



## Review on Common Microbiological Contamination Found in Hospital Air

Pallabi Pati\*

Department of Microbiology, National Health Mission, Odessa, India

\*Corresponding author: Pati P, District Microbiologist, National Health Mission, Odessa, India, Tel: +91-7873617959; E-mail: ricky\_pati@yahoo.co.in

Received date: November 07, 2017; Accepted date: December 27, 2017; Published date: January 05, 2018

Copyright: © 2018 Pati P. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

### Abstract

Common microbial contamination inside hospital air occurs due to the presence of different kinds of microorganisms like fungi, bacteria, virus. Those pathogenic microbial organisms needs to be identified and screened properly, can be isolated from the air of different hospitals areas by following proper procedure of isolation and characterization. By proper identification of those pathogenic microbes and routine infection control can lead to the protection of the patients, hospital staff as well as surrounding areas and people associated with hospital are protected. This effort will strengthen the hospital and healthcare facility.

**Keywords:** Hospital air; Microbial contamination; Healthcare facility

### Introduction

There are more than 10,000 airborne microorganisms found inside the hospital environment [1] which include fungal spores, yeast, molds, bacteria and viruses. They are transmitted through indoor biological aerosols [2,3] and under some kind of special clinical circumstances like skin lesions may also be a source of airborne particles [4]. One of the common mechanism contributing airborne microbial pathogens is the production of aerosol droplets by sneezing or coughing. Subsequent water loss helps the droplets to float in the air where they can survive for a long time and can spread to a considerable distance. There are many biological aerosols that contain viruses, bacteria, fungal spores, yeasts and molds [2,3].

Quantification of airborne microbial pathogens causing infections is a difficult matter and the hospital air quality assurances have no particular widely accepted standard. As many critical patients are treated in hospital, they may emit various microbes from their disease prospects like flu, tuberculosis, sepsis, burn injury, sample collecting areas and inward patient diagnosis department [5,6]. Pathological microbes can transmit themselves from an infected patient to susceptible person via air and can initiate infection [7]. Common air contaminants can affect hospitalized patients, with conditions like chemotherapy and transplantation recipient [8]. Routine air quality assurance in hospital based environment is required for providing a healthy environment to clinicians, patient's relatives, the hospital staffs and daily wage workers; otherwise all the non-infected people have a chance to carry airborne microbial infection.

Earlier studies have reported investigations of many kind of airborne microorganisms and hospital based microbes [5,6,9]. Hospital based investigation reports provide the idea about some specific microbial pathogens like *Clostridia*, *Staphylococci* and *Streptococci* [10-12]. One of the report suggested that from hospital based isolates, 42.6% were gram-positive cocci, 19.2% were gram-positive bacilli, 14.0% were gram-negative bacilli, 17.1% were molds, 2.2% were actinomycetes, 1.2% were yeasts and others were coccobacilli and diphtheroids. Among all, gram-positive cocci, around 34.9% were hemolytic and 16.4% were penicillin-resistant. It was found that

different area of hospital have different types of penicillin-resistant types ranging from 21.4 in area of surgery to 4.3% in incinerator rooms [1].

### Common Sources of Air Contamination

The main cause of nosocomial infection is, presence of pathogenic microbe in the hospital environments containing several kind of pathogen as well as aerosol in hospital air i.e. basic cause of airborne microbial disease transmission. Previously it was reported that the main entrance of the hospital act as one of the major link of air exchange between indoor hospital and the external environment. Again by means of the homogenization of indoor air of buildings, open door and window of the hospitals are the major source of microbial air contamination. During the whole day period microbial contamination is high during the visiting hours as well as the afternoon period which is the main active time of the day and when there is incoming and outgoing of large numbers of patients, visitors and the other people or regular visitors of hospitals [13,14]. It was reported that the grills of the ventilation are one of the major sources of airborne bacteria and fungi [15]. In the same way the air-conditioning systems act as one of the major source of pathogenic microbial contamination in hospital air [16]. The intensive care units (ICU's) are high-risk areas for infections caused by antibiotic-resistant bacteria that may spread to other clinical areas of the hospital [16-18].

