A STUDY ON ASSESSMENT OF CHALLENGES AND EFFECTIVENESS OF INFECTION CONTROL MEASURES IN A TERTIARY CARE HOSPITAL USING SPECIFIC INFECTION CONTROL INDICATORS

A THESIS SUBMITTED TO THE TAMILNADU DR.MGR MEDICAL UNIVERSITY FOR THE DEGREE OF **DOCTOR OF PHILOSOPHY IN BASIC MEDICAL SCIENCE - MICROBIOLOGY**

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DECLARATION BY THE CANDIDATE

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This is submitted to **THE TAMILNADU DR. MGR MEDICAL UNIVERSITY** for the award of degree of **DOCTOR OF PHILOSOPHY IN BASIC MEDICAL SCIENCE – MICROBIOLOGY.**

This work is original and has not been submitted in part or full to any other Master degree or Academic award of this or any other university.

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LIST OF ABBREVIATIONS

AST	-	Antibiotic Susceptibility Testing
AMR	-	Anti Microbial Resistance
AMRSN	-	Anti Microbial Resistance Surveillance and Research Network
ASPIC	-	Antibiotic Stewardship, Prevention of Infection and Control programme
ATCC	-	American Type Culture Collection
BAP	-	Blood Agar Plate
BHI	-	Brain Heart Infusion
CAP	-	Chocolate Agar Plate
CAUTI	-	Catheter Associated Urinary Tract Infection
CDC	-	Centre for Disease Control and prevention
CLABSI	-	Central Line Associated Blood Stream Infection
CLED	-	Cysteine Lactose Electrolyte Deficient media
CoNS	-	Coagulase Negative Staphylococcus
CLSI	-	Clinical Laboratory Standards Institute
DOE	-	Date of Event
ESBL	-	Extended Spectrum Beta Lactamases
FGD	-	Focus Group Discussion
GNB	-	Gram Negative Bacilli
HCAI	-	Health Care Associated Infection
HAI	-	Hospital Acquired Infection
HCP	-	Health Care Provider
HBV	-	Hepatitis B Virus
HH	-	Hand Hygiene
HHC	-	Hand Hygiene Compliance
HIV	-	Human Immunodeficiency Virus
ICU	-	Intensive Care Unit
IC	-	Infection Control

ICC	-	Infection Control Committee
ICMR	-	Indian Council of Medical Research
IEC	-	Information Education and Communication
IMCU	-	Intensive Medical Care Unit
KAP	-	Knowledge Attitude and Practice
KPC	-	*Klebsiella pneumonia* Carbapenemase
MAC	-	Mac Conkey
MDR	-	Multidrug Resistant
MDRO	-	Multidrug Resistant Organism
MHT	-	Modified Hodge Test
MIC	-	Minimal Inhibitory Concentration
MRSA	-	Methicillin Resistant *Staphylococcus aureus*
NA	-	Nutrient Agar
NHSN	-	National Healthcare Safety Network
PBP	-	Penicillin Binding Protein
PPE	-	Personal Protective Equipment
SPSS	-	Statistical Package for the Social Science
SSI	-	Surgical Site Infections
UP	-	Universal Precaution
UTI	-	Urinary Tract Infection
VAP	-	Ventilator Associated Pneumonia
WHO	-	World Health Organization

A study on assessment of challenges and effectiveness of Infection control measures in a tertiary care hospital using specific infection control indicators

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"A STUDY ON ASSESSMENT OF CHALLENGES AND EFFECTIVENESS OF INFECTION CONTROL MEASURES IN A TERTIARY CARE HOSPITAL USING SPECIFIC INFECTION CONTROL INDICATORS"

INTRODUCTION

Health Care Associated Infections (HCAI) or infections acquired in health-care settings are a major public health problem for patient safety and its impact can result in prolonged hospital stay, long-term disability, increased resistance of microorganisms to antimicrobial agents, a massive additional financial burden for the health care system, high costs for patients and their families, and increased mortality.[1,2]

The hazard extends to the staff working in hospitals and also into the community at large. This has become more important in today's changing environment, dealing with the threats of newly emerging pathogens and the widespread dissemination of old pathogens.

The World Health Organization (WHO) Report on the burden of endemic HCAI worldwide, states that the incidence of Intensive Care Unit (ICU) acquired infection among adult patients in low and middle income countries ranged from 4.4% up to 88.9% [3]. As per a systematic review, pooled overall HCAI density in adult ICU was 47.9 episodes per 1000 patient-days which are at least three times as high as densities reported in developed countries.[2]

Among the HCAI, Urinary tract infections (UTI) are the most common, accounting for up to 40% of infections reported by acute care hospitals.[4,5]Also, 70 - 80% of UTI are associated with the presence of an indwelling urinary catheter.[6]

Antibiotic resistance in Gram-negative pathogens is a major global concern, bacterial resistance particularly in relation to Catheter-Associated Urinary Tract Infections (CAUTI) has major implications[7] leading to increased hospital cost and increased

morbidity[8] and mortality[5,9]. Up to 69% of CAUTIs are considered to be avoidable, provided that recommended infection-prevention practices are implemented.[10]

Surveillance of health-care-associated infections, defines the extent and nature of problem, which is the initial step toward reducing threat of infection in vulnerable hospitalized patients. Infection Control Committee (ICC), of any hospital, serves as a major tool for the surveillance of these infections.

