Nosocomial Infections: A Long-Lasting Challenge in Public Health

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Abstract

Nosocomial or hospital-borne infections are one of the most difficult challenges faced by health care professionals, as these infections are arises in hospital settings. Both human and non-human contaminations are responsible for these infections inpatients during their hospital stay. This article helps to understand the epidemiology of nosocomial infections and to overcome major public health challenges. It also identifies the factors responsible and the mode of transmission of these infections to overcome some major public health challenges.

Keywords: *Nosocomial infections; Antibiotic resistance; Multidrug-resistant bacteria; Public health challenges*

Introduction

The word nosocomial has been adopted from the Greek words 'nosos', meaning "disease" and 'komein', means "to care for". Nosocomial infection or "hospital-acquired" or "hospital-borne infection"occurs in the hospital settings, which means it is an infection picked up by a patient in the hospital who has been admitted to the hospital for an ailment other than any disease caused by microorganisms. These microorganisms are present in the hospital settings, devices or among hospital staff and get transferred to a newly admitted patient with no infection history (Figure 1). These infections can be defined based on a period within the hospital stay, like among those occurring within 48-hours of hospital admission, in the last few days of discharge or within 30 days of surgery. Nosocomial infections are always associated with large numbers of co-morbidities, initiating new illness and are the common cause of mortality among hospitalized patients.[1,2]

Nosocomial infections majorly occur orspread through respiratory tract infections, surgical abrasions, and urinary tract infections (UTI). Areport from the World Health Organization (WHO) suggests the nosocomial infections are highly prevalent in Intensive Care Units (ICU) and hospital wards. They are most prevalent among patients with comorbidities, older groups of people, children (especially below <5 years), and among chemotherapy patients.[3] The major factors responsible for acquiring these infections include patient's immunity, increasing variation of medical and invasive techniques, exposure to infected health professionals, hospital hygiene policy, microorganism's longevity on the surface or in air, size of the agents, etc. e.g. air particulate matters and multidrug-resistant (MDR) bacteria.[4]

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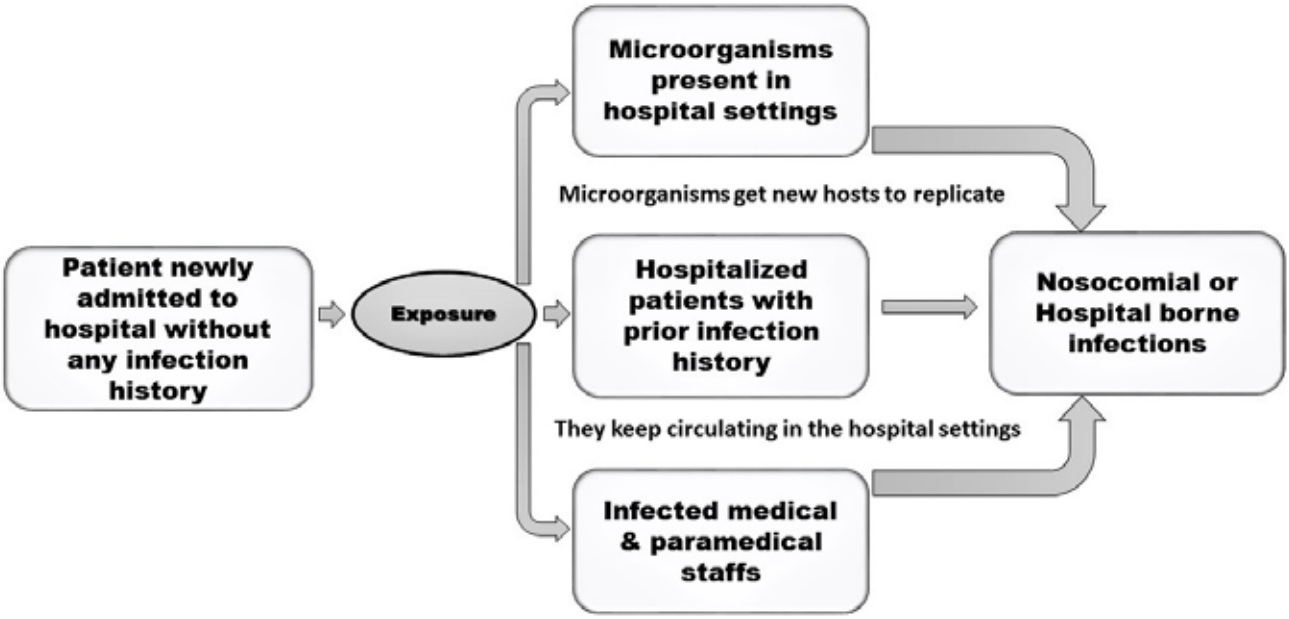