### Hospitals Reported with Acquired Microbial Pathogens in Air

It was previously reported that Birmingham medical institution had infection of *Clostridium welchi* most of the time which was isolated from the indoor hospital air most times, and it had a tendency to carry those pathogenic micro-organisms to the outpatient diagnosis ward and to the clinic by means of air [19].

It was reported from the University of Benin City teaching Hospital in Nigeria that the common microbial pathogens present in hospital air, mainly belong to six bacterial genera such as *Staphylococcus aureus*, *Staphylococcus epidermis*, *Escherichia coli*, *Proteus mirabilis* and *Bacillus* sp. The major fungal isolates included *Penicillium* spp., *Aspergillus* spp., *Mucor* spp., *Verticillium* spp. and *Candida* spp. [20].

It was reported from selected hospitals of Zarqa city, Jordan that, commonly *Micrococcus luteus*, *Staphylococcus aureus*, coagulase negative *Staphylococcus* were predominantly isolated bacterial pathogens from indoor hospital air whereas the common fungal pathogens isolated are *Penicillium* spp., *Aspergillus* spp., *Alternaria* spp. and *Rhizopus* spp. These organisms are predominantly found in the hospital air indoor patient ward of the hospital [14].

The poor air quality can lead to several diseases like sick building syndrome which comprises of several kinds nonspecific symptoms that commonly observed in residents of a building. The bacterial or fungal contaminations are one of the major causes of sick building syndrome. Legionnaire's disease or Monday fever is also a part of these building related illnesses which includes fever (humidifier fever). This fever mainly caused by bacteria containing droplets present inside the humidifiers. The exposure of this contaminated air can leads to extrinsic allergic alveolitis.

### Legionnaire's Disease

Legionnaire's disease or Legionellosis is caused by a gram negative bacterium named *Legionella pneumonia*. In this disease the patient develops flu like symptoms and later on severe interstitial pneumonia is observed. This organism generally present in air conditioners, water of cooling towers, and the bacteria are generally disseminated in the form of aerosols, which are small droplet [21]. This disease is now a major reason to spread both nosocomial and community acquired pneumonia in developed countries like Germany and USA. The diagnosis of this disease is difficult both in clinical method and laboratory method [22].

### Pulmonary Tuberculosis

One of the major disease pulmonary tuberculosis caused by *Mycobacterium tuberculosis* and transmitted by small aerosols around 1-5 µm diameter. When the infected tuberculosis patient especially infected with pulmonary or laryngeal tuberculosis spreads the infected droplets by means of sneeze, cough, shout or song and the transmission of the pathogen occurs when occurs when a susceptible individual inhales those *Mycobacterium tuberculosis* infected droplet nuclei containing droplet nuclei (CDC, TB).

## Common Microbes Found Inside Operation Theatre

### Common fungal isolates

Previous studies reported about major fungal pathogens in hospital air (not only hospital air but also normal air) were sporulated fungus such as *Aspergillus fumigates*. The low concentration of *Aspergillus* spp. is not a big problem but its increasing count or high index is always a cause of clinical problem which require quick treatment before any kind of serious issues or septic condition [1,8]. Other fungal contaminants such as *Penicillium* spp., *Alternaria* spp. and *Rhizopus* spp. were found in hospital air Other than *Aspergillus* spp, reported in previous studies [14].

