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## NOSOCOMIAL INFECTION: SOURCE AND PREVENTION

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**ABSTRACT:** Nowadays, Hospital-acquired infection is one of the significant issues, as the mortality rate is frequently increasing. This may be due to the unhygienic environment of various medical clinics and hospitals, a wide range of antibiotic uses. Nosocomial infections are those which are acquired by the patient within 48-72 h or 3 days of admission in the hospital or medical care unit. The microbes cause nosocomial infections originated in hospitals, clinics, and medical care center. The mode of transfer of hospital-acquired infection can be either by direct or by indirect contact. Vectors involve the organisms that act as a carrier for the spread of disease by dispersion of causative pathogens. Cockroaches, ants, and flies come in direct contact with faces of the patient, and contaminated objects can cause disease by cross-contamination of other objects which can lead to infection. Nosocomial infection can be prevented by minimizing the spread of causative agents, isolation for the patient suffering from infectious disease and maintaining well sanitary conditions in hospitals and medical care unit. A medical device or surgical instrument which comes in contact with the patient during treatment or operation procedure has an associated risk of disease transmission which is due to failure of sterilization or disinfection. Microbial air contamination is monitored by colony forming unit per cubic meter (CFU/m<sup>3</sup>) count. This can be done either by passive or active sampling methods. Nosocomial infection can be prevented by minimizing the spread of causative agents, isolation for the patient suffering from infectious disease and maintaining well sanitary conditions in hospitals and medical care unit.

**INTRODUCTION:** Nosocomial infections are those which are acquired by the patient within 48-72 h or 3 days of admission in the hospital or medical care unit. Immuno-compromised and patient admitted to the Intensive Care Unit (ICU) are at high risk of acquiring the nosocomial infection. It has been reported that out of 10 patients every one patient gets infected by nosocomial infection, increasing the stay of the patient in the hospital for treatment.

This causes a significant increase in the cost of the treatment for patient <sup>1</sup>. In a study conducted by Sahni *et al.*, 2005 on nosocomial infection caused by *Candida* species, it has been reported that out of the total 200 known species of *Candida*, about 10% cause infection in humans. They screened 101 patients of the age from 18 to 80 years showing signs of nosocomial infection and observed that 42.8% of patients were suffering from a disease caused by *Candida albicans*.

From this study, they concluded that nosocomial infection caused by *Candida* species is a significant problem in hospitals <sup>2</sup>. Nosocomial infections are one of the significant causes of mortality and morbidity in hospitals. The rate of nosocomial infections is more in neonatal hospital followed by second to burn in hospitals.

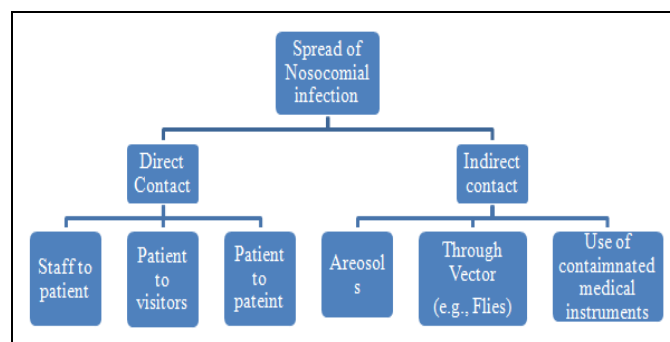
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In immunocompromised patients, patients with multiple organ failure, burn victims, the mortality rate is high. In the neonatal ward, the common pathogen causing nosocomial infections are *S. aureus*, *Klebsiella*, *E. coli* and *Staphylococcus epidermis*<sup>3</sup>. Stay of patients in ICUs can also lead to nosocomial infections and the factors are increasing the length of ICU stay (>48 h) mechanical ventilation, diagnosis of trauma, central venous, pulmonary artery and urinary catheterization and stress ulcer prophylaxis. The pathogens which are found to be causative of agents include *Enterobacteriaceae*, *Staphylococcus aureus* (60% resistant to methicillin), *Pseudomonas aeruginosa*, coagulase-negative Staphylococci and fungi<sup>4</sup>. Most frequent infection sites associated with nosocomial infection include urinary tract infection pneumonia, primary bloodstream, use of contaminated mechanical ventilation; urinary catheters are a source of nosocomial pneumonia and urinary tract infection respectively. Bloodstream infections are caused by coagulase-negative *Staphylococcus* and *S. aureus*. Nosocomial Pneumonia is caused by Gram-negative aerobic microorganism, *Pseudomonas aeruginosa*, and *Staphylococcus aureus*. *Candida albicans* is found in urinary tract infection<sup>5</sup>.

