



Airborne Antibiotic Resistant Bacteria: Hospital Indoor Air Pollution and the Challenge of Nosocomial Infection

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Hospitals have a unique and complex environment in comparison with other commercial and residential buildings. In hospital environments, a greater risk exists for health problems such as headache, dizziness, eye irritation, coughing, asthma, respiratory, and cardiovascular disorders¹.

The transmission modes of microbial infection in hospitals are often in the form of airborne, contact, and droplet². Indoor air quality (IAQ) is an important factor in hospital-acquired infection (HAI). Low air quality of hospitals can lead to HAI or nosocomial infection and sick building syndrome (SBS)^{3,4}.

About 8.7% of the hospitalized patients around the world are infected with nosocomial infections⁵. *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Escherichi coli*, *Enterococci*, *Acinetobacter spp.*, and *Coagulase-negative Staphylococci* are the main pathogenic bacteria that are the common causes of nosocomial infections with high survival capability in the environment, which can easily become resistant to antibiotics^{6,7}. More than 0.7 million people die each year from antibiotic-resistant infections; it is estimated that this type of death rate will reach to 10 million by 2050⁶.

The airborne form of these bacteria can cause nosocomial infections for patients and hospital staff. People in the operating room, delivery room, and intensive care unit (ICU) are at greater risk than others^{6,7}. Therefore, controlling airborne infectious agents should be considered as an important factor in the hospitals' design, preparation, and maintenance⁸.

One of the factors that make the pathogenic bacteria more viable and effective in hospital environments is their resistance to antibiotics. The most common and widely used antibiotics are in hospitals. Due to the high exposure of pathogens to antibiotics, antibiotic resistance is also high in hospitals. Increased development of the antibiotic-resistant bacteria threatens effective treatment of infectious diseases and poses many health risks. Studies also showed that a significant proportion of deaths was due to antibiotic-resistant pathogens. Furthermore, major concerns exist about their release into the environment⁹⁻¹². Antibiotic-resistant bacteria (ARB) cause serious problems in the treatment of infectious diseases. These bacteria and antibiotic-resistant genes (ARGs) enter the environment through various sources¹³.

Currently, antibiotics make up about 13% of the total expenditure of the pharmaceutical market in Iran. In Iran, the cost of antibiotics is about three trillion Rials a year, which is a high value⁹. The most important cause of increased bacterial antibiotic resistance in Iran is prescription and overuse of antibiotics. Previous studies (such as in Dutch for β -lactam ARG genes) revealed that the amounts of ARGs in agricultural soils significantly increased between the 1940s and 2010¹⁴. Microbial resistance reduces or eliminates susceptibility of the germs to antibiotics. Increased percentage of the antibiotic-resistant bacterial strains in different environments can make problems in the selective treatment of the bacterial infections¹⁵.

In order to control the microbial quality of the air protective barriers should be considered to prevent the infections caused by airborne microorganisms. Airborne biological materials can be measured and counted by active and passive air sampling including the Anderson (active) and the 1/1/1 methods (passive)^{16,17}.

Frequent epidemics of infections with several disease-resistant organisms have appeared in hospitals since 1950 with *Staphylococcus* resistance to penicillin. Despite the advancement of science in factors controlling the development of bacterial resistance over the past 60 years, this problem has now become one of the world's most severe threats to treat infectious diseases¹⁸. Increased incidence of microbial resistance to antibiotics is especially evident in hospital ICUs. Moreover, the incidence rates of methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), and ICU-resistant gram-negative bacilli are on the rise¹⁹.

Multidrug-resistant genes, probably cells of methicillin-resistant *Staphylococcus aureus*, and other staphylococci are occasionally present in hospital atmosphere²⁰. Some studies showed that the air inside the hospital was a possible way for transmission of β -lactam-resistant bacteria, like *Staphylococcus* and *Acinetobacter*. Furthermore, these bacteria were the principal cause of nosocomial infection²¹.

Airborne microbial contamination in the inpatient facilities was higher compared to the public and restricted zones of the hospital²². Stand-alone air cleaning devices can diminish the amount of airborne bacteria. Atmospheric dust may act as a source of genetic components capable of attributing drug resistance²⁰. The hospitals with enhanced mechanical ventilation systems had the lowest airborne microbial contamination²². Therefore, use of advanced air purification and ventilation equipment, their constant monitoring, as well as continuous microbial sampling of the hospital air are strongly recommended for preventing nosocomial infection.

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