Figure 1. Source, spread and sequence of events in leading to nosocomial infections

Epidemiology of nosocomial infections: Nosocomial infections are considered either epidemic or endemic. It was reported in the National Nosocomial Infection Study (NNIS) from 1992 to 1998, that 90% of the nosocomial infections have been endemic, where 54% infections were in surgical patients, 28% in elderly patients (above 55 years), and the rest in device associated patients. Bloodstream, respiratory, surgical-site and UTI were the most common hospital-borne infections. There is also an association between the increase in MDR bacteria and nosocomial infections. Apart from this accessibility to handwashing stations and usage of alcohol gets improves compliance with washing hands. Numerous studies have also shown that doctors wash their hands less frequently than other health professionals. Proper infection control measures are needed for the control and prevention of such infections.[5]

The common sites of infections: Respiratory or Nosocomial pneumonia: Respiratory tract infections are the commonest of nosocomial infection. In an "NNIS" study pneumonia had accounted for about 31%. These types of infections occur in different groups of patients and health professionals not taking proper precautions. This type of infection is found among patients in the ICU who are on ventilators, where the rate of incidence of pneumonia is about 3% perday. A high rate of fatality is also associated with ventilator-associated pneumonia.[6-8]

Urinary tract infections: UTI is another common hospital-borne infection and around 80% of this is found to have been associated with the use of a bladder catheter. UTI can occasionally lead to bacteremia and death. The major bacteria responsible for UTI can be either commensal turned opportunistic pathogens like *Escherichia coli* or acquired infectious bacterial like MDR *Klebsiella* species.[6-8]

Surgical site infections (SSI): The incidence of such infections varies from 0.5-15% which usually depends upon the type and size of operation along with underlying patient status. The length of stay in the hospital is considered as one of the underlying factors. These type nosocomial infections are acquired usually during surgery, from surgical equipment, doctors, para-medical staff, from the commensal-flora present of the patient's skin near the operative site and rarely from blood used in surgery. These kinds of infections arise if proper aseptic measures are not followed before, during and post-surgery and it delays the healing of surgical sites that lead to septicemia and bloodstream infections.[6-8]

Nosocomial bacteremia: These infections are responsible for about 5% of nosocomial infections but fatalities rates are high due to bacteremia are considerably high about more than 50%. There is an increase in particularly for specific organisms such as methicillin-resistant *Staphyloccocus aureus* and *Candida* spp.[6-8]

Other nosocomial infections: Bedsores, burns and ulcersare the other kinds of hospital-borne infections that affect the skin and soft tissues, leading to unnecessary bacterial colonization. Secondly, gastroenteritis is the most common type of nosocomial infection among children generally caused by members of Enterobacteriaceae, rotavirus and *Clostridium* species. Other infections like sinusitis, endometritis, conjunctivitis and infections of the reproductive organs post-childbirth are also common in hospitals of developed and underdeveloped countries.[5-7]

Factors responsible for nosocomial infections: Infection source: During hospitalization, the patient usually gets exposed to a variety of microorganisms; bacteria, viruses, fungi and parasites can cause infections. These infections are acquired from another person in the hospital (cross-infection) or the patient's normal microbial flora (endogenous infection). Infections may also be acquired the infectious microorganisms present on inanimate objects or substances, a surface that had come in contact with the hospitalized patient. Such infections are known as fomite infection. If infection occurs from devices for the patients such as ventilators and catheters, they are known as device-associated infections.[9-11]