Medical devices are also associated with the spread of nosocomial infections. Stethoscopes are also a source of nosocomial infection. Sengupta et al., 2000 have isolated such as coagulase-negative *Staphylococcus*, coagulase-negative *Staphylococcus*, *Enterococci*, *Escherichia coli*, *Klebsiella* species and *Acinetobacter* species found to be sensitive to ciprofloxacin, netilmicin, and amikacin from stethoscopes. Nosocomial infection caused by extended-spectrum beta-lactamases (ESBL) producing *Klebsiella* species and methicillin-resistant *Staphylococcus aureus* (MRSA) in neonatal intensive care unit affect the recovery of neonates and can also lead to prematurity, low birth weight, hospital stay. Associated microbes in nosocomial infection include *Klebsiella* species, *Enterobacter* species, *E. coli* and *Citrobacter* species<sup>6</sup>. Gram-positive bacteria, like methicillin-resistant *Staphylococcus aureus* (MRSA), spread more drastically in burn unit than not burn area. About 1 to 18% contaminated in the non-burn group compared to 64% in the Burn Unit at the hospital.

Other gram-positive bacteria which contaminate inanimate object like mattress etc. include *Pseudomonas aeruginosa*, Vancomycin-resistant *Enterococci* (VRE) and *Acinetobacter* sp. Enteric Gram-negative bacteria very rarely spread through the dry inanimate environment. However, *Acinetobacter baumannii* non-fermentative bacteria have been found to cause ventilator-associated pneumonia, and bloodstream infection showed resistant and cause antibiotic recalcitrant nosocomial infection outbreak. *Acinetobacter baumannii* has been isolated from the beds colonized patients and nearby surface. *Clostridium difficile* has been isolated from surfaces and equipment like commodes, bedpans, blood pressure cuffs, walls, floors, washbasins, and furniture<sup>7</sup>. More use of antibiotic also increases in some multidrug-resistant bacteria. Non-fermenting Gram-negative bacilli belong to the opportunistic pathogen and can service a wide range of environment. Not a single antibiotic found to be 100% sensitive against MDR bacteria<sup>8</sup>.

**1. Source of Nosocomial Infection:** The microbes cause nosocomial infections originated in hospitals, clinics, and medical care center. **Fig. 1** represents a direct and indirect mode of pathogen spread. The method of transfer of hospital-acquired infection can be either by direct or by indirect contact. Touching an infected person, animals or reservoir of infection count to be in direct contact. Contaminated hands are one of the principal routes of disease transmission. Communicable infectious agents cause indirect disease transmission does not require direct connection of an infected person with a healthy one. Pathogens present in inanimate object and utilization of these objects can lead to transmission of pathogens. Aerosols originated by coughing and sneezing of patients may carry pathogens that can transmit the diseases.



**FIG. 1: SPREAD OF NOSOCOMIAL INFECTION**

**Table 1** represents the spread of various pathogens from patients and staff carries, contaminated aerosols and electrical or other appliances. The respiratory tract infection is mainly spread through the aerosol. It has also been observed that infectious agents are already present in the patient’s body but do not show any symptoms of the infection, but when the patients are admitted in the hospital, the infection developed. It has been reported that weakness in the immunity and reduced resistance of the patient towards the infectious agent can lead to diseases. This type of infection is known as Endogenous infection, self-infection or autoinfection. Cross-contamination followed by cross infection is another route of infection transmission.

In this case, the admitted patient can be exposed to a new infective agent leading to the development of another infection. Contaminated water can also be a source of nosocomial infection. In a study conducted by Anaissie et al., 2002 it was observed that nosocomial infection due to *Pseudomonas aeruginosa* causes the death of 1400 people each year in the United States of America.

They have recommended the use of sterile water for the patients more prone to infection and avoid using hospital water <sup>9</sup>. Monitoring and quality of air in the hospitals, clinics and medical care units is also an essential aspect of dealing with as these places are visited by patients suffering from illness; communicable infectious agents cause some.  $\beta$ -lactam resistant strains such as *Acinetobacter* and *Staphylococcus* have been detected in hospital environment <sup>10</sup>.

Biofilm developed by microbes has an essential role in the ecosystem. If the pathogenic microbes are present in the biofilm they can cause infection even in the presence of high a concentration of antibiotic “recalcitrant” can lead to one of the primary cause of disease. Microbial growth can occur on various types of medical device favors microbial film growth. Implanted devices such as studs in the blood vessels have a high chance of microbial growth which can cause severe infection if not treated in time. *Staphylococcus aureus* has been reported to causes bloodstream infection which is associated with pacemaker <sup>11</sup>.