### Common bacterial isolates

Previous studies reported about major bacterial pathogens in hospital air, were *Staphylococcus aureus*, *Clostridium perfringens*. *Staphylococcus aureus* majorly found in septicemia and wound infection cases. As per previous reports these bacterial pathogens

should be avoided in hospital air during surgery and the bacterial count in total air should be <180 cfu/m<sup>3</sup> in a period of 5-min and inside operation theatre, it should be <35 cfu/m<sup>3</sup> with less than one colony of *Clostridium perfringens* but it was not validated scientifically [8]. Another study revealed Coagulase-negative *Staphylococcus* (13%), Coagulase-negative *Staphylococcus* (17.2%), *S. aureus* (16.8%) and *M. luteus* (10.7%) as the most common bacteria in a private hospital whereas in governmental hospital *Staphylococcus aureus* (16.2%), *Micrococcus luteus* (13.3%) were found as the most common microbe. Other than above bacteria *B. subtilis*, *Bacillus cereus*, *Klebsiella* spp., *Escherichia coli*, *Enterobacter* spp. was also reported to be present in hospital air [14]. As per some of the previous reports, some gram-positive bacteria such as *Streptococcus pneumoniae* and *Staphylococcus aureus*, can survive in dust particles for several months [7,23,24]. It was also reported in a previous study that *Closteridium tetani*, *Pseudomonas aeruginosa*, *S. epiderrmidis*, *Micrococcus lutes* etc. were found in hospital air.

### Common viral isolates

There are many kinds of pathogenic viruses like Ebola virus and Measles virus that multiply inside the host and spread by means of air way specifically in hospital based air by the formation aerosol, which can help them to survive for a long time period. These viruses can spread infection from one susceptible individual to another, as in case of Ebola virus it needs a large number of droplet nuclei for transmission through air (CDC, Ebola).

Depending upon the number of individual present inside the operation theatre, microbial count in air samples can fluctuate. Again, the whole operation theatre along with the design and types of various kind of clothing worn by clinicians, nursing and surgical staff are important to contaminant through air contamination. To provide a proper healthy hospital care facility, the hospital should be properly designed and built by identification and proper elimination of engineering faults and difficulties during the construction of hospital especially critical care units, Intensive care unit and operation theatre as proper ventilation is needed for a good healthy hospital environment. As a faulty designed hospital can carry more amount of microbial contaminated air which is also a major factor to increase infection in post-operative cases as well as any other hospital based air borne infections. These situation can cause severity in critical cases such as elderly patient suffering from critical diseases, patient with cytotoxic therapy, burn injury or severe accidental injured patients which are undergoing a prolong duration of stay in hospital during patient with chemotherapy [1,14]. So the proper and timely and routine examination of hospital air or air quality assurance of hospital based air should be done for the hospital welfare and betterment of health care facility which can strengthen the healthcare system.

### Air Sampling Can be Done by Proper Sampling of Air by Selective Methods

There are many kinds methods for sampling of air previously reported; briefly they are described as following manner:

#### Slit samplers and SAS samplers

Slit samplers are manufactured by Casella Ltd, Bedford and SAS samplers are manufactured by Chenvall Labs, Bicester are very user friendly, easy to handle reported in many previous reported

investigations and acceptable for most of the previous studies regarding bacterial and fungal counts in air quality assurance [8].

### The RCS centrifugal air sampler

In this method the air sampling is done by the RCS centrifugal air sampler manufactured by Biotest Folex, Birmingham, this method is very easy to handle but the limitation of this method are it is unable to detect large number *Aspergillus*, it always detect a very low number of *Aspergillus* [8].

### Agar settle plates methods

Collection on agar settle plates by taking proper volume of air, it is inexpensive, easy to handle and convenient. But the limitation of this method is unreliable as it can take up larger air particles [8].

Air sampling is followed by quantitative study of the air samples, and then the characterization microbes are done properly to identify the microbial pathogen. The sampling should be proper and the result are carefully analyzed and cross checked for better result and better health care facility [14].

### Impactor air samplers

It was the most widely used method for the quantification of air contamination is impact or air samplers [25,26]. This method is one of the best methods as agar plates directly incubated without further treatment, which indicates that from collected viable airborne particles the microbial colonies; grow directly [26-28].

