How to Manage and Control Healthcare Associated Infections

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Abstract. Healthcare associated infections (HAI) are the major complications of modern medical therapy. The most important HAIs are related to invasive devices including central line-associated bloodstream infections (CLABSI), catheter-associated urinary tract infections (CAUTI), ventilator-associated pneumonia (VAP) and surgical-site infections (SSI). Excessive use of antibiotics has also led to the emergence and the global dissemination of antibiotic resistant bacteria over the last few decades. Reducing HAIs will involve a multi-modal approach to infection control practices as well as antibiotic stewardship program.

1. Introduction

Healthcare associated infections (HAI) are a leading cause of morbidity and mortality amongst patients. HAI pose a significant threat to the population and yet patient safety is an everyday event in the health care setting. The history of infection control dates back to the time of Florence Nightingale in 1854, during the Crimean war, when she served in a military hospital in Scutari, Italy.[1] The conditions in the hospital were deplorable. Nightingale’s observations led her to believe that improving hygienic conditions would decrease the number of deaths. She then “championed the cause of improved hygiene, food, and living conditions for the hospitalized soldiers and called for basic public health, infection control measures, cleanliness, hygiene and education about the importance of the issue”.[1]

Healthcare associated infections are by definition the infections that the patients acquire during their stay in the health care setting. This health care setting is not limited to only an acute care facility or in long term health care facility but also in outpatient settings of dialysis centers, community hospitals and rehabilitation centers.

There are multiple factors contributing to HAI and include healthcare associated factors, environmental factors, and patient-related factors that interact in any given healthcare system. Healthcare related factors include the use of invasive devices, surgical procedures, and selection pressure from excessive antibiotic use. Environmental factors include contaminated air-conditioning systems and the physical layout of the facility (e.g., open units with beds close together). Patient-related factors include severity of underlying illness, use of immunosuppressive agents, and prolonged hospital stays. Multiple factors may play a role such as staffing (e.g., nurse-to-patient ratio) and the lack of effective intervention programs designed to reduce HAI.

2. Morbidity and Mortality

There are 1.7 million patients with an HAI in 2002 in United States. Out of these, there were 155,668 deaths, of which 98,987 were caused by or associated with the HAI.[2] World Health Organization (WHO) estimated the prevalence of health care-associated infection in developed countries varies...
between 3.5% and 12%.[3] On average, the cumulative incidence of infection in adult high-risk patients is 17.0 episodes per 1000 patient-days. High frequency of infection is associated with the use of invasive devices, in particular central lines, urinary catheters, and ventilators. Limited data, often of low quality, are available from low- and middle-income countries. However, recent analysis by World Health Organisation (WHO) found that health care-associated infections are more frequent in resource-limited settings than in developed countries. At any given time, the prevalence of health care-associated infection varies between 5.7% and 19.1% in low- and middle-income countries. Average prevalence is significantly higher in high- than in low-quality studies (15.5% vs 8.5%, respectively).[2-4]

3. Healthcare-Associated Multidrug-Resistant Bacteria

Hospital associated infections are caused by various organisms. Bacteria are responsible for the vast majority of the infections, whereas fungi, non-mycobacterium organisms are less frequent, though these may reflect on breaches in infection control and environmental hygiene.

Since the advent of antibiotics, each class of antibiotic is followed by a wave of emergent resistance. Asia has a higher proportion of the burden of the gram-negative resistance. The spread of the New Dehlimetallo-β-lactamase-1 (NDM-1) from India, to the west reflects the rapidity of global dissemination.[5]

Methicillin-resistant *Staphylococcus aureus* (MRSA) was first identified 2 years after the discovery of penicillin, in 1961.[6] MRSA subsequently became established in hospitals, starting from North America and Europe and subsequently to Asia (Figure 1). In early 2000, the emergence of community-associated MRSA (CA-MRSA) with a predominantly soft and skin tissue infections as well as necrotising pneumonia.[7,8]

![Dissemination of MRSA globally. (Adapted from Molton et al.)](image)

Carbapenem-resistant Enterobacteriaceae (CRE) is a growing problem globally, especially in Asia. KPC-producing *K. pneumoniae* had caused major outbreaks in United States, Israel in 2004 and Greece in 2007 (Figure 2). KPC then spread to China and Taiwan by 2004. Singapore reported the first few cases in 2012.[9,10]
The recently identified NDM-1 plasmid-carrying organism possesses a concern as it frequently possesses multiple resistance mechanism to other classes of antibiotics. As such, it is often resistant to all antibiotics except polymixin and occasionally tigecycline. NDM-1 was first reported in an Indian patient managed in Sweden, coming from New Delhi hospital.[11] Subsequent to this case, NDM-1 was identified in multiple patients in United States and United Kingdom.[5] Now, it has spread via plasmid into various other organism and been identified in sewages in India and Vietnam.[12,13]

![Figure 2. Dissemination of KPC and NDM-1. (Adapted from Molton et al.).](image)

Antimicrobial resistance is the inevitable consequence of prescribing antibiotics. While infectious agents are becoming more and more resistant to the medicines that are currently in use, not enough drugs are being developed to combat them. There is less incentive for the pharmaceutical industry to discover new antibiotics as these drugs are only used for a short period of time, as compared to the drugs to treat chronic diseases (Figure 3).
Figure 3. Development of antibiotics and resistant organism.

