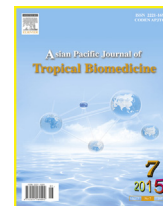




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## Asian Pacific Journal of Tropical Biomedicine

journal homepage: [www.elsevier.com/locate/apjtb](http://www.elsevier.com/locate/apjtb)



Review article <http://dx.doi.org/10.1016/j.apjtb.2015.05.001>

### Nosocomial infections and their control strategies

Hassan Ahmed Khan<sup>1</sup>, Aftab Ahmad<sup>2</sup>, Riffat Mehboob<sup>3,4,a\*</sup>

<sup>1</sup>University of Lahore, Lahore, Pakistan

<sup>2</sup>National Academy of Young Scientists (NAYS), University of the Punjab, Lahore, Pakistan

<sup>3</sup>Department of Biomedical Sciences, King Edward Medical University, Lahore, Pakistan

<sup>4</sup>Department of Neuroscience, SISSA, Trieste, Italy



#### ARTICLE INFO

##### Article history:

Received 9 Mar 2015

Received in revised form 30 Mar 2015

Accepted 26 Apr 2015

Available online 16 June 2015

##### Keywords:

Hospital-acquired infection

Antibiotics

Control strategies

Surveillance

#### ABSTRACT

Nosocomial infections are also known as hospital-acquired/associated infections. National Healthcare Safety Network along with Centers for Disease Control for surveillance has classified nosocomial infection sites into 13 types with 50 infection sites, which are specific on the basis of biological and clinical criteria. The agents that are usually involved in hospital-acquired infections include *Streptococcus* spp., *Acinetobacter* spp., enterococci, *Pseudomonas aeruginosa*, coagulase-negative staphylococci, *Staphylococcus aureus*, *Bacillus cereus*, *Legionella* and Enterobacteriaceae family members, namely, *Proteus mirabilis*, *Klebsiella pneumoniae*, *Escherichia coli*, *Serratia marcescens*. Nosocomial pathogens can be transmitted through person to person, environment or contaminated water and food, infected individuals, contaminated healthcare personnel's skin or contact via shared items and surfaces. Mainly, multi-drug-resistant nosocomial organisms include methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant enterococci, *Pseudomonas aeruginosa* and *Klebsiella pneumoniae*, whereas *Clostridium difficile* shows natural resistance. Excessive and improper use of broad-spectrum antibiotics, especially in healthcare settings, is elevating nosocomial infections, which not only becomes a big health care problem but also causes great economic and production loss in the community. Nosocomial infections can be controlled by measuring and comparing the infection rates within healthcare settings and sticking to the best healthcare practices. Centers for Disease Control and Prevention provides the methodology for surveillance of nosocomial infections along with investigation of major outbreaks. By means of this surveillance, hospitals can devise a strategy comprising of infection control practices.

### 1. Introduction

“Nosocomial” term is used for any disease acquired by patient under medical care [1]. It is an infection acquired by patient during hospital stay. Recently, a new term, “healthcare associated infections” is used for the type of infections caused by prolonged hospital stay and it accounts for a major risk factor for serious health issues leading to death [2]. About 75% of the burden of these infections is present in developing

countries [3]. Asymptomatic patients may be considered infected if these pathogens are found in the body fluids or at a sterile body site, such as blood or cerebrospinal fluid [4]. Infections that are acquired by hospital staff, visitors or other healthcare personnel may also be considered as nosocomial [5].

The situations in which infections are not believed as nosocomial are: (1) The infections that were present at the time of admission and become complicated, nevertheless pathogens or symptoms change resulting to a new infection; (2) The infections that are acquired trans-placentally due to some diseases like toxoplasmosis, rubella, syphilis or cytomegalovirus and appear 48 h after birth [6].

Hospital-acquired infections appeared before the origination of hospitals and became a health problem during the miraculous antibiotic era. Due to these infections, not only the costs but also

\*Corresponding author: Dr. Riffat Mehboob, Department of Biomedical Sciences, King Edward Medical University, Lahore, Pakistan.

E-mail: [mehboob.riffat@gmail.com](mailto:mehboob.riffat@gmail.com)

Peer review under responsibility of Hainan Medical University.

<sup>a</sup> Present address: Neurobiology sector, SISSA, Trieste, Italy.

the use of antibiotics increased with an extended hospitalization. This resulted in elevated morbidity and mortality. Studies conducted in different parts of the world show that in North America and Europe 5%–10% of all hospitalizations result in nosocomial infections, while Latin America, Sub-Saharan Africa and Asia show more than 40% hospitalizations with nosocomial infections [7].

Nosocomial infections can be caused by any organisms but few organisms are particularly responsible for hospital-acquired infections. In this review article, a brief overview on different aspects of nosocomial infections, particularly sites of infections, common nosocomial bacterial agents, selected antibiotic-resistant pathogens along with their modes of transmission and control measures will be discussed.