Various methods are used for the counting of air borne microbes majorly four types:

- Counts of colony forming units per cubic meter of air (CFU/m<sup>3</sup>);
- Counts of CFU on settle plates;
- Counts under a microscope;
- Measurement of a chemical component of the microbial cells per cubic meter of air [29].

For sampling airborne microbial pathogens no single method is there to follow [30,31].

### Microbial air sampler (PBI International, Milano, Italy)

A microbial air sampler (PBI International, Milano, Italy) are reported to be used for air sampling of airborne fungi and bacteria. In This method microbial air sampler was operated at 100 L/min air flow-rate with 5 min of sampling time, here drying of the agar surface is to be strictly avoided by overloading of the collection plate.

Some older methods are also used in traditional practices and still exist for microbial sampling from air by aero scope which was mainly used for the collection of bacteria in a fluid medium by bubbling or on porous solid filters [31].

### Viral air sampling

Viral load in the air for airborne viruses can be done by using methodologies like filters, liquid impactors and solid impactors to collect ambient air. After collection of air, the sample is subjected to molecular tests like PCR and tissue culture for viral detection.

## Calculation and Estimation of Bacterial and Fungal Load Present in the Air

Formula for measuring microbial load In case of bacteria and fungi, is given below

$$B=1000 N/RT \text{ bcp (bacteria containing particles)/m}^3$$

B=Bioload

N=Number of colonies appear on the plate

R=Rate of sampling

T=Time period for sampling (Collee et al.).

## Control

Some kind of environmental conditions can help in the prevention and elimination by inhibiting growth and reproduction of pathogenic microorganisms like, ultraviolet radiation for microbicidal effect can reduce aerosolized microbe, dryness and variation in temperature unless and until those airborne microbes adapt a new host [7,23,24].

Bacterial population growth rate is more sensitive than fungal population rates in the hospital. The age of the hospital buildings, disinfection strategies and number of beds inside the hospital also play a great role in the population of air microorganisms. So well-constructed with air-conditioning systems and proper ventilation systems are needed which can help decrease the pathogenic microbial population. There should be a time limit for visit otherwise as the number of people visit increases it leads to increase the number of airborne microbial pathogen [14]. Changing of air is strictly required with proper air ventilation with filtration i.e. minimum of 20 changes per hour for proper clean ventilation inside hospital indoor patient wards and operation theatres, as is air filter [31].

Moisture is the main cause of growth of fungal population in the indoor air, so presence of moisture should be avoided in hospital building.

One of the previous research finding from India strongly recommends both the methods like fumigation and proper use of updated new cleaners such as Vikron and Bacillocidrasant should be used for significant cleanliness as well as the absolute removal of the infectious and pathogenic microorganisms present in indoor hospital environment as well as operation theatres [32].

Inside operation theatre during surgeries where body parts were incised as per their concerning disease severity and condition of the patient such as eye operation, joint replacement operation in knee, cardiac operation, treatment of accidental injuries, and the indoor operation theatre environment should be clean and properly ventilated with clean air. But during the operation procedure automatic contamination occurred which hamper the health condition of the indoor patients. So to limit the pathogenic microbial contamination in air some steps should be taken regarding the assurance of indoor air quality by determining the sterility of total internal indoor environment of the operation theatre. Hospital administration has to take strong and vigilant step in this concern by means of proper infection control strategies and policies. Especially hospital directors, clinical staff, doctors, nurses, administrative staff with other clinical and nonclinical staff availing Operation Theater should be strictly following the infection controlling guidelines. Control of airborne microbial pathogens in healthcare facilities is not only important for the safety of the patient, but it is also important for hospital personnel

so proper and timely implementation of several kinds of infection control/contamination control programs can reduce and prohibit the growth of some kinds of microbial pathogens [33-37]. Total elimination of microbial pathogens may not be possible but these infection control programme and policies can reduce their incidence not possible to eliminate all kinds of pathogenic microbial infection and their transmission [38,39].