**TABLE 1: REPRESENTS SPREAD OF VARIOUS PATHOGENS FROM PATIENTS AND STAFF CARRIES, CONTAMINATED AEROSOLS AND ELECTRICAL OR OTHER APPLIANCES**

Bacteria spread through the air	Complications	References
<b>From the patient and staff carries</b>		
Group A streptococcus (GAS)	Bacteremia, pneumonia, puerperal sepsis, necrotizing fasciitis (NF), and streptococcal toxic shock syndrome (STSS). Acute rheumatic fever, post-streptococcal glomerulonephritis, pharyngitis, mild skin/soft tissue infections	39
Methicillin-resistant <i>Staphylococcus aureus</i> (MRSA)	Skin structure infections (SSSIs), Pneumonia, MRSA bacteremia, Right-sided endocarditis, Surgical site infections	40
<i>Neisseria meningitidis</i>	Meningitis, Invasive meningococcal disease (IMD), Meningococcal meningitis and sepsis	41, 42
<i>Bortetia pertussis</i>	Pertussis high rate of infection in the infant, highly contagious	43
<i>Mycobacterium tuberculosis</i>	Tuberculosis at the different organ of the body, which can be drug resistant	44
<b>Contaminated aerosols</b>		
<i>Pseudomonas</i>	Nosocomial pneumonia	45
<i>Acinetobacter baumannii</i>	Pneumonia, meningitis, Necrotizing Fasciitis, and sepsis	46
<i>Legionella</i>	Legionnaires' disease	47
<b>Electrical or other appliances (Ventilation system, fan, air conditioner, etc.,)</b>		
<i>Legionella</i>	Legionnaires' disease	47
<i>Clostridia</i>	Colitis, nosocomial Clostridium difficile-associated diarrhea (CDAD)	48, 49
<i>Nocardia abscesses</i>	Respiratory tract infection, primary cutaneous infection, pericarditis, cerebral abscess, ocular infection, and disseminated infection	51

Direct contact involved cross transmission through the hands of health care workers who are involved in patient care. They come in direct contact with the patient, patient body secretion and the

contaminated site where the patient releases the pathogen. It has been reported that the pathogens survive on the hands of the health workers it can be and transmitted further. *Staphylococcus aureus* is

carried by at least 25% of the staff in their nostrils and transmitted through sneezing. The suspended particles carry pathogens which settled down as fomites and are spread through contact<sup>12</sup>. Currently, digitalization is an effective method for keeping the record and effective governance. In the hospital, computers are one of the components placed in every hospital and health care department. The computers may harbor infectious pathogens and serve as their reservoir of pathogens. Microbes associated with computer-based reservoir include primitive pathogens like MRSA, *Acinetobacter* and normal microbes which can be

opportunistic pathogens. Direct contact with contaminated computers, hospital floor, and other objects transmits the infection<sup>13</sup>. **Fig. 2** represents a common vehicle involved in the transmission of nosocomial infection. Air born nosocomial infections spread through the patients, care-workers, and carriers of pathogens not showing symptoms of the disease. Pathogens are disseminated from various sites including nares, anus, skin, skin scales, etc. Viruses are believed to spread through the air; **Table 2**, represents viruses and origin source spread through the air.

**TABLE 2: REPRESENTS AIR BORN DISEASE CAUSED BY VIRUSES**

Viruses spread through the air	Complications	References
Rhinovirus	Common cold	
Influenza viruses (Three groups type-A, B and C)	Flu	32, 33
Respiratory syncytial virus (RSV)	Lower respiratory tract infection; common in infant and immunodeficient patients	34
Adenoviruses	Adenovirus pneumonia and Bronchiolitis obliterans (BO)	35, 36
Varicella zoster viruses (VZV)	Chicken pox, shingles	37
Rubella Viruses	Illness in children, rashes in the skin, infection to a pregnant woman can lead to fetal death	38

Air born disease caused by various source listed in **Table 3**. The common vehicle of transmission involves the use of the contaminated medical instrument, inhalation of infected air, consuming contaminated water and food. Microorganisms, except viruses, multiply in inanimate objects. Consuming unprocessed water and food products can also cause infection<sup>14</sup>.

**TABLE 3: REPRESENTS AIR BORN DISEASE CAUSED BY VARIOUS SOURCES**

Probable Sources of Airborne nosocomial infection	
Within the hospital	From the patient and staff carries Contaminated aerosols Electrical or other appliances (Ventilation system, fan, air conditioner, etc.,)
Outside the hospital	Contaminated soil Contaminated Water Decomposing matters Open urinary places / Public toilet

Animal MRSA isolated from different sources including dairy cow and chicken specimen are closely related to human MRSA, and it can cause infection to human by consumption of unprocessed food products<sup>15</sup>. Salmonella infection mostly occurs due to the use of contaminated food. The occurrence of disease is widely reported in immuno-compromised patients. It has been reported

that eleven patients in the Philippines were admitted in hospital for the treatment of diaries acquired Salmonella enteric serotype Schwarzengrund. The pathogen was found to be resistant against fluoroquinolone and leads to a major outbreak in the United States of America in 2001<sup>16</sup>. Different types of fungus are involved spread on nosocomial infection listed in **Table 4**.

