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Hospital Infection Control

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ABSTRACT

HAI (Hospital acquired infections) are responsible for increased morbidity and mortality and increases the length of stay in hospital thereby increasing the cost. HAIs are caused by multidrug resistant (MDR) organisms which are difficult to treat and also it transmits rapidly between the patients. The rates vary between countries, within the country, within the districts and sometimes even within the hospital itself due to complex mixture of the patients, aggressive treatment and local practices of infection control. Each hospital should have infection control programme for implementation of good infection control practices and to ensure well-being of both staff and the patient by preventing and controlling HAI. Regular surveillance of HAIs in the hospital help in monitoring the prevalence and distribution of HAIs for intra- and inter-hospital comparisons and to identify high risk areas in the hospital so that possible preventive measures can be taken and further studies can be done. Infection control committee also has an important role in investigation of outbreak so that timely investigations and application of specific control measures can limit the spread of outbreak and prevent deaths. Every hospital should have a simple, flexible and regularly updated antibiotic-prescribing policy on a disease specific basis, depending on the knowledge of antibiotic sensitivity pattern and limiting the use of reserved antibiotics in the hospital. Antibiotic policy constitutes one of the most important aspects of infection control programme to prevent the emergence of MDR organisms and to avoid wasteful expenditure of the hospital. Biomedical waste management also has a major role in prevention of HAI and its complications.

Keywords: Hospital Acquired Infection, Infection Control, Surveillance, Multidrug Resistant Organisms, and Antibiotic Policy.

INTRODUCTION

“Hospital acquired infection” (HAI) is defined as an infection occurring in a patient in a hospital or other health care facility in whom the infection was not present or incubating at the time of admission. This also includes infections acquired in the hospital but appearing after discharge, and occupational infections among staff of the facility. Infections occurring more than 48 hours after admission are usually considered HAI [Benson, 1995]. Infection is more common in hospitalised patients due to suppressed immunity, various medical procedures, introduction of invasive devices, presence of drug resistant organisms in hospital population and poor infection control practices. HAI are responsible for increased morbidity and mortality and increases the length of stay in hospital thereby increasing the cost. HAIs are caused by multidrug resistant (MDR) organisms which are difficult to treat and also it transmits rapidly between the patients [Proceeding of Atlanta Georgia, 1990]. HAIs are further characterised as endogenous and exogenous infection. Endogenous infection is an infection caused by the patient’s own flora due to damage to tissue or inappropriate antibiotic that allows overgrowth. E.g. *E.coli* causes SSI after abdominal surgery or UTI in catheterised patients. Exogenous infection is acquired from the environment or from inanimate objects like water, linen, equipments, droplets, dust etc. It may also be caused by a microorganism acquired from another person or members of staff in the hospital (cross-infection). HAIs account for 5-10% of infections in developed countries, while 10-30% in developing countries. However, the rates vary between countries, within the country, within the districts and sometimes even within the hospital itself due to complex mixture of the patients,

aggressive treatment and local practices of infection control. Hospital infection control programs can prevent 33% of nosocomial infections [Horan and Gaynes, 2004].

Factors influencing the development of HAIs

I. Agent: The patient is exposed to a variety of microorganisms during hospitalization. Various factors of microorganisms like resistance to antimicrobial agents, virulence, and inoculum of infective material aid in development of HAIs.

II. Host: Important patient factors influencing acquisition of infection include age, immune status, underlying disease, and diagnostic and therapeutic interventions. Extremes of age (infancy and old age), immune suppressed conditions like HIV, diabetes mellitus, malignancy, steroid therapy, irradiation or immunosuppressive drugs increase the chances of infections. Breach in the skin or mucous membrane e.g. burns bypass natural defence mechanisms.

Many diagnostic and therapeutic procedures, such as biopsies, endoscopic examinations, catheterization, intubation and suction and surgical procedures increase the risk of infection.

III. Environment: Crowded conditions within the hospital, frequent transfers of patients from one unit to another, and highly susceptible patients in one area (e.g. newborn infants, burn patients, intensive care) all contribute to increase in HAIs. Microbes may contaminate objects, devices, and materials which come in contact with susceptible body sites of patients. Use of antibiotics suppress the sensitive strains, however resistant strains persist and these resistant genes can also be transferred to other micro-organisms via transferrable genetic elements thereby contributing to the emergence of MDR strains in the hospital [Ducel, 2012].

Types of HAI

1. Urinary tract infection (UTI): UTI is the most common HAI and 80% of UTI is associated with the use of indwelling catheter i.e. Catheter associated UTI (CA-UTI). Positive urine culture (1 or 2 species) with at least 10^5 bacteria/ml, with or without clinical symptoms is considered as UTI. It is either caused by the organisms present in the gut flora (*E.coli*) or acquired from the hospital environment (multiresistant *Klebsiella*, *Pseudomonas aeruginosa*, *proteus* etc) [5].

2. Surgical site infection (SSI): Any purulent discharge, abscess, or spreading cellulitis at the surgical site during the month after the operation is considered as SSI. The incidence of SSI is variable ranging from 0.5 to 15% depending on the type of operation and underlying patient status. The infection is usually acquired during the operation itself; either exogenously (e.g. from the air, medical equipment, surgeons and other staff), endogenously from the flora on the skin or in the operative site or, rarely, from blood used in surgery. It has an high impact on hospital cost and increases postoperative length of stay in hospital further exposing to risk of HAIs. Factors contributing to SSI are extent of contamination during procedure (clean, clean-contaminated, contaminated, dirty), duration of operation, patient's general condition, presence of foreign bodies including drains, the virulence of the microorganisms, concomitant infection at other sites and the quality of surgical technique [Ducel, 2012].