Bacteria: Bacteria are the common form of pathogens responsible for nosocomial infections. These infections causing bacteria are further divided into:

Commensal bacteria are found in the normal flora of healthy humans. The bacteria include cutaneous coagulase-negative *Staphylococci* and *E. coli* which behave as opportunistic pathogens and cause bloodstream, respiratory, urinary and gastrointestinal tract infections. They can be fatal under some circumstances.[9-11]

Pathogenic bacteria: *Clostridium* species causes gangrene, *Staphylococcus aureus* causes a wide variety of lung, bone, heart and bloodstream infections and is frequently resistant to antibiotics; beta-hemolytic *Streptococci, Pseudomonas* and members of family Enterobacteriaceae may colonize the immune-compromised sites of a patient and cause serious infections in the surgical site, lung, bacteremia, peritoneum infection.[9-11]

Viruses: Viruses are widely responsible for causing many nosocomial infections which include the hepatitis B and C viruses transmitted during transfusions, dialysis, injections, endoscopy, etc., respiratory syncytial virus (RSV), rotavirus, and enteroviruses which are transmitted by hand-to-mouth contact and via the fecal-oral route. Other viruses such as cytomegalovirus, HIV, Ebola, influenza viruses, herpes simplex virus, and varicella-zoster virus, may also be transmitted.[9-11]

Parasites and fungi: Organisms like *Giardia lamblia* are transmitted easily among both adults and children. Some other fungi and parasites cause infections during extended antibiotic treatment and severe immune suppression (e.g. *Candida albicans, Aspergillus sp., Cryptococcus neoformans, Cryptosporidium*). [9-11]

Environmental factors: Environment has always acted as a game-changing role by acting as a host for carrying airborne infections. Environmental factors play a major role in causing nosocomial infections. The environment sometimes acts as a reservoir of the agents or even sometimes acts as a source. These infections can be caused among patients, staff and non-medical staff and patient's attendants and when admitted to the hospital acts as a potential source of causing infection. Infections transmit most frequently in crowded conditions within the hospital settings. Airborne transmission occurs through fungal pathogens, like *Aspergillus* which are soilborne. *Sarcoptes scabies* (scabies) is another such organism causing major outbreaks in the health care system. [9-11]

Bacterial Resistance: Apart from their association with an increase in morbidity and mortality, hospital-borne infections have a strong association with MDR microorganisms, including "methicillin-resistant *Staphylococcus aureus* (MRSA)" and "extended-spectrum-lactamase-producing (ESBL) gram-negative bacteria", those causing huge clinical consternations. MDR bacteria increase in number exponentially through natural selection and exchange of plasmids carrying resistant genes with normal human flora which were originally sensitive to antibiotics.[12] The extensive and unprescribed use of antimicrobial drugs is one of the major factors of the emergence of MDR bacteria. Bacterial strains of *Staphylococcus, Pseudomonas, Enterobacteriaceae and Mycobacterium tuberculosis* are currently considered are superbugs and are probably resistant to almost all antibiotics. These organisms are highly prevalent in hospitals and community settings. The problem of antibiotic resistance is a major issue in developing and under-developed countries as the affordability of hospital stay and higher antibiotics become serious concern.[13]

Modes of transmission of nosocomial infections: Nosocomial infection can be both endogenously and exogenously, endemic or epidemic transmission which means the transmission of infection from the surface and when transmission occurs internally in a manner unusual to normal cases.[3, 14, 15]

Endogenous Infection: The human microfloraismajorly responsible for causing opportunistic infections in various other parts of the body such as urinary and GIT, wound's site and nearby tissues, depending on the host's immunity and ongoing antibiotic therapy

Exogenous cross-infection: Transmission of pathogenic infection happens because of : (a) direct contact with patients (infected body part, body fluids, saliva) (b) aerosols and saliva droplets (c) hospital staffs, patient caretakers (may act as carriers), visitors (d) from contaminated devices, instruments, clothes, beds and toilets used for and by the patients.[3, 14]