**TABLE 4: REPRESENTS FUNGUS INVOLVED IN NOSOCOMIAL INFECTION INVOLVED<sup>52</sup>**

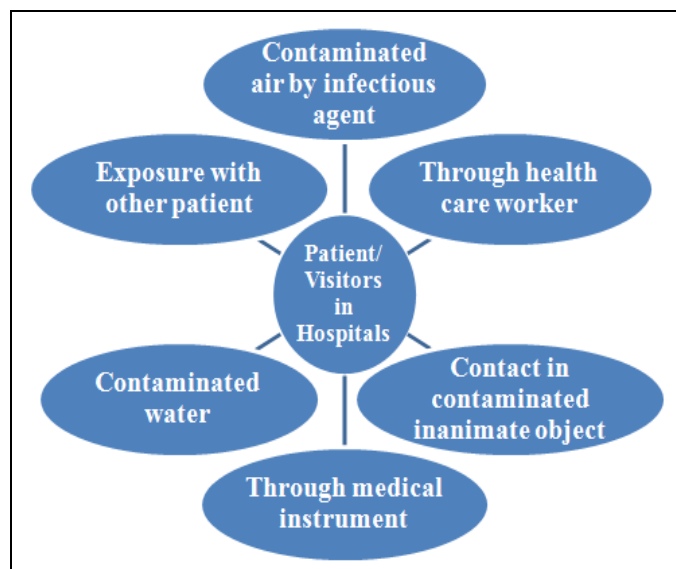
Fungus	Disease cause
<i>Candida species:</i>	Cause through invasive disease
<i>C. albicans</i>	viz., arthritis, Osteomyelitis,
<i>C. Tropicana</i>	endocarditis, Endophthalmitis,
<i>C. parapsilosis</i>	Meningitis or Fungemia
<i>C. krusei</i>	
<i>C. glabrata</i>	Conidia fungal inhalation can
<i>Aspergillus species:</i>	lead to pulmonary infection
<i>A. fumigates</i>	granulocytopenia
<i>A. flavus</i>	
<i>A. terreus</i>	The rate of infection usually
<i>Zygomycetes:</i>	preserved in
<i>Mucor species</i>	immunocompromised hosts and
<i>Absidia species</i>	rick factor involved
<i>Rhizopus species</i>	hematologic malignancy,
	myelosuppression, renal failure,
	diabetes

Vectors involve the organisms that act as a carrier for the spread of infection by dispersion of

causative pathogens. Cockroaches, ants, and flies come in direct contact with faces of the patient, and contaminated objects can cause disease by cross-contamination of other objects which can lead to infection. More than 80 bacterial species across 51 genera have been identified including antimicrobial resistance. Some of the vector transmitted diseases are enlisted in **Table 5**.

**TABLE 5: REPRESENTS VECTOR TRANSMITTED DISEASE**<sup>53</sup>

S. no.	Vector	Transmit bacteria
1	Cockroaches	<i>Enterobacter</i> <i>Enterococcus</i> <i>Salmonella</i> <i>Staphylococcus aureus</i> <i>Shigella</i> <i>Klebsiella pneumonia</i> <i>Escherichia coli</i> <i>Microbacterium</i> <i>Micrococcus</i> <i>Proteus</i>
2	Ants	<i>Pseudomonas aeruginosa</i> <i>Clostridium</i> , <i>Corynebacterium</i> <i>Listeria monocytogenes</i> <i>Pseudomonas aeruginosa</i> <i>Klebsiella pneumonia</i> <i>Staphylococcus</i> <i>Streptococcus</i>
3	Fly	<i>Bacillus species</i> <i>Salmonella</i> <i>Citrobacter</i> <i>Enterobacte</i> <i>Escherichia coli</i> <i>Salmonella typhi</i> <i>Campylobacter</i>



**FIG. 2: COMMON VEHICLE INVOLVED IN TRANSMISSION OF NOSOCOMIAL INFECTION**

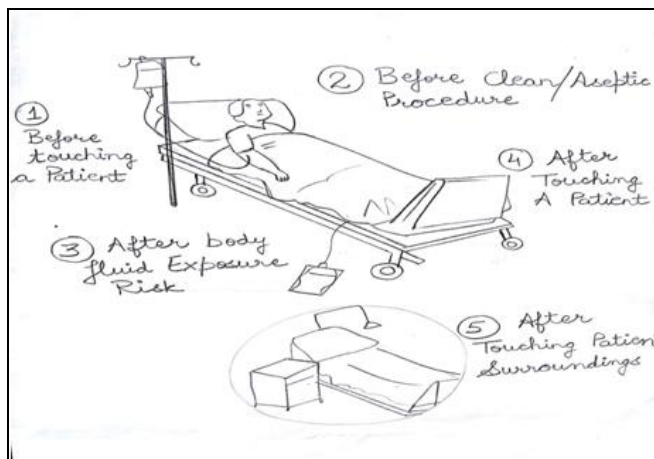
**2. Prevention of Nosocomial Infection:**

Nosocomial infection can be prevented by minimizing the spread of causative agents, isolation for the patient suffering from infectious disease and maintaining well sanitary conditions in hospitals and medical care unit. In the present review, we

have selected five significant areas, in which efforts can be made to prevent nosocomial infections.