## Conclusion

Detail study of type specific air contaminants with their mode of multiplication can help to find a solution to eradicate recurrent and specific infection persisting in hospital environment, which needs to carry routine microbial investigation of hospital air specifically CCU, ICU, surgery, neonatal wards because those patients are prone to infection. Again after the identification of particular pathogenic microbe needs to be clean from that environment by following proper eradication methods including infection control strategies with other efforts to clean and remedies to eliminate the contamination by proper disposing of contaminated body fluids, contaminated bandage, plasters (can cause dissemination of microbial types which will persists during ventilation and lead to contaminate the background area). To strengthen basic hospital facility proper air hygiene is to be maintained which can be done by routine air quality assurance and routine infection control management with proper sanitation measures. A healthy hospital environment needs to breathe a clean pathogen free hygienic air which will strengthen the health care facility to the entire population inside the hospital as well as nearby it. Proper sanitation, cleanliness and maintenance of basic infection control strategies can help to clean the hospital based air.

## Acknowledgements

Author would like to acknowledge the previous publication regarding this investigations scientists and researchers which are cited in this article.

## References

- Greene VW, Vesley D, Bond RG, Michaelsen GS (1962) Microbiological contamination of hospital air. I. Quantitative studies. *Appl Microbiol* 10: 561-565.
- Gillette B (2000) Indoor air quality important. *Mississippi Bus J* 22: 14-16.
- Nevalainen AK, Willeke F, Liebhaber J, Pastuszka A, Burge H, et al. (1993) Bioaerosol sampling. In K. Willeke and P.
- Hambraeus A (1988) Aerobiology in the operating room- a review. *J Hosp Infect* 11 : 68-76.
- Bourdillon RP, Colebrook L (1946) Air hygiene in dressing rooms for burns or major wounds. *Lancet* 1: 601-610.
- Engley FB, BASS JA (1957) The comparative antibiotic resistance of airborne microorganisms isolated from hospital areas. *Antibiotics Ann* 1956-1957: 634-639.
- Atlas RM (1995) Microorganisms and Human Diseases. In Microorganisms in Our World. Mosby-Year Book, Inc.
- Humphreys HS (1992) Microbes in the air - when to count. *J Med Microbiol* 37: 81-82.
- Fredette V (1958) The bacteriological efficiency of air conditioning systems in operating rooms. *Can J Surg* 1: 226-229.
- Blowers R, Crew B (1960) Ventilation of operating theatres *J Hyg* 58: 427-448.
- Hardyment AF, Wilso RA, Cockcrof W, Johnson B (1960) Observations on the bacteriology and epidemiology of nursery infections. *Pediatrics* 25: 907-918.
- Duguid JP, Wallace AT (1948) Air infection with dust liberated from clothing. *Lancet* 2: 845-849.
- Jaffal AA, Nsanze H, Bener A, Ameen AS, Banat IM, et al. (1997) Hospital airborne microbial pollution in a desert country. *Environ Internat* 23: 167-172.
- Qudiesat K, Abu-Elteen K, Elkarmi A, Hamad M, Abussaud M, (2009) Assessment of airborne pathogens in healthcare settings. *African Journal of Microbiology Research* 3 : 066-076.
- Chuaybamroong P, Choomseer P, Sribenjalux P (2008) Comparison between hospital single air unit and central air unit for ventilation performances and airborne microbes. *Aerosol and Air Qual. Res*, 8: 28-36.