4. Strategies to reduce HAI
The solution is not simply the discovery of new drugs, though that is also important. Data has shown that a coordinated infection control response in the institution is important. A care-bundle approach has been introduced for reducing central line-associated bloodstream infections (CLABSI), catheter-associated urinary tract infections (CAUTI), ventilator-associated pneumonia (VAP) and surgical-site infections (SSI). There is a global wave to participate in the ‘Save Lives: Clean Your Hands’ campaign in order to combat antimicrobial resistance.

In order to have a multi-modal approach, surveillance is required to identify lapses and areas of improvement. The constant feedback, education and training for health care workers, in addition to the checklist prior to insertion of lines, intubation and use of urine catheters are aimed at reducing the rates of HAIs. A compendium of strategies by the Society of Healthcare Epidemiology of America (SHEA), the Infectious Diseases Society of America (IDSA) and the American Hospital Association (AHA), the Association for Professionals in Infection Control and Epidemiology (APIC) and The Joint Commission and various organizations to prevent healthcare-associated infections in acute care hospitals was first published in 2008 and revised in 2014. Some of the strategies are summarized in Figure 4.[14,15]

4.1. Hand Hygiene
The association between hand hygiene improvement and HAIs has been well demonstrated. Hand hygiene is the foundational component of infection prevention programs. Yet the adherence to hand hygiene practices remain low.[16] Reasons for the lack of hand hygiene and low adherence to guidelines can be from the lack of facilities such as the sinks, understaffing or busy work schedule to lack of role models.[17,18]
The commitment to hand hygiene via the ‘Save lives: Clean your hands’ encourages many countries and facilities to hand hygiene. The WHO’s 5 moments for Hand Hygiene becomes the most recognized frame work for measuring hand hygiene opportunities.[15]

**Table 1.** Strategies to prevent Healthcare-associated infections. Clinical Recommendations. (Adapted from SHEA/IDSA recommendations)

| **To prevent central line-bloodstream infections:** |
|---------------------------------------------------|
| Before and during insertion:                      |
| Use sterile barrier precaution                     |
| Avoid femoral vein for central venous catheter insertion, if possible |
| Prepare skin with chlorhexidine                    |
| After insertion:                                   |
| Ensure appropriate nurse-to-patient ratio          |
| Disinfect catheter hubs, needles connectors and injection ports before accessing the catheter |
| Remove nonessential catheters                     |

| **To prevent catheter-associated urinary tract infections:** |
|---------------------------------------------------------------|
| Insert a urine catheter only if necessary, and leave in place only as long as necessary |
| Maintain a sterile, continuously closed drainage system        |
| Change the catheter when obstructed                           |
| Special approaches: Implement an organization – wide program to identify and remove catheters that are no longer necessary |

| **To prevent ventilator-associated pneumonia:** |
|------------------------------------------------|
| Promote non-invasive positive pressure ventilation |
| Keep mechanically ventilated patients in the semi-recumbent position rather than supine |
| Minimize sedation – interrupt sedation once a day for patients without contra-indications |
| Provide early exercise and mobilization                |

| **To prevent surgical site infections** |
|----------------------------------------|
| Remove hair preoperatively only if necessary, using clippers rather than razors |
| Treat infections remote to the surgical site before an elective surgery |
| Control blood glucose preoperatively   |
| Administer preoperative prophylactic antibiotics, given at the right time and dose |

| **To prevent Clostridium difficile infections** |
|------------------------------------------------|
| Use routine contact precautions for patients with *C. difficile* infections or colonisation |
| Minimize the number and duration of antibiotic therapy |
| Implement a systematic approach to reduce inappropriate antibiotic prescribing such as antibiotic stewardship program |

4.2. **Antimicrobial Stewardship Programs (ASP)**

Antimicrobial Stewardship Programs is a systematic effort to educate and persuade prescribers of antimicrobials to follow evidence-based prescribing, in order to stem antibiotic overuse, and thus antimicrobial resistance. Antimicrobial stewardship requires a strategic multidisciplinary effort from specialists in infectious diseases, Internal Medicine working together with hospital pharmacists. Studies have shown that ASPs can effectively reduce antibiotic utilization, cost of care and possibly antimicrobial resistance rates.[19-21]

Surveys show that 25-33% of hospitalized patients receive antibiotics and up to 65% of antibiotic use in patients is inappropriate.[22] A restrictive approach to antibiotic prescription may work better than a persuasive technique. This may involve a step order to the duration of the antibiotics, making it more difficult for physicians to prescribe certain antibiotics and working with microbiologists to report a more restrictive antibiotics susceptibility.
5. Conclusion

Healthcare-associated infections are a threat to patient safety. Patients treated in healthcare settings can get HAIs, which cause sickness and death and add billions of dollars to healthcare costs each year. Along with the risk of HAIs, antimicrobial resistance is a global public health challenge which has accelerated by the overuse of antibiotics worldwide. Increased antimicrobial resistance is the cause of severe infections, complications, longer hospital stays and increased mortality. Overprescribing of antibiotics is associated with an increased risk of adverse effects, more frequent re-attendance and increased medicalization of self-limiting conditions.

A compendium of strategies, developed through investigations and research are available. Antimicrobial stewardship programme is developed in the hope to stem the overuse of antibiotics and reduce resistance. The implementation of these strategies needs a national or institutional leadership, in surveillance, research and a multi-modal approach.

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