- a) Maintenance of hygiene
- b) Avoid surgical site infection
- c) An isolation unit for a patient infected by an infectious disease
- d) Sterilization of medical equipment
- e) Validation and cleaning of hospitals environment

**2.1 Maintain Hand Hygiene:** One of the most important routes of disease transmission of the infectious agent is hand. According to WHO while visiting in hospital one should follow the standard practices as shown in **Fig. 3**.<sup>17</sup>



**FIG. 3: REPRESENTS FIVE STEPS AT WHICH HAND IN HEALTH CARE [ADOPTED FROM WHO GUIDELINE]**

Improper hand wash does not lead to complete eradication of germs and can be a reason for infection. Factors involved lack of education, poor hygiene habit, perceived lack of importance, lack of time, dry skin, skin irritation or dermatitis, the absence of suitable cleansing agent and inadequate hand washing<sup>18, 19</sup>. Spread of antibiotic-resistant strains MRSA through the hands were reported by researchers<sup>20</sup>. The rate of infection agent spread through hands can be reduced by merely following hand hygiene practice involved 11 steps of hand washing shown in **Fig. 4**.<sup>21</sup>

The normal flora of the body generally doesn't cause illness. But in the case of an immunocompromised patient who has undergone surgery or invasive procedure, the vegetation moves to another site of body and start colonization which can disrupt the normal flora leading to illness<sup>22</sup>.