3. Respiratory tract infection (RTI) Respiratory symptoms with at least two of the following signs appearing during hospitalization i.e. cough, purulent sputum, fever, new infiltrate on chest radiograph consistent with infection is suggestive of pneumonia. Hospital acquired pneumonia (HAP) is defined as

an inflammatory condition of the lung parenchyma caused by infectious agents not present or incubating at the time of hospital admission; that is, conditions that develop more than 48 h after admission. In intensive care units, rate of pneumonia is high due to the presence of ventilators called as ventilator associated pneumonia (VAP), associated with high case fatality rate [Garner et al., 1988]. Microorganisms may colonize the stomach, upper airway and bronchi, and cause pneumonia, they are often endogenous (digestive system or nose and throat), or may be exogenous derived from contaminated respiratory equipment. Diagnosis is made by quantitative microbiological sampling technique. Various risk factors associated with pneumonia include the type and duration of ventilation, the quality of respiratory care, severity of the patient's condition (organ failure), previous use of antibiotics, patients with seizures or decreased level of consciousness.

4. Bloodstream infections (BSI): Fever or rigours and at least one positive blood culture suggests BSI. It has a high case fatality rate, particularly when caused by MDR strains. the incidence of BSI is increasing particularly for Coagulase negative staphylococcus and *Candida* spp. The main risk factors are the length of catheterization, level of asepsis at insertion, and continuing catheter care and they are described as catheter related bloodstream infections (CA-BSI). Infection may occur at the skin entry site of the intravascular device, or in the subcutaneous path of the catheter which may produce bacteraemia without visible external infection. The resident skin flora is most commonly responsible for bacteremia.

5. Other nosocomial infections

- Skin and soft tissue infections: open sores (ulcers, burns and bedsores) encourage bacterial

colonization and may lead to systemic infection.

- Gastroenteritis: It is mostly caused by *Clostridium difficile* due to use of antibiotics. In children, rotavirus is the most common cause of nosocomial diarrhoea.
- Eye and conjunctival infections are rare.
- Endometritis and other infections of the reproductive organs following childbirth.

Microorganisms responsible for HAI

The infecting organisms vary among different patient populations, different health care settings, different facilities, and different countries.

Bacteria: These are the most common nosocomial pathogens. Gram-positive bacteria: *Staphylococcus aureus*, *Coagulase negative Staphylococcus*, *Enterococcus* are responsible for wide variety of HAI in the form of SSI, BSI, skin and soft tissue infections. CoNS are readily able to form biofilms, and cause infections associated with indwelling foreign devices such as intravenous catheters, shunts, prosthetic joints, and pacemakers. MDR organisms like MRSA (methicillin resistant *S. aureus*), VRSA (Vancomycin resistant *S. aureus*) and VRE (Vancomycin resistant enterococci) are recent threats among HAIs which have high morbidity and mortality and difficult to treat with very limited reserve antibiotics. Gram-negative bacteria: Enterobacteriaceae (e.g. *Escherichia coli*, *Proteus*, *Klebsiella*, *Enterobacter*, *Serratia marcescens*) can cause serious infections like UTI, SSI, BSI. *Pseudomonas* and *Acinetobacter* spp. are important causes of VAP, BSI, UTI etc. *Legionella* species may cause pneumonia (sporadic or endemic) through inhalation of aerosols containing contaminated water (air conditioning, showers, therapeutic aerosols etc.).

Viruses: Hepatitis B and C, HIV are important cause of needle stick injury [Ducel, 2012]. Other viruses such as cytomegalovirus, rotavirus, influenza viruses, herpes simplex virus, and varicella-zoster virus, may also be transmitted.

Parasites and fungi: Many fungi and other parasites are opportunistic organisms and cause infections during extended antibiotic treatment and severe immunosuppression (*Candida albicans*, *Aspergillus* spp., *Cryptococcus neoformans*, *Cryptosporidium*, *Cyclospora*, *Isospora* etc.).

Routes of transmission of HAI

There are five major routes of transmission of HAI and are summarised below:

- ✓ **Contact spread:** It is the most common route of transmission of HAI. It may be due to direct spread from person to person (*Staphylococcus aureus*) or by indirect spread via contaminated hands or equipments (*Pseudomonas* infection)
- ✓ **Inhalation of aerosols and droplets:** HAIs may be transmitted by inhalation of aerosols (<5 µm in diameter), droplet nuclei (>5 µm in diameter), dust from bedding, floors etc. Eg. *Mycobacterium tuberculosis*, gram negative respiratory infections, measles etc.
- ✓ **Oral route:** pathogens may be transmitted via water or foods served in the hospital, also these routes are responsible for transmission of drug resistant organisms. Eg. *E. coli*, *Pseudomonas* spp., *Salmonella* etc.
- ✓ **Parenteral route:** transmission of infection by needle, syringes and other devices during blood transfusion, contaminated blood products or from accidental injury with contaminated sharp instruments, eg. HIV, Hepatitis B and Hepatitis C infection. Infection is

also possible by inoculation of contaminated intravenous fluids like normal saline etc.

- ✓ **Self infection:** it is caused when infection is transmitted from patient's own flora like skin, nose, nasopharynx or bowel. Eg. *S. aureus*, *E. coli* etc.