Enough scientific evidence supports the observation that if properly implemented, hand hygiene alone can significantly reduce the risk of cross-transmission of infection in healthcare setting.[11,12] Also presence of an active surveillance was associated with a 32% decrease in nosocomial infection rate, while absence of such a program was associated with an 18% increase in the nosocomial infection rate.[13] Thus systematic surveillance is the most common activity of the Infection Control (IC) programme.

As infection control requires the ability to detect infections when they occur,the Clinical Microbiology laboratory is inextricably linked to any comprehensive IC programme.[14]

The role of Microbiology laboratory in infection control includes:Specimen collection, Antimicrobial Susceptibity Testing (AST) of HCAI pathogens, reporting laboratory data of organism requiring immediate notification, reviewing and analysing culture and AST which are important data source and providing summary of antibiogram of HCAI pathogen.

Like in other developing countries, the priority given to prevention and control of HCAI is minimal in India. This is primarily due to lack of infrastructure, trained manpower, surveillance systems, poor sanitation, overcrowding and understaffing of hospitals, lack of

legislations mandating accreditation of hospitals and a general attitude of non-compliance amongst health care providers towards even basic procedures of infection control.[15]

As per WHO fact sheet, the main solutions and perspectives for improvement are:[16]

- identifying local determinants of the HCAI burden;
- improving reporting and surveillance systems at the institutional level, including Microbiology laboratories' capacity;
- ensuring that core components for infection control are in place at the national and health-care setting levels;
- implementing standard precautions, particularly best hand hygiene practices at the bedside;
- improving staff education and accountability;
- conducting research to adapt and validate surveillance protocols based on the reality of developing countries;
- conducting research on the potential involvement of patients and their families in HCAI reporting and control.

Each year more is learnt about hospital infection control as a science, yet the human input is never as important as now to keep pace with the challenges of modern medicine and sophisticated therapeutic modalities many of which cause a significant increase in patient population susceptible to hospital infection.

The prevention, control and treatment of such infection is a concern of all health care professionals working in a hospital including microbiologists, clinical specialists from various disciplines of medicine and surgery, medical and nursing administrators.

A periodical surveillance system for HCAI which is virtually non-existent in most low- and middle-income countries is essential to record the size of this infection burden and the effect of interventions. Moreover, many studies have stated that by itself, surveillance can lead to reduction in health-care-associated infection.[2,13,17]

The interrupted time series is the predominant study design for infectious disease epidemiology, especially in the hospital setting.[18]

With this background, this prospective interventional study was undertaken with the aim of assessment,intervention and evaluation of infection control measures in Intensive Medical Care Unit (IMCU) of a tertiary care hospital.

AIMS & OBJECTIVES

AIMS

- Assessment, Planning, implementation and evaluation of Infection control measures in IMCU of a tertiary care hospital using specific infection control indicators.

OBJECTIVES

- To determine the rate of infection control indicators viz Hand Hygiene Compliance (HHC), Catheter Associated Urinary Tract Infection (CAUTI), Prevalence of Multi Drug Resistant Organisms (MDROs) like Methicillin Resistant *Staphylococcus aureus*(MRSA) and Extended Spectrum Beta Lactamase (ESBL) in IMCU in the pre-intervention phase as the baseline evaluation.
- To implement a comprehensive multimodal infection control programme as the intervention.
- To re-evaluate the same infection control indicators in the post intervention phase.
- To assess the challenges and effectiveness of infection control measures by statistically analyzing the rate of infection control indicators before and after the implementation of infection control measures.

REVIEW OF LITERATURE

HCAI

Modern healthcare especially intensive care units, employs many types of invasive devices and procedures to treat patients and to help them recover. Also our knowledge and understanding of medical and Clinical Microbiology is constantly growing and expanding. The bacterial cell in the microbiota, (normal flora) outnumbers the human cells in the host by 10:1. In the hospital acute care IMCU settings, where vulnerable people are crowded together, the battle between man and microbe is at its most obvious. Patients are exposed to a variety of microorganisms during hospitalization and HCAI is the most frequent adverse event for hospitalized patientsand is a major global issue for patient's safety.It refers to infection associated with health care delivery in any setting.

Factors influencing the development of HCAI are severity of infection and existing illness, comorbid conditions, equipment and environment sanitation, practices and adherence to recommended guidelines. The more susceptible patients usually require the most intensive care with far more daily contacts with staffs who act as vectors in the transmission of microbes.Inanimate reservoir of infection, such as equipments, instruments and materials like fomites, linen used in hospitals often become contaminated with microorganisms which may subsequently transfer infection to susceptible patients.

Pathogenesis of infectious diseases depend on three main factors: the number and virulence of the microorganism, and the immune status of the host. The establishment of the infection is directly proportional to number and virulence characteristic of microbe and inversely proportional to immune status of the host.[19]

The infection may be of exogenous and endogenous. Endogenous are self-infection where the organisms are derived from patient's own skin, GI, upper respiratory flora.

Exogenous infections may be a cross infection when it is acquired from another patient or from HCP in the hospital or environmental infection when it is acquired through contaminated item from equipment or environment.

Burden of HCAI

The frequency of IMCU-acquired infection in low- and middle-income countries is