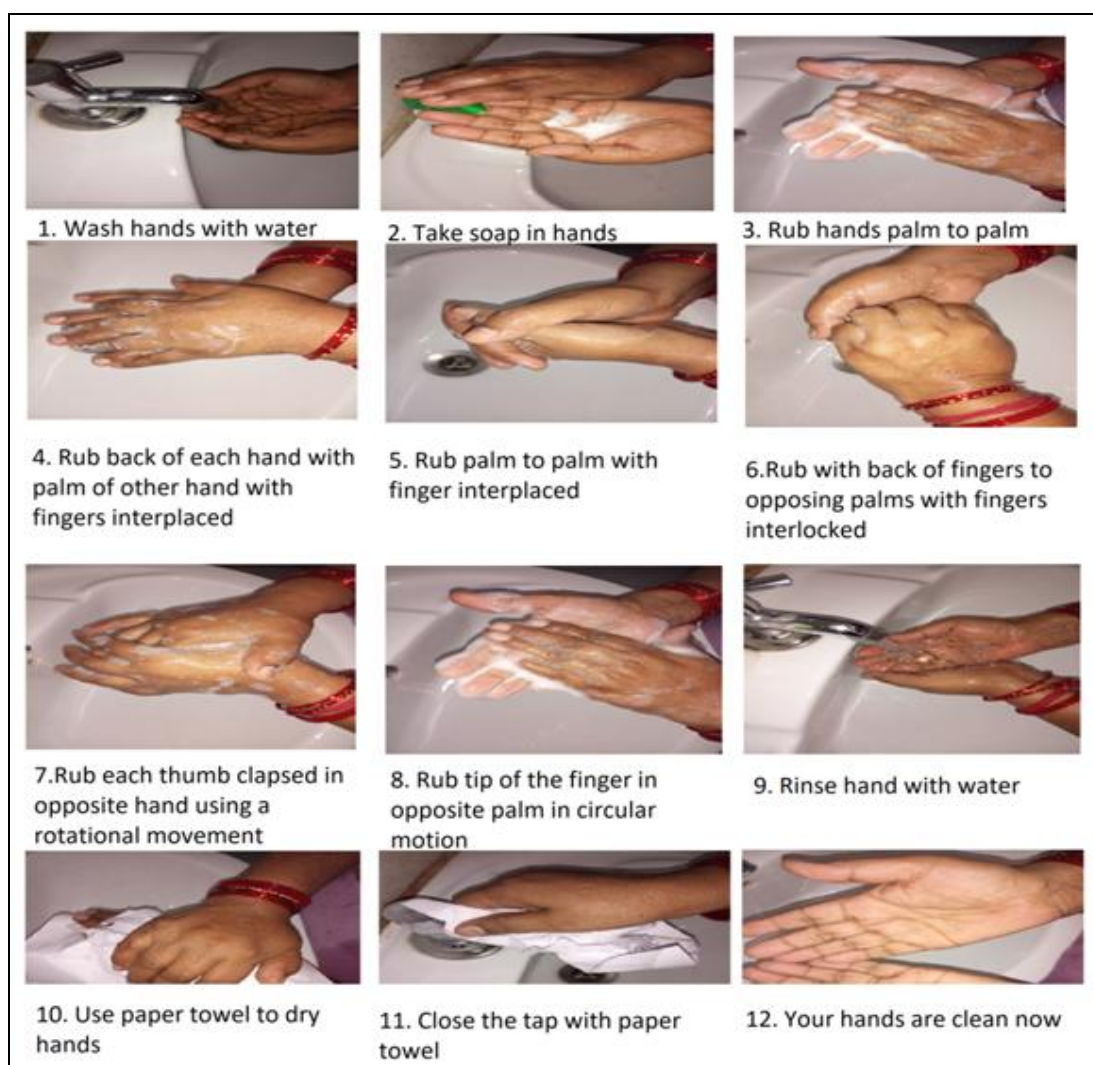


FIG. 4: SOURCE REPRESENTS STEPS OF HAND WASHING RECOMMENDED BY WHO<sup>17</sup>

**2.2 Avoid Surgical Site Infection:** Surgical site infection (SSI) is the infection that occurs within 30 days up to 1 year of the surgical process. SSI is one of the significant causes of mortality; therefore; it

must be prevented and taken in critical concern<sup>23, 24</sup>. **Table 6** depicts different risk factor involved in surgical site infection viz., age, health, a habit like (smoking, drinking, etc.) and immunity.

**TABLE 6: REPRESENTS RISK FACTOR INVOLVED IN SURGICAL SITE INFECTION**

S. no.	Risk factor	Remarks	References
1	Age	Increase in age results in the higher possibility of acquiring Nosocomial infection	54
2	Health (obesity, diabetic, immunity)	Increasing time duration of operation, disturbance in homeostasis balance in obese patients. The obese patient undergoes surgery especially laparoscopy more prone to infection as the oxygenation of subcutaneous tissue reduced which may lead to wound infection. The increase of nosocomial infection is seen in the obese patient	55, 56
3	Another habit (smoking, drinking, etc.)	Smoker is more prone to respiratory infection by bacterial <i>Streptococcus pneumonia</i> , <i>Neisseria meningitides</i> , <i>Haemophilus influenza</i> , and <i>Legionella pneumophila</i> . Smoking also associated with the risk of non-wound infections, bacteremia, and urinary tract infection	57
4	Immunity	The patients undergo organ transplantation treated with immunosuppressive drugs to avoid the rejection, and this may lead to the patient more prone to the patient susceptible to infection. The patient is in exposure to invasive instrument s and the environment contaminated with <i>Aspergillus species</i> , <i>Legionella pneumophila</i> , <i>Pseudomonas aeruginosa</i> , and other microbial pathogens	58

### 2.2.1 Preoperative Phase:

- Treat remote infection from the site of surgery before operative procedure.
- Only remove hair if they interfere in surgery and use electric clipper with a single use. Avoid use of the razor; it may increase the SSI.
- Blood sugar level must be controlled before surgery.
- To reduce staphylococcus infection nasal decolonized by intranasal mupirocin ointment for *Staphylococcus*.
- Antibiotic prophylaxis must be given to a patient undergoing surgery, and it must be well defined. The antibiotic must not be given rottenly to the patient as it has an adverse effect also. The antibiotic should be administrated intravenously timely so meaning that serum and tissue contain bactericidal concentration at the time of incision and the concentration can be maintained after a few hours of surgery.
- Appropriate skin antiseptic for skin incision preparation.
- For hand hygiene to maintain nails should be short, no artificial nails to be applied and perform preoperative scrub for 25 min using appropriate antiseptic, Scrub hands and forearms up to the elbow and keep hands up and away from the body. Flex the elbow after performing surgical scrub. Dry the side with a sterile towel.

### 2.2.1 Intraoperative Phase:

- Ventilation
  - A positive pressure must be maintained in the operation theater compared to corridors, and fifteen air changes should be maintained per hour, and three should be of fresh air.
  - Recirculated air must be fresh and filtered through the appropriate filters. The UV radiation is prohibited in Operation Theater and door should be closed except for the passage of essential requirement.
- Cleaning and disinfection

- Disinfection should be performed before and after the operation procedure and clean visible soiling and blood/fluid spread contamination by appropriate disincentive agents.
- Avoid use of trace mat at the entrance of Operation Theater.
- Microbiological sampling.
  - Routine microbiological sampling is not required daily, but monitoring of operation theater surface and air sampling can be performed as a part of the epidemiological investigation.
- Sterilization of surgical instruments.
  - All the surgical instruments must be sterilized according to the guidelines provided by CDC<sup>21</sup>.
  - Flash sterilization for the patient care instrument that will be used immediately. For example to reprocess a dropped device.
- Surgical attire and drapes.
  - Before entering the operation theater wear a surgical mask that thoroughly covers the mouth and nose.
  - For effective barrier for liquid wear surgical gowns and drapes that inhibit penetration.
  - Change Scrub suits contaminated with visibly soiled Blood or other potentially infectious material.
- Asepsis and surgical technique.
  - The aseptic condition should be maintained during the entire operative procedure.
  - Dead space must be eradicated at the surgical site. Maintenance hemostasis, minimize devitalized of tissue should be kept in concern.
  - If the surgical site is found to be contaminated, it must leave to heal incision by the second intention.
  - Use close suction drainage for the drain and a separate incision distance from the operative incision is preferred and remove waste as soon as possible.

