The second chosen strategy is the education of HCW, which will educate the HCW on the adherence and compliance with the guidelines, in order to complement the infection control program and make it more effective. It is also politically and financially feasible to implement and achieve our goal.

Implementation and Evaluation

For the implementation of the infection control program, compliance with guidelines and education of HCW is an essential component. The guidelines are on appropriate hand hygiene use, antibiotic use and specific medical procedures on appropriate ventilatory care, gastrointestinal care, oropharyngeal care and urinary catheter care. To make the compliance with the guidelines mandatory for all facilities in India, there is a need for legislative acts through passing a bill in the parliament, which will take time - approximately 6 months in India. The political will plays a major role in the implementation of the suggested strategy. The Ministry of Health and Family Welfare should develop the regulations and be in charge of

implementing and be responsible for enforcing compliance on guidelines for all the healthcare facilities nationwide.

In order to facilitate functioning of the infection control program, in parallel to legislative changes, the specialists for ICT should be recruited and trained at the facility level. The ICT will be the responsible body for carrying out the infection control program in the facility, and they will be monitoring the compliance of HCW with the guidelines and educating the HCW. Training and education sessions for the HCW will be conducted, when the guidelines are updated, new instruction manual will be developed or when a new HCW/staff is recruited to the facility they will receive the manual and participate in a training. It will take about 18 months to establish ICT in nationwide health facilities.

The potential barriers for the implementation of the suggested strategies will be the lack of financial and human resources for hiring the specialists for ICT and setting it up for education of HCW in all health facilities. And it will take time for enforcing the compliance on guidelines and implementing it in all health facilities.

The Ministry of Health and Family Welfare should mandate and enforce periodical trainings and education sessions for HCW on the guidelines. It also should mandate and regulate the accreditation requirements for the health facilities to have an infection control program. The full implementation of the infection control program in a healthcare facility will take approximately two years.

Evaluation of the implemented infection control program is done to see the effectiveness of the chosen strategy. This will be done as a two staged evaluation as: observation of HCW and before/after comparison of the HAI rates.

During the observation, the HCW will be observed for the compliance with the guidelines during specific clinical procedures. It will be conducted 12 months after the implementation of infection control program to see if any additional training and education or changes in the infection control program should be made for their compliance with the guidelines. Based upon the observation of HCW on the specific clinical procedures, whether there is adherence or not with the guidelines among the HCW will be noted. For this purpose, specific checklists will be developed on hand hygiene practice of nurses and physicians, on antibiotic use and specific medical procedures on appropriate ventilatory care, gastrointestinal care, oropharyngeal care and urinary catheter care. The checklist measurements through observations could be taken on a quarterly basis for trend analysis.

HAI rates for the health facility will be compared before and after the implementation of the infection control program. The first follow-up measures will be taken two years after the implementation of the two interventions on an annual basis. The expectation is that the HAI rates will have a decreasing tendency. The chosen strategy will be effective by evaluating the HAI rates. If the HAI rates are still the same and not reduced, then the infection control program is not effective. But, if the HAI rates start reducing after the implementation of the infection control program, then the implementation is effective and this recommended intervention strategy will be continued to achieve our stated goals.

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Table 1: Assessment of the Strengths and Weaknesses of the Intervention Strategies

		Interventions					
		Compliance with the guidelines	**Education of healthcare workers**	**Use of financial incentives**	**Surveillance**	**Reducing hospital overcrowding**	**Tackling nursing shortage**
Eligibility criteria	**Intervention effectiveness**	++++	++++	+++	++++	++	++
	Intervention feasibility	++++	++	+++	+	++	++
	Financial resources available	++++	+++	++	+	+	+
	Intervention sustainability	++++	++	+++	+++	++++	+++
	Political feasibility	++++	+++	++	+++	+	+
Priority setting		++++	++++	++	+++	+	++

Coding for priority:

+ very low

++ low

+++ medium

++++ high