Endemicor epidemic exogenous environmental infections: Most pathogenic organisms like strains of *Pseudomonas, Acinetobacter, Mycobacterium* dwell well in a hospital environment as the damp and moist *conditions suit* them well and there no shortage of hosts and nutrition. They can survive for months together as spores and are generally resistant to disinfectants which are used to maintain hospital cleanliness.[16]

Infection	Measures
UTI	Limit duration of Catheter use Aseptic technique during insertion Closed drainage system
SSI	Clean operating environment & staff cleanliness Limiting hospital stay Optimal antibiotic prophylaxis Aseptic practices during surgery Surgical wound surveillance
RTI	Ventilator-associated Limit duration in ICU Non-invasive ventilation Prevention of *Legionella* and *Aspergillus* during renovations
Device-associated infections	All Catheters limit duration Local skin preparation Limitation of frequency of dressing change Antibiotic-coated catheter for short term

Table 1. Effective measures for prevention of nosocomial infections

Modes of prevention: The major illness or morbidity occurring due to nosocomial infections can be prevented through various measures if taken proper care. Table 1 shows the effective measures for the prevention of major nosocomial infections.[17]

In general prevention at various levels is going to be helpful for control and precaution from infection. This prevention at the individual level includesi. Reducing person-to-person transmission ii. Preventing transmission from the environment iii. Cleaning of the hospital environment, disinfection of patient equipment, sterilization.[18] There has to be the utilization of preventive measures and equipment in day to day activity for the prevention of hospital-borne infections,a standard guideline for health professionals introduced by WHO gives a detailed preventive measure (Figure 2).

Figure 2. Standard WHO preventive measure guidelines for health professionals

Major public health challenges: At individual level, spread of contamination through frequent contact and close contact between patients and unaffected individuals.

At environmental level, spread of infection through material and objects, improper sanitations, not using proper sterilizations, uncleaned environment and healthcare can be responsible for causing infection and when there are gatherings in hospital setting infection which are airborne are transmitted faster than it could be expected. Therefore, during epidemics, people are asked to avoid social gatherings even at healthcare.

At healthcare, level, spread through an affected healthcare professional, use of infected linen, equipment, and injection because of which infection travel from an infected individual to a healthy individual.[19]

Public health interventions: These interventions at large scale help in safeguarding and treating masses all at a given time and even over some time. The "Centre of Disease Control and Prevention's"in 1985 reported on the efficiency of Nosocomial Infection Control had reported of four components of key infection control which includes: (i) an effective epidemiologist, (ii) one infection control practitioner for every 250 beds, (iii) active surveillance, (iv) control efforts. CDC's National Nosocomial Infection Surveillance (NNIS) system has been working for more than 25 years. WHO on the other hand is working towards improving global health care and preventing healthcare-related infections.[20]

Applying intervention in hospital settings is not enough, as improvement in a continuous manner would be required to avoid contamination and support good health. Therefore, WHO has suggested multimodal improvement strategy in 5 useful steps as shown below in Figure 4, which shows the 5 key elements identified by WHO for prevention and control of multimodal strategies in a healthcare setting, the 'system change' can be implemented in Infection prevention and control which includes the availability of infrastructure, supplies (E.g. frequent hand washing intervention needs availability of wash basin and infrastructure for health professionals and patients to avoid contamination and transmission of infections), 'training and education' of health professional which will not only improve their knowledge will also help in implementing knowledge into sensible actions (E.g. knowledge about evidence based surgical site infection prevention), 'monitoring and feedback', will help in assessing the problem and continuous flow of information will improve action

(E.g. information regarding localization of the particular pathogen/microbe), 'reminders and communication' regarding right action in the right situation (E.g. awareness regarding the importance of regular hand-wash), a 'culture of safety' to facilitate an organization to value an intervention and institutional safety atmosphere for sustainable improvement.[21-24]