Infection control programme (ICP):

This programme mainly focus on different measures to be carried out for reducing the incidence of HAI. Each hospital should have infection control programme for implementation of good infection control practices and to ensure well- being of both staff and the patient by preventing and controlling HAI [Haley et al., 1985].

Objectives of ICP

- Monitoring of HAI
- Training of staff in prevention and control of HAI
- Investigation of outbreak
- Controlling outbreak by rectification of technical problems
- Monitoring of staff health to prevent staff to patient and patient to staff spread of infection
- Advice on isolation procedures and infection control measures
- Infection control audit including inspection of waste disposal, laundry and kitchen
- Monitoring and advice on safe use of antibiotics.

Responsibilities of hospital administrator:

- Provide funds and resources for infection control programme
- Ensure safe and clean environment
- Ensure availability of safe food and drinking water
- Ensure availability of sterile supplies and materials and
- Establish infection control committee and team

Infection control organisation is the essential feature of infection control programme. It includes

1. Infection Control Committee(ICC)

An Infection Control Committee formulates policy for prevention and control of HAIs. It includes representative of microbiology, medicine, nursing, administrative, pharmacy, central supply, maintenance, and housekeeping, training services etc. one member is elected as a chairperson and has a direct reporting relationship to the head of hospital administration

or the medical staff to promote programme visibility and effectiveness. The Committee should meet regularly to formulate and update the policy for all areas in the hospital and having implications for infection control. The purpose of this committee is to conduct surveillance and monitoring hygiene practices to control infection and education of all staff regarding infection control measures. Close working links between the microbiology laboratory and clinical specialities are important to establish and maintain the infection control policy, and to ensure that it is rationally based and that the recommended infection control practices are practicable [Schechler et al., 1998].

2. Infection Control Officer (ICO)

Generally, infection control officer is the medical microbiologist or it could be any physician with interest in HAI. Functions of infection control officer:

- ICO is the secretary of ICC and responsible for recording minutes and arranging meetings.
- Identification and reporting of pathogens and their antimicrobial sensitivity testing.
- Regular analysis and dissemination of antimicrobial resistance data, emerging pathogens and unusual laboratory findings.
- Initiating surveillance of hospital infection and detection and investigation of an outbreak.

- Regular training and education of hospital staff in infection control procedures and practices.

3. Infection Control Nurse (ICN)

Senior nursing staff is appointed for full time as infection control nurse and is allotted with various functions:

- She has to collaborate with infection control officer on surveillance of infection and detection of outbreak.
- She is trained for collecting surveillance samples and preliminary processing.
- Training and education of other nursing staff under supervision of infection control officer.
- Increase awareness among patients and visitors about infection control.

4. Infection Control Manual (ICM)

Each hospital should develop its own infection control manual and updated timely by the infection control officer and committee. It should be modified based on local circumstances and risks of infection and it must be available readily for patient care [Haley et al., 1985].

Surveillance of Hospital Acquired Infections

According the Centers for Disease Control and Prevention (CDC), epidemiologic surveillance is “the ongoing systematic collection, analysis, and interpretation of health data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know” [Gaynes 1998]. Surveillance information has many uses, including monitoring disease trends, describing the natural history of diseases, identifying epidemics or new syndromes, monitoring changes in infectious agents, identifying areas for research, evaluating hypotheses, planning public health policy, and evaluating public health policy and interventions [Buehler et al., 2004]. The ultimate aim of surveillance of HAI is the

reduction of nosocomial infections, and their costs.

Objectives of surveillance of HAI:

- Improve awareness of clinical staff about hospital acquired infections and increasing antimicrobial resistance, so that preventive measures can be taken for infection control.
- To monitor the prevalence and distribution of HAIs for intra- and inter-hospital comparisons.
- To identify the high risk areas in the hospital where HAIs are maximum, so that possible preventive measures can be taken and further studies can be done.
- To identify the need for new or intensified prevention programmes for control of infection.

Surveillance is classified as passive or active. In Passive surveillance, local and state health departments rely on health care providers or laboratories to report cases of disease. Its primary advantage is that it is simple and requires relatively few resources. But, there is possibility of incomplete data due to underreporting. However, majority of public health surveillance systems are passive. In Active surveillance, health department contacts health care providers or laboratories requesting information about conditions or diseases to identify possible cases and requires more resources than passive surveillance. However it is useful in conditions when it is important to identify all cases [Lee et al., 1998]. Example: between 2002 and 2005, active surveillance used to detect adverse events associated with smallpox vaccine. Prevalence rate of HAI is defined as the number of infected patients at the time of study as a percentage of number of patients observed at the same time. The point prevalence rate comprises all the cases of a disease that exist at a point in time while Period prevalence is all cases

whether old, new or recurrent, arising over a defined period, say a year or two and the denominator is the average population over the period.

Targeted surveillance

- **Site-oriented surveillance:** The target is to monitor infections with significant morbidity and mortality with increase hospital stay leading to increase in the cost. E.g. VAP (ventilator associated pneumonia), SSI (Surgical Site infection).
- **Unit-oriented surveillance:** Surveillance is to be conducted in high risk areas. Eg. ICUs, burn units, surgical units, neonatology.
- **Priority-oriented surveillance:** Surveillance to be undertaken for a specific issue of concern in the hospital. Eg. Surveillance of UTI in catheterised patients in long term care facility [Ducel, 1988].