## 2. Types of nosocomial infections

National Healthcare Safety Network with Center for Disease Control (CDC) for surveillance has classified nosocomial infection sites into 13 types, with 50 infection sites, which are specific on the basis of biological and clinical criteria. The sites which are common include urinary tract infections (UTI), surgical and soft tissue infections, gastroenteritis, meningitis and respiratory infections [8]. A change regarding nosocomial infection sites can be easily detected with time due to the elevated use of cancer chemotherapy, advancement in organ transplantation, immunotherapy and invasive techniques for diagnostic and therapeutic purposes. The perfect example of this can be seen in the case of pneumonia as prevalence of nosocomial pneumonia increased from 17% to 30% during five years [9].

## 3. Agents of nosocomial infections

Nosocomial infections are caused by many microbes and each one can cause infection in healthcare settings. Bacteria are responsible for about ninety percent infections, whereas protozoans, fungi, viruses and mycobacteria are less contributing compared to bacterial infections [10]. The agents that are usually involved in hospital-acquired infections include *Streptococcus* spp., *Acinetobacter* spp., enterococci, *Pseudomonas aeruginosa* (*P. aeruginosa*), coagulase-negative staphylococci, *Staphylococcus aureus* (*S. aureus*), *Bacillus cereus* (*B. cereus*), *Legionella* and Enterobacteriaceae family members including *Proteus mirabilis*, *Klebsiella pneumoniae* (*K. pneumoniae*), *Escherichia coli* (*E. coli*), *Serratia marcescens*. Out of these enterococci, *P. aeruginosa*, *S. aureus* and *E. coli* have a major role [11]. UTI usually contain *E. coli*, while it is uncommon in other infection sites. Contrarily, *S. aureus* is frequent at other body sites and rarely causes UTI. In blood-borne infections, coagulase-negative *S. aureus* is the main causative agent. Surgical-site infections contain *Enterococcus* spp. which is less prevalent at respiratory tract. One tenth of all infections are caused by *P. aeruginosa*, which is evenly distributed to the entire body sites [4].

Excessive and improper use of broad-spectrum antibiotics, especially in healthcare settings, are elevating nosocomial infections. Penicillin-resistant pneumococci, multi-drug-resistant tuberculosis, methicillin-resistant *S. aureus* (MRSA), vancomycin-resistant *S. aureus* are common examples of drug-resistant bacteria. The distribution of bacteria in nosocomial infections is changing over time. For example, *Proteus* spp., *Klebsiella* spp. and *Escherichia* spp. were responsible for

nosocomial infections in the 1960s, but from 1975 to 1980s, *Acinetobacter* spp. with *P. aeruginosa* created clinical difficulties [12]. During the recent years, streptococci along with coagulase-negative staphylococci and coagulase-positive staphylococci reemerged and incidence level of *K. pneumoniae* and *E. coli* declined from 7% to 5% and 23%–16%, respectively [13].

## 4. Bacteriology of commonly isolated nosocomial pathogens

A multicenter study was conducted in Japan to isolate bacteria from surgical infections during 2011–2012. About 785 strains including 31 of *Candida* spp. were isolated from 204 out of 259 surgical patients. About 523 strains were isolated from primary infections and 231 from surgical site infection. From primary infections, anaerobic Gram-negative bacteria were prevalent. *Enterococcus* spp. was the highest among Gram-positive aerobic bacteria followed by *Streptococcus* and *Staphylococcus* spp. *E. coli* was the predominant form among the Gram-negative aerobic bacteria followed by *K. pneumoniae*, *P. aeruginosa* and *Enterobacter cloacae* [14].

### 4.1. *S. aureus*

Out of many species of *Staphylococcus* genus, *S. aureus* is considered one of the most important pathogens, responsible for nosocomial infections. It is Gram-positive cocci, non-spore forming, catalase- and coagulase-positive, immotile, facultatively anaerobe [15]. It is not only a disease-causing organism but also plays its role as commensal. It mainly colonizes in nasal passages. About 20% individuals have persistent colonization of *S. aureus*, whereas 30% are intermittent. Hospitalized patients with decreased immunity and immunocompetent people in community are more prone to *S. aureus* infections. *S. aureus* infects not only the superficial but also the deep tissues and local abscess lesion. Toxin-mediated diseases of *S. aureus* include food poisoning, due to ingestion of enterotoxins, while toxic shock syndrome toxin 1 is responsible for toxic shock syndrome [16] and exfoliative toxins cause staphylococcal scalded skin syndrome. Virulence mechanisms of *S. aureus* include toxins, enzymes and immune modulators [15].

### 4.2. *E. coli*

*E. coli* is an emerging nosocomial pathogen causing problems in health care settings [17]. *E. coli* is Gram-negative and oxidase-negative facultative anaerobe bacteria. It can colonize in gastrointestinal tract of human beings and other animals. *E. coli* is responsible for a number of diseases including UTI, septicemia, pneumonia, neonatal meningitis, peritonitis and gastroenteritis. Virulence factors meant for its pathogenicity are endotoxins, capsule, adhesions and type 3 secretion systems [18]. Specialized virulence factors are seen in case of UTI and gastroenteritis.

### 4.3. Vancomycin-resistant enterococci

Enterococci is the second leading cause of hospital acquired infections worldwide and the main leading cause in United States contributing 20%–30% of infections. These are facultative anaerobic Gram-positive enteric microbes [19]. They are a part of

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