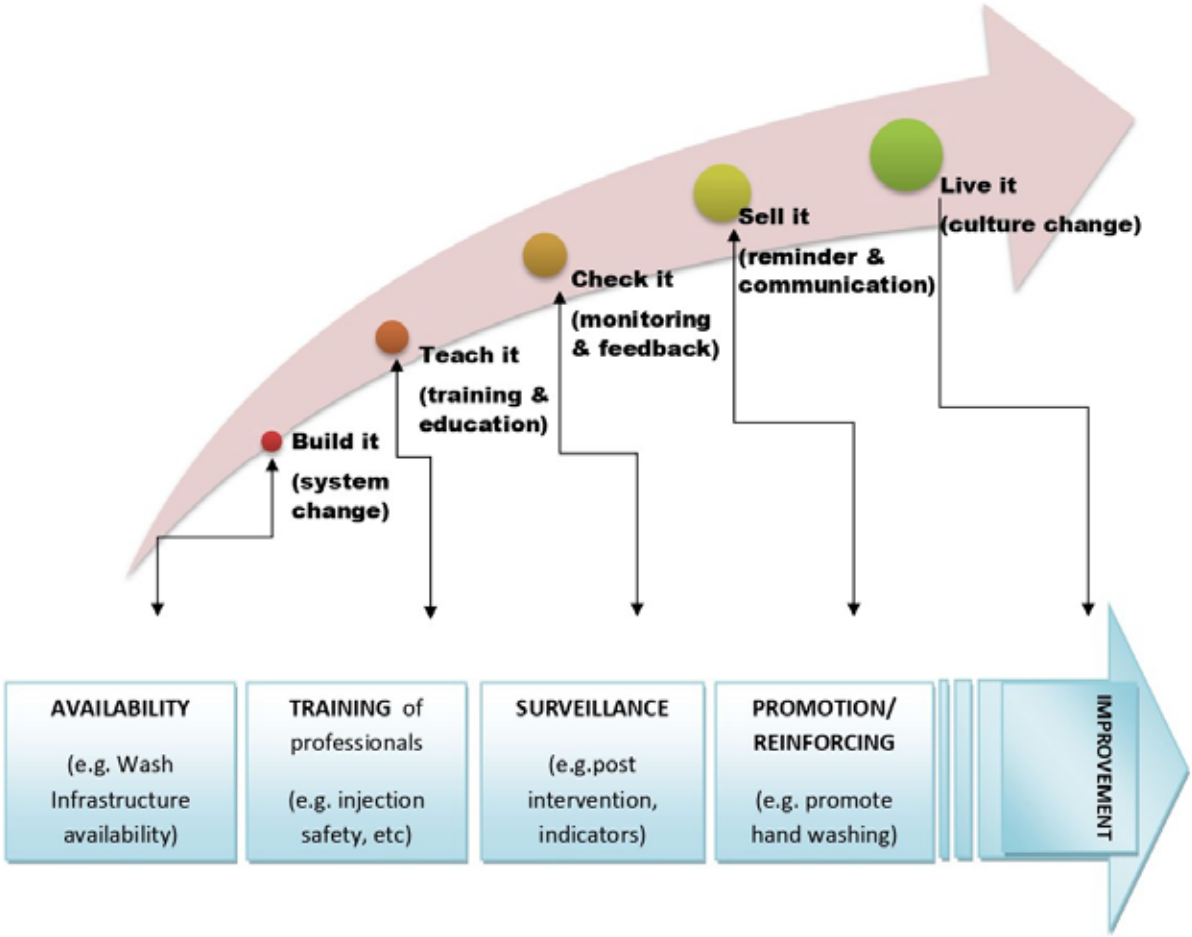

Figure 3. Infection prevention and control (IPC) multimodal strategies for health-care.

This model (Figure 3) enables the understanding of the occurrence and spread of nosocomial infections and prevent it by carefully implementing a strategic control and monitoring system in healthcare settings. Not only health professionals but a complete effort by all sections of the health care system will help in taking prevention against nosocomial infections and prevent infections.[21-24]

Conclusion

Public health challenges are difficult to overcome in-spite of various interventions. The rapid transmission of infection in the hospital setting has been one of the most difficult challenges to overcome, irrespective of development in the field of medical sciences. Surveillance mechanisms like NNIS will enable in taking proper and timely interventions at different levels for smooth functioning and prevention of nosocomial infection. The multimodal strategies would enable health professions to take strategic intervention at different stages and sectors. Further research on specific infections will increase the chances of better awareness and prevention of nosocomial infections.

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