HAI surveillance includes data collection, analysis and interpretation, feedback leading to interventions for preventive action, and evaluation of the impact of these interventions. While surveillance is focused in high-risk sectors, some surveillance activity should occur for the rest of the hospital. For Data collection, training of the staff regarding HAI and its prevention and information regarding filling the minimum data collection form for calculation of infection rate is done. Analysis includes the description of the population, frequency of risk exposure and infections, calculation of rates, comparisons of patient groups and comparisons of rates over time. National Nosocomial Infection Surveillance (NNIS) system which was replaced by the National Health Safety Network (NHSN) is a voluntary reporting system that monitors components of HAIs, including those in acute-care settings. This system uses strict definitions, standard case-

finding procedures, and risk stratification to generate data that are fed back to participating institutions and later used as benchmarks [NNIS, 1999]. Computer software has been developed which integrates microbiological, clinical, radiographic, and pharmacy data, and allows automated surveillance for HAIs. In Automated surveillance systems, the infection control team is free and can focus on infection prevention, policy implementation, and educational activities [Wright et al., 2004].

Investigation of an outbreak:

Outbreak can occur anywhere from a very remote area to nosocomial outbreaks in a sophisticated hospital. While outbreaks cannot always be predicted or prevented, recognition of early warning signals, timely investigations and application of specific control measures can limit the spread of outbreak and prevent deaths. Outbreak is defined when diseases or health events occur at a greater frequency than normally expected in a specific place and person. Even a single case of emerging disease is outbreak or two cases linked epidemiologically to each other and transmitted from person to person is also outbreak [Gordis, 1996].

Why to investigate?

- To identify etiological agents
- To find source of infection by studying occurrence of disease and
- To formulate recommendations to prevent further transmission

Steps of outbreak investigation:

Step 1: Confirm existence of outbreak i.e. when observed number of cases exceeds the expected number.

Step 2: Verify the diagnosis and determine the etiology: Verify the diagnosis by clinical findings and laboratory results. Several patients with disease to be visited to know about the etiology.

Step 3: Define and identify cases: Case definition is a standard set of criteria for

deciding whether an individual should be classified as having health condition of interest and it is divided as confirmed, probable or suspect cases. Confirmed case is the case with positive laboratory report, probable case is the patient having typical clinical picture but without laboratory confirmation, while possible case is patient presenting with fewer symptoms or with atypical symptoms. All the collected information is described in a standard format known as line listing, which helps investigator to scan key information on every case and update it easily.

Step 4: Descriptive data collection and analysis: the data needs to be oriented in terms of time, place and person.

Step 5: Generate hypothesis: Hypothesis needs to be generated regarding disease, reservoir, routes of transmission, known risk factors or any other association.

Step 6: Testing hypothesis: hypothesis is tested by analytical studies like case control study or cohort study, and p value is determined to assess the statistically significant findings of the study.

Step 7: Refine hypothesis and carry out additional studies: additional studies in the form of environmental or laboratory studies to conclude to the hypothesis.

Step 8: Implementing control and preventing measures: control measures should be implemented as soon as possible. Preventive measures are aimed at specific links in chain of transmission, agent, source or the reservoir. Eg. Destroying contaminated food, water or mosquito breeding places.

Step 9: Follow up of control implementation: follow up studies need to be undertaken to regulate the improvements achieved by infection control measures.

Step 10: Communicate findings: findings of outbreak investigation are communicated to the health authorities in

the form of written document which serves as a record of performance and reference. Document briefly describes relevant data, method of collection of samples, performed analysis and interpretation, control measures implemented, effectiveness of control measures and further recommendations regarding future surveillance and control [14].

Prevention of Hospital acquired infections:

It is an integrated, monitored, programme which includes the following features:

- Limiting transmission of organisms between patients during patient care through adequate use of PPE (personal protective equipment) and thorough hand washing, aseptic techniques, isolation practices and sterilization and disinfection practices.
- Minimizing invasive procedures and pre-operative disinfection of patient's skin thereby limiting the risk of endogenous infections
- Rational antibiotic prophylaxis
- Prevention of infection in staff members and enhancing education regarding infection control practices
- Proper surveillance of HAIs and treatment of patients and the carriers accordingly

Infection control is the responsibility of all health care professionals — doctors, nurses, therapists, pharmacists, etc. Isolation and other barrier precautions must have clearly written policies which are standardized, and adaptable to the infectious agent and the patients.

Standard Precautions are used in the care of all hospitalized individuals regardless of their diagnosis or possible infectious status. These are typically practiced in any environment where health care workers are exposed to highly infectious body fluids, such as blood, semen, vaginal secretions, synovial fluid, amniotic fluid,

cerebrospinal fluid, pleural fluid, peritoneal fluid, pericardial fluid. However body fluids which are considered as less infectious includes faeces, nasal secretions, urine, vomitus, perspiration, sputum and saliva unless they are mixed with blood or other infectious body fluids [Ducel, 2012].

Standard precautions to be taken for all patients

- Wash hands promptly after contact with infective material and after removing gloves
- Use no touch technique wherever possible
- Wear gloves when in contact with blood, body fluids, secretions, mucous membranes and contaminated items. Appropriate environmental and equipment cleaning, disinfection, and sterilization.
- All sharps should be handled with extreme care
- Clean up spills of infective material promptly
- Ensure that patient-care equipment, supplies and linen contaminated with infective material is either discarded, or disinfected or sterilized between each patient use
- Ensure appropriate waste handling [WHO, 1995]

Transmission-Based Precautions are used in addition to standard precautions for patients in hospitals with suspected infection with pathogens that can be transmitted by airborne, droplet or contact routes.

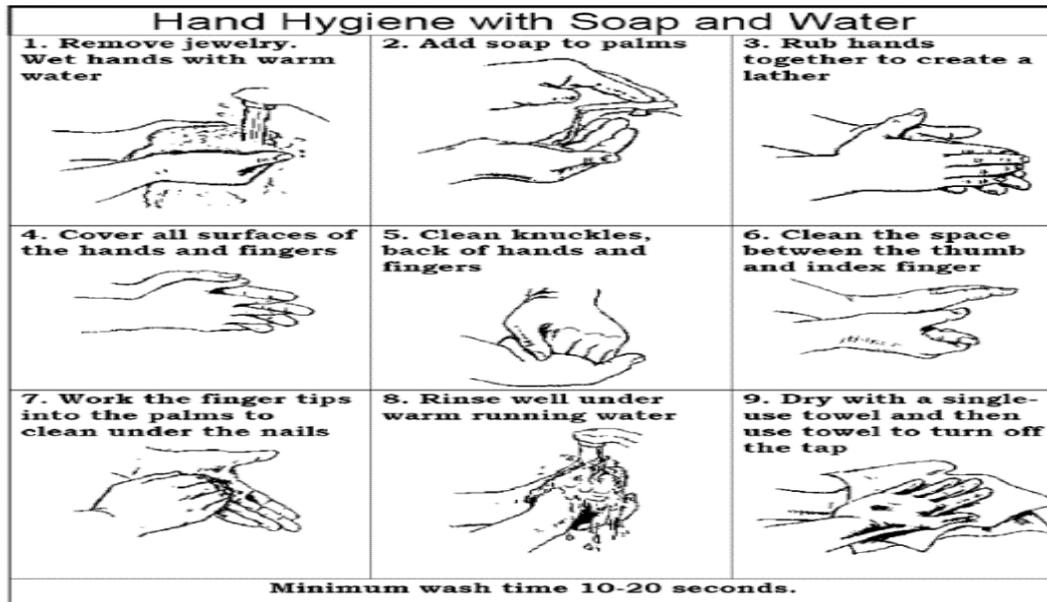
The following precautions need to be taken to prevent airborne infection and contact infection:

- Individual room for patient with adequate ventilation; if possible under negative pressure; door closed; at least six air exchanges per hour; exhaust to outside.

- High efficiency mask and PPE for all health care workers.
- Restrict patient movement outside the room and entry of visitors and staff in the room.
- Daily disinfection and terminal disinfection of the linen and other medical equipments at the end of the stay.
- Absolute isolation is required when there is risk of infection by a highly virulent or other unique agent (eg. Haemorrhagic fevers, MRSA, VRSA i.e. *vancomycin-resistant S. aureus* etc) [WHO, 1995].

Hand Hygiene

Hands should be washed as soon as possible when come in contact with potentially infectious materials, before wearing gloves, after removing gloves, before doing any invasive procedure, in between patient and before leaving the working areas. A vigorous hand-washing with a mild soap or alcohol based rub for 20-40 full seconds is appropriate. Alcohol based rub is equally efficient as soap and water however it cannot be used in visibly soiled hands where hand washing with soap and water is ideal [Pratt et al., 2001]. Simple hand hygiene procedure may be limited to hands and wrists; while surgical procedures include the hand and forearm and the duration is increased to 3-5minutes. Ideally, liquid soap dispensers should be provided in all the wards of the hospital, which should be regularly cleaned and maintained. If not feasible, soap bars after washing should be left in a dry tray to prevent contamination with some microorganisms which grow in moist conditions. Drying of hands should be done by disposable towels, reusable sterile single use towels or roller towels which are suitably maintained.



Steps of Hygiene

Personal hygiene

All staff should maintain good personal hygiene like nails must be clean and kept short and hair must be pinned up. Staff should wear a white apron above the clothes white coat. In aseptic units like ICUs, burn unit and in operating rooms, staff should wear dedicated shoes, and caps which completely cover the hairs.

Personal Protective Equipment

The appropriate personal protective equipment (PPE) need to be worn as the primary barrier of protection whenever dealing with infectious material like blood and body fluids and removed immediately if gross contamination of PPE occurs. Infection control committee is responsible for the initial demonstration and periodic follow-up of proper use of PPE.

Face Protection: When splash or splatter of infectious substances is anticipated, like while performing surgical procedure, appropriate face protection should be worn. Such equipment would include cap, goggles and face mask. Staffs must wear mask when dealing with airborne infections like tuberculosis etc [WHO, 2001]. N-95 and triple layer mask is used

while handling of patient's samples who are suspected of Avian influenza.

Lab Coats and Gowns: Long sleeved lab coats or gowns should be worn to protect skin and street clothes from contamination. In circumstances when splash or splatter is anticipated, the garment must be resistant to liquid penetration. Reusable clothing should be laundered on-site or by a laundering service. Personnel should not wash hospital gowns at home.

Gloves: Sterile gloves should always be worn when dealing with infectious material. Staff should wear disposable gloves for surgery, care for immune compromised patients, during invasive procedures etc. Disposable gloves can provide an adequate barrier between the hospital staff and infectious materials. Double gloves should be considered when handling sharp items and should be changed immediately after any accidental puncture [Knight, 1973].

Disposable Shoe-covers/Booties: When significant splash and splatter are anticipated, shoe-covers/booties should be considered. Prior to exiting the

infected area, these must be removed and disposed of properly.

Management of a spill

If there is a spill of infectious or potentially infectious material, the following procedure should be used:

1. Wear gloves and protective clothing, including face and eye protection if indicated.
2. Cover the spill with some absorbent material like cloth or paper towels to contain it.
3. Pour an appropriate disinfectant over the paper towels and the immediately surrounding area (generally, 5% bleach solutions are appropriate)
4. Apply disinfectant concentrically beginning at the outer margin of the spill area, working toward the centre.
5. After the appropriate amount of time (e.g. 30 min), clear away the materials. If there is broken glass or other sharps involved, use a dustpan or a piece of stiff cardboard to collect the material and dispose the contaminated materials into a leak proof, puncture-resistant waste disposal container [Ducel, 2012].

Prevention of environmental transmission

Hospital should be divided into various areas according to the risk of patient population for acquisition of infection. Low-risk areas include the administrative sections, Moderate-risk area includes regular patient units, High-risk-areas include isolation unit, intensive care units, oncology, burn unit, neonatology unit etc. and Very-high-risk areas include operating theatres. Infected patients must be separated from immune compromised patients and contaminated areas must not compromise non-contaminated areas. The number of organisms present in room air depends on the number of people occupying the room, amount of movement in the room, and the rate of air exchange. Adequate ventilation and

negative air pressure removes airborne bacterial contamination. Negative air pressure produces an inflow around openings and reduces the movement of contaminated air out of the area. All outdoor air inlets must be located as high as possible above ground level and away from discharge outlets. High-efficiency filters must be provided in high and very high risk areas. Regular inspection and maintenance of filters, humidifiers, and grills in the ventilation system must be performed and documented [Ducel, 2012 and Knight 1973].

Operating room (OR) environment

The microbial level in OR is directly proportional to the number of individual entering in the room, hence trafficking should be minimum during surgery. Sliding doors should be preferred in OR as swinging door movement creates turbulence. HEPA (High-efficiency particulate air) filters which removes particles $>0.3\mu\text{m}$ with an efficiency of 99.97% should be used especially for high risk surgeries like neurosurgery. OR should be ventilated with 15-20 air changes per hour and should be under positive pressure relative to surrounding corridors to minimize inflow of air into the room. Temperature of 20-22°C and humidity of 30-60% should be maintained [Knight 1973]. Fumigation of operation room should be done regularly. Air sampling should be done regularly in various OR by settle plate method or slit sampler method.

Settle plate method: It measures the rate at which bacteria carrying particles especially the large particles settle by gravity on the exposed culture plate. Blood agar plates are exposed for 30-60 minutes followed by incubation at 37°C for 24hrs and the number of colonies counted.

Slit sampler method: It counts the number of bacteria-carrying particles

contained in one foot³ of air. Air is directed through a slit 0.25mm wide to a mechanically rotated plate. Plates are incubated at 37°C for 24hrs and the number of colonies counted.

Bacterial count should not exceed 10 per foot³ in general OR and 1 per foot³ in OR for neurosurgery.

Quality of water in hospital environment

The physical, chemical and bacteriological characteristics of water used in health care institutions must meet local regulations. Organisms present in tap water have frequently been implicated in HAIs. *Pseudomonas aeruginosa*, *Stenotrophomonas maltophilia*, *Serratia marcescens*, *Acinetobacter calcoaceticus*, *Legionella pneumophila* and *Mycobacterium chelonae* or *Mycobacterium avium-intracellulare* are commonly present in tap water and can cause burn wound infections, surgical site infections and respiratory tract infections [WHO, 1993]. Sterile water used for the preparation of drugs and dilution water for haemodialysis must be pyrogen-free. Infection control team should have written policies for water quality to minimize risk of adverse outcomes attributable to water in health care settings. Bacteriological sampling of water of various areas should be done regularly in the hospital setting. Presumptive coliform count can be tested with multiple tube test and the results are determined using McCrady probability table.

Disinfection and Sterilisation

Adequate methods for cleaning, disinfection and sterilisation is required for preventing transmission of HAIs. 90% of microorganisms are present within "visible dirt" hence wet mopping of hospital is necessary. Disinfection removes microorganisms without complete sterilization to prevent transmission of organisms between patients. There must be disinfection policy

in every hospital because the choice of disinfection for a particular purpose is important because too low concentration will be ineffective and too high concentration is uneconomical and possibly hazardous. Disinfection of area with visible contamination with blood or body fluids prior to cleaning is necessary. Different products achieve different level of disinfection and they are classified as high, intermediate or low-level disinfection. **High-level disinfection** (critical) — this will destroy all microorganisms, with the exception of heavy contamination by bacterial spores. **Intermediate disinfection** (semi-critical) — this inactivates *Mycobacterium tuberculosis*, vegetative bacteria, most viruses and most fungi, but does not necessarily kill bacterial spores. **Low-level disinfection** (non-critical) — this can kill most bacteria, some viruses and some fungi, but cannot kill more resistant bacteria such as *M. tuberculosis* or bacterial spores [Alvarado and Reichelderfer, 1999].

There are certain organisms like *Pseudomonas* spp. who have tendency to survive and flourish in the disinfectant like savlon. Hence disinfectant testing from high risk areas should be done regularly to assess its efficacy and to check for any contamination. Commonly used test are phenol coefficient test, capacity test, in use test etc. However, **In use test** is the simplest and economical and most commonly used test in various hospitals. Here 1ml of disinfectant mixed with 9ml of nutrient broth and then 0.02ml drop is put in 10 different areas in two nutrient agar plates. one plate incubated for 3 days at 37°C and other plate at 25°C for 7 days and failure of disinfection is considered when growth is seen in >5drops. Sterilization is the destruction of all microorganisms including spores. Sterilization is required for medical

devices and surgical instruments penetrating sterile body sites, as well as all parenteral fluids and medications. Sterilisation procedures could be thermal or chemical. Thermal methods include autoclave, hot air oven etc. while, chemical sterilisation includes Ethylene

oxide and formaldehyde and peracetic acid in automated systems. Sterilisation controls in the form of chemical control and biological control is required regularly for all the sterilisations equipments used in the hospital.

Table showing level of disinfection for patient equipment

Devices Use	Class	Level of risk	Level of disinfection	Spectrum of activity	Examples
Devices entering into vascular system, sterile cavity, tissues. e.g. Athroscopes, biopsies, instrumentation, etc.	critical	high	high-level disinfection	All microorganism, except few bacterial spores	Peracetic acid, Formaldehyde, Glutaraldehyde, Peracetic acid, hydrogen peroxide, Ortho-phthalaldehyde etc.
Mucous membrane contact, non-intact skin: e.g. gastroscopy, endoscopy etc.	semi-critical	medium	Intermediate level disinfection	All microorganism including tubercle bacilli, except bacterial spores	Phenol derivatives, Ethyl and isopropyl alcohols
Intact skin or without contact with patient: e.g. beds, sink, etc.	non-critical	low	Low level disinfection	most bacteria, some viruses and some fungi	Quaternary ammonium compounds

Antimicrobial Resistance

Multidrug resistant organisms are increasing worldwide due to overuse or misuse of antibiotics. Resistant bacteria may cause increased morbidity and mortality, particularly among patients with significant underlying diseases or who are immune compromised. In hospital the MDR spread amplifies due to highly susceptible population and the continuous use of antimicrobial agent's increases selection pressure favouring the emergence, multiplication, and spread of resistant strains [Shlaes, 1997]. The

spread of multiresistant strains of *S. aureus* (MRSA) and VRE may cause epidemics. The following precautions are required for the prevention of spread of MRSA and VRE [Muto et al., 2003 and Siegel et al., 2007]:

- Active surveillance for detection of cases and carriers, and their isolation in isolation unit.
- Re-inforce hand washing by staff after contact with infected or colonized patients
- Use PPE for handling MRSA-contaminated materials, or infected or

- colonized patients. Ensure careful handling and disposal of medical devices, linen, waste, etc.
- Treatment of nasal carriers with mupirocin ointment and daily antiseptic detergent wash for MRSA carriers.
- Antimicrobial stewardship to avoid inappropriate or excessive antibiotic use.

Table showing specific measures to be taken to reduce common HAIs

Infections	Measures to be taken
Urinary tract infection	Minimum duration of catheter Follow aseptic techniques during insertion of catheter Perineal cleaning with an antiseptic solution prior to insertion Maintain closed drainage system [CDC, 1983]
Surgical site infection	Surgical technique Clean operating environment Personal protective equipment Short duration of surgery or minimum contaminated surgery Minimum entry in the operating room Limiting preoperative hospital stay Preoperative shower and local skin preparation of patient Limited antibiotic prophylaxis Aseptic practice in operating room [Mangram et al., 1999]
Pneumonia	Aseptic intubation and suctioning Limited duration of ventilation Prefer non-invasive ventilation Physiotherapy to assist with drainage of secretions Influenza vaccination for staff Isolation policy if infected from aerosol transmitted disease Sterile water for oxygen and aerosol therapy [Tablan et al., 1994]
Vascular device related blood stream infections	Limit duration Local skin preparation and aseptic technique at insertion Closed system maintained Cover the catheter site by transparent dressing Removal if infection suspected Antibiotic-coated catheter for short term use [Wijngaerden and Bobbaers, 1997]

Antibiotic policy

Antibiotic policy constitutes one of the most important aspects of infection control programme to prevent the emergence of MDR organisms and to avoid wasteful expenditure of the hospital. The prerequisites of an antibiotic policy are data of resistance among commonly isolated organisms in the community and hospital setting, pattern of resistance to newer antimicrobial agents and recognition of the trends of

resistance. Antibiotic committee should carry intermittent audits to explore the appropriateness of antimicrobial use. Hence hospitals should have a simple, flexible and regularly updated antibiotic-prescribing policy on a disease specific basis, relying whenever possible on knowledge of prevailing antibiotic-sensitivity patterns and controlled use of reserve antibiotics [Shlaes, 1997].

Factors to be considered before prescribing antibiotics

- Any antibiotic use must be justifiable on the basis of the clinical diagnosis and known or expected infecting micro organisms.
- Appropriate specimens for bacteriological examination must be obtained before initiating antibiotic treatment
- Antibiotic should be selected on the basis of sensitivity pattern, patient tolerance, and cost. If antibiotic started, then do not change the antibiotic if patient condition is improving.
- Correct dose must be used. Under dosing or overdosing increase resistance.
- Combination of antibiotics use should be limited to specific indications.
- If an antibiotic has not been effective after three days of therapy, the antibiotic should be discontinued and the clinical situation reassessed.
- Oral route to be preferred over intravenous route, and if intravenous route used then duration of therapy should be minimum.
- For surgical prophylaxis, start antibiotic before one hr of intervention and continue for maximum of 24 hrs only.