**2.2.3 Postoperative Incision Care:** Incision must have to close by sterile dressing for 24-48 h postoperative. Before and after changing dressing and surgical contact wash hand with appropriate antiseptic.

**2.3 Isolation Unit for Patient Infected by Communicable Disease:** Isolation refers to the separation of the patient to control the infection or communicable disease. Patients are isolated according to the mode of transmission of the disease.

- **Strict Isolation:** To prevent the transmission of highly communicable disease, susceptible to transfer through contact as well as air born route for example chicken pox and rabies.
- **Respiratory Isolation:** To prevent the respiration spread of organism through droplet sneezed or breathed into by infected patient into the environment. Examples of influenza. *Mycobacterium tuberculosis*.
- **Protective Isolation:** To prevent contact between potentially pathogenic microbes and the unaffected person who is undergoing certain therapy resulting suppression of immunity. Example patient undergoing chemotherapy for the treatment of leukemia is more prone to infection.
- **Enteric Isolation:** The disease transmitted through direct and indirect oral contact with infected feces or contaminated items. Examples of dysentery and hepatitis.
- **Wound and Skin Precautions:** To prevent the spread of microorganism found in infected wounds (including burns and open sores) and contaminated articles. Precaution should be taken in infected burns, infected wounds, and infections with purulent discharge. It includes herpes, impetigo, and ringworm.
- **Blood Precaution:** It includes the prevention of the spread of blood-transmitted diseases which are due to use of infected blood-contaminated items for example use of contaminated needle; razor can be a reason of spread of blood-transmitted infection. Examples of this infection includes are HIV and HBV<sup>19</sup>.

### 2.3.1 Isolation Techniques Involved:

1. Private room with minimum ventilation of six air changes per hour. Cross circulations of air are prohibited and only allowed if there are high air filters installed.
2. An anteroom for the storage of gowns, gloves, and masks. They make a barrier between the isolated rooms and hall and possibly avoid air born spread of infectious agents from the rooms and corridors whenever the door is opened. Always maintain the negative pressure in the anteroom compared to the hall and separate air supply and exhaust for ventilation. **Fig. 5** represents differential air pressure control to confine air outflow in a single direction so that cross-contamination could be avoided.
3. Hospital personnel hygiene: It includes wearing of masks, gowns, gloves, caps, and booties. These once used should not be reused. Masks should cover the nose and mouth. High efficient disposable masks that prevent the inhalation of the infectious agent and trap infectious agent outside preferable. Before entering the isolation area, one must wear the mask and other things required include gowns, caps, and booties if required. Patients with extensive infected burns or extensive infected wounds are recommended to wear a sterile gown before dressing. Caps and booties are not required in any isolation category. Gloves should be wearing before in contact with the patient and other contaminated object and discard after use. If the used cap must cover all scalp hairs and booties should cover open ends of trousers.
4. Hands washing with soap before and after contact with the patient and other contaminated objects are must to prevent the rate of infection spread<sup>25</sup>.

**2.4 Sterilization of Medical Equipment:** A medical device or surgical instrument which comes in contact with the patient during treatment or operation procedure has an associated risk of disease transmission which is due to failure of sterilization or disinfection. The procedure of sterilization is based on the object to be sterilizing which can be divided into critical, semi-critical and non-critical objects **Table 7**.



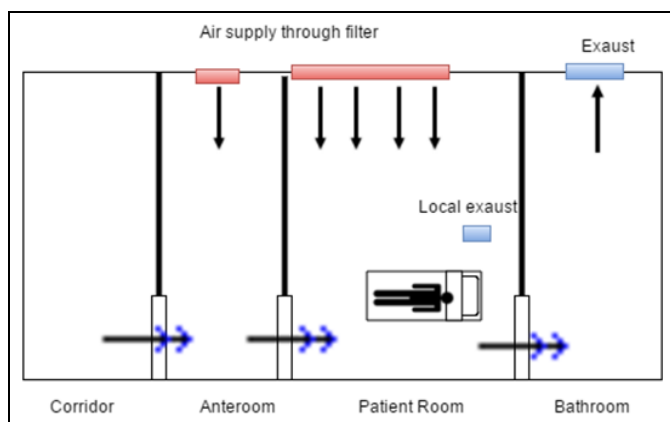


FIG. 5: REPRESENTS AIR PRESSURE CONTROL IN INFECTIOUS ISOLATED ROOM<sup>60</sup>

The hospital staff must be educated to avoid nosocomial infection, and special attention should be given to teach them about infection control and prevention.