- O'Connell NH, Humphreys H (2000) Intensive care unit design and environmental factors in the acquisition of infection. *J. Hosp. Infect.*, 45: 255-262.
- Hsueh PR, Teng LJ, Yang PC, Chen YC, Ho SW, et al. (1998) Persistence of a multidrug-resistant *Pseudomonas aeruginosa* clone in an intensive care burn unit. *J Clin Microbiol* 36: 1347-1351.
- Akinci E, Colpan A, Bodur H, Balaban N, Erbay A (2005) Risk factors for ICU-acquired imipenem-resistant Gram-negative bacterial infections. *J Hosp Infect* 59 : 317-323.
- Lowbury, EJLDM, Lilly HA (1996) Contamination of Operation theater air With, CI tetani. *British Medical Journal* 1334-29.
- Ekhaise FO, Isitor EE, Idehen O, Emoghene AO (2010) Airborne microflora in the atmosphere of an hospital environment of University of Benin Teaching Hospital (UBTH), Benin City, Nigeria. *World Journal of Agricultural Sciences* 6: 166-170.
- Mercante JW, Winchell JM (2015) Current and Emerging Legionella Diagnostics for Laboratory and Outbreak Investigations *Clin Microbiol Rev* 28: 95-133
- Caratalla J, Garcia-Vidal C (2010) An update on Legionella. *Curr Opin Infect Dis* 23: 152-57.
- Augustowska M, Dutkiewicz J (2006) Variability of airborne microflora in a hospital ward within a period of one year. *Ann. Agric. Environ Med* 13: 99-106.
- Matar GM, Chaar MH, Araj GF, Srour Z, Jamaledine G, et al. (2005) Detection of a highly prevalent and potentially virulent strain of *Pseudomonas aeruginosa* from nosocomial infections in a medical center. *BMC Microbiol* 5: 29-36.
- Nesa D, Lortholary J, Bouakline A, Bordes M, Chandener J, et al. (2001) Comparative performance of impactor air samplers for quantification of fungal contamination. *J Hosp Infect* 47: 149-155.
- Morris G, Kokki MH, Richardson MD (2000) Sampling of Aspergillus spores in air. *J Hosp Infect* 44: 81-92.
- Gangneux JP, Gangneux FR, Gicquel G, Tanquerel JJ, Chevrier S, et al. (2006) Bacterial and fungal counts in hospital air: comparative yields for 4 sieve impactor air samplers with 2 culture media. *Infect Control Hosp Epidemiol.* 27: 1405-1408.
- Prigione V, Lingua G, Marchisio VF (2004) Development and use of flow cytometry for detection of airborne fungi. *Appl. Environ Microbiol* 70: 1360-1365.
- Pasquarella C, Pitzurra O, Savino A (2000) The index of microbial air contamination. *J Hosp Infect* 46: 241-256.
- Dharan S, Pittet D (2002) Review: Environmental controls in operating theatres. *J Hosp Infect* 51: 79-84.
- Bourdillon RB, Lidwell OM, Thomas JC (1941) A slit sampler for collecting and counting air-borne bacteria. *J Hyg (London)*, 41: 197-224.
- Patwardhan, Narendra, Uday Kelkar (2011) Disinfection, sterilization and operation theater guidelines for dermatosurgical practitioners in India. *Indian J Dermatol Venereol Leprol* 77: 83-40.
- Montz JR, Edward W (2000) Contamination control in hospitals. *Engineered Systems*, 17: 68-71.

- 
34. Abussaud MJ (1991) Prevalence of nosocomial infections in Saudi Arabian teaching hospital. *J Hosp Infect* 17: 235-238.
  35. Blowers R, Crew B (1960) Ventilation of operating theatres *J Hyg* 58: 427-448.
  36. Centres for Disease Control and Prevention.
  37. Collee JG, Fraser AG, Marmion BP, Simmons A, Mackie, et al. (2006) *Practical Medical Microbiology*. Elsevier Churchill Livingstone. New Delhi. pp 908-910.
  38. Fredette V (1958) The bacteriological efficiency of air conditioning systems in operating rooms. *Can J Surg* 1: 226-229.
  39. Mercante JW, Winchell JM (2015) Current and Emerging Legionella Diagnostics for Laboratory and Outbreak Investigations *Clin Microbiol Rev* 28: 95-133.