The Global Antibiotic Resistance Partnership (GARP) was started in 2009 to create a platform for developing actionable antibiotic policy proposals on antibiotic resistance in low-income and middle-income countries (India, Vietnam, Kenya and South Africa). This is a multi disciplinary group, with representatives from all sectors and deals with both human and animal antibiotic use and current global activities in antibiotic

resistance. GARP Phase 1 culminated on October 3-5, 2011, in New Delhi, India. Since GARP Phase 2 began in 2012, national working groups have been established in Mozambique, Nepal, Tanzania and Uganda [GARP, 2011].

Needle stick injury

A needle stick injury is the result of an accident with a needle. These injuries can occur at any time when people use, disassemble, or dispose of needles. It is considered as a medical emergency and immediate measures are taken to prevent the transmission of HIV, Hepatitis B (HBV) and Hepatitis C virus (HCV). The transmission rate for HBV is 22-31%, HCV 0-7% and HIV is 0.03-0.3% after needle stick injury and the risk is much less after contact of blood with mucous membrane. After cleaning the area with soap and water, person should immediately report to the ICTC (Integrated counseling and testing centre) of the hospital. Sample of the source and health care worker should be taken immediately for HIV, HBV and HCV testing. On the basis of degree of exposure and status of source, decision regarding the post-exposure prophylaxis (PEP) is taken and it should be started preferably within two hours but maximum up to 72 hours. Repeat testing of HCW is done after 6 wks, 12 wks & after 6 months. Similarly if patient is HBV or HCV positive the appropriate authority should be informed and in a non immune health care worker(not previously immunized) hepatitis B vaccination should be started as soon as possible .If immunoglobulin for HBV is available it should be started within 7-8 hours. HCW exposed to an HCV positive source, follow-up HCV testing should be performed to determine if infection develops [National AIDS Control Organization, 2007 and Antiretroviral Therapy Guidelines, National AIDS Control Organization, 2007].

Categories of Bio-Medical Waste

Category 1	Human anatomical	Tissues body parts etc.
Category 2	Animal waste	Animal tissues, organs, body parts etc.
Category 3	Microbiology & biotechnology	Cultures, vaccines etc.
Category 4	Sharps	Needles, scalpels, blades, glass etc.
Category 5	Medicines & cytotoxic drugs	Outdated, contaminated, discarded etc.
Category 6	Solid waste	Soiled dressings, plasters, contaminated beddings, linen etc.
Category 7	Solid disposables	Plastic tubings, catheters, disposable syringes etc.
Category 8	Liquid waste	Waste fluid from laboratory, washing, disinfection etc.
Category 9	Incineration ash	From incinerator
Category 10	Chemical waste	Reagents, disinfectants, acids

Bio-Medical Waste Management (BMWM)

Bio- Medical Waste (BMW) is any waste generated during the diagnosis, treatment or immunization of human beings or in research activity [WHO, 1998]. BMW generated in the hospital falls under two major Categories – Non Hazardous and Bio Hazardous. Constituents of Non Hazardous waste are Non-infected plastic, cardboard, packaging material, paper etc. Bio hazardous waste again falls into two types (a) Infectious waste- sharps, non sharps, plastics disposables, liquid waste, etc. (b) Non infectious waste-radioactive waste, discarded glass, chemical waste, cytotoxic waste, incinerated waste etc. Approximately 75-90% of the BMW is non-hazardous and remaining 10-25% is hazardous and can be injurious to humans and deleterious to environment. It is important to realise that if both these types are mixed together then the whole waste becomes harmful, hence

segregation of the waste at the point of generation is most important in BMWM. Every hospital should have a waste management programme and an appropriate biomedical waste facility in the premises according to the guidelines by the appropriate authority. Waste survey regularly helps in determining both the type and quantity of waste being generated in the hospital and also determines the feasible methods of disposal.

Safe handling of sharps

Extreme care should be used to avoid auto-inoculation. All chipped or cracked glassware should be discarded in appropriate containers. Broken glass should be picked up with a brush and pan, hands must never be used. The disposable needles should never be manipulated, bent, broken, recapped or removed from the syringes. The used sharps should never be passed directly from one person to another; a kidney tray may be used for

this purpose. Each Health Care Worker should dispose of his/her own sharps. Used needles should be discarded in puncture-proof rigid container after destroying it by needle destroyer. Sharp disposable containers should be located

close to the point of use. Sharp disposal containers should be sent for disposal when three- fourth full and within 48 hours of use [WHO, 1998 and WHO, 2004].

Colour coding and type of container for disposal of BMW

Colour Coding	Type of Container	Treatment options
Yellow	Plastic bag Cat. 1, Cat. 2, and Cat. 3, Cat. 6.	Incineration/deep burial
Red	Plastic bag Cat. 3, Cat. 6, Cat.7.	Autoclaving/Microwaving/ Chemical Treatment
Blue/White Translucent	Plastic bag/puncture proof Cat. 4, Cat. 7.	Autoclaving/Microwaving/ Chemical Treatment and destruction/shredding
Black	Plastic bag Cat. 5 and Cat. 9 and Cat. 10. (solid)	Disposal in secured landfill

Health check up and vaccination

There should be regular health check up of all health care workers. The objective of such check up is to monitor for occupationally acquired diseases. It is recommended that all staff should receive **Hepatitis B vaccination** as per approved schedule (0, 1 and 6 month's interval). Antibody titre four to six weeks after last dose >10 mIU/mL, then no booster is recommended. If titres are low then the whole schedule of vaccination is repeated. Regular health check up of the staff should be done where ever indicated and the record for the same should be maintained [WHO, 2004].

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