General practices including hand wash before and after patient care, avoid touching inanimate object, wearing of gloves and mask while cleaning contaminated goods and learning than about sterilization of equipment used in patient care<sup>19</sup>.

Diarrhea caused by rotavirus is frequent in children both in developing and developed countries. Now many potent rotaviruses vaccine are tested as a potent vaccine. Two companies Merck and GlaxoSmithKline (GSK) are licensed to manufacture rotavirus-vaccines. The Merck prepared vaccine RotaTeq TM is composed of 5-rotavirus strains. The GSK Rotarix Tm vaccine is derived from a human rotavirus strain G1. These vaccines are prepared by attenuation of rotavirus to be non-pathogenic but immunogenic<sup>26</sup>.

TABLE 7: REPRESENTS DIVISION OF SUBJECT ACCORDING TO STERILIZATION REQUIREMENT

Critical object	Semi-critical object	Non-critical objects
Critical items involved surgical items, catheters (urinary and cardiac) and Ultrasound probes. These items should be purchased sterile or sterilized before use either by Heat sterilization or if the item is heat sensitive gas or chemical method can be used. Heat sterilization involved autoclave and heat sensitive items agents such as EtO, hydrogen peroxide gas, if the method is not suitable chemicals namely >2.4% glutaraldehyde-based formulations, 0.95% glutaraldehyde with 1.64% phenol/phenate, 7.5% stabilized hydrogen peroxide, 7.35% hydrogen peroxide with 0.23% peracetic acid, 0.2% peracetic acid, and 0.08% peracetic acid with 1.0% hydrogen peroxide can be used	Semicritical items contact with the skin surface and mucous membranes. It includes endoscopes, laryngoscope blades, esophageal manometry probes, cystoscopes, anorectal manometry catheters, and diaphragm fitting rings. These items require a high level of disinfection chemical	These involved the instruments which come in contact with the skin but not mucous membrane, for instance, blood-pressure cuffs, crutches, bed rails, furniture, and floor

**2.5 Microbiological Validation and Cleaning of Hospitals Environment:** Microbial air contamination is monitored by colony forming unit per cubic meter (CFU/m<sup>3</sup>) count. This can be done either by passive or active sampling methods. Passive air sampling includes measuring of Index of Microbial Air (IMA) Contamination, which is defined as the count of microbial fall out on a Petri plate of 9 cm diameter placed in area according to 1/1/1/ scheme (1 h / 1m above the floor, about 1 m away from walls or any major obstacle) and

incubate at 36 ± 1 °C for 248 h<sup>20</sup>. IMA has been divided into five classes described in Table 8 and 9.

TABLE 8: REPRESENTS CLASSES OF INDEX OF MICROBIAL AIR (IMA)

IMA value	Cfu/dm <sup>2</sup> /h range	Performance
0-5	0-9	Very good
6-25	10-39	Good
26-50	40-84	Fair
51-75	85-124	Poor
≥ 76	≥ 125	Very poor

TABLE 9: REPRESENTS ACCEPTABLE RANGE OF INDEX OF MICROBIAL AIR (IMA) IN HOSPITALS

Environment at risk	Area	Maximum acceptable level of IMA
Very high	Ultra clean room, reverse isolation, operative room, operative room for joint replacement	5
High	Conventional operating theaters, continuous care unit and dialysis unit	25
Medium	Day hospitals, hospital wards	50
Low	Facilities	75

Air monitoring surveillance is essential in the hospitals and area high in bio-risk<sup>27, 28</sup>. Active air sampling referred to the use of an air sampler, which collects known air volume that is blown on a nutrient medium. Different type of air samplers are available in the market viz., impingers, impactors (slit type), impactors (sieve type), filtration sampler, centrifugal sampler, electrostatic precipitation sampler, thermal precipitation samplers, etc. Each of these gives different result in the same place for the same duration of time. In an empty operation room where the air is provided by a conditioned and controlled ventilation system (CCVS), 500 L of air was sampled compared to the one-hour exposure of settle plate for sampling<sup>29</sup>. Air sampling should be done at regular intervals of time as there is some persons are present and active sampling should be performed for an hour and at a different site of operation room<sup>30</sup>. A considerable range of microbial contamination with turbulent airflow ranges from  $\leq 35\text{cfu/m}^3$  at rest and  $\leq 180\text{cfu/m}^3$  in Operation Theater<sup>31</sup>.

**CONCLUSION:** From the present study, it is concluded that immuno-compromised patients, children and old age people are more prone to nosocomial infection and advised to avoid unnecessary visit or exposure to the contaminant environment. Routine surveillance of medical center should be monitored and required action to keep the climate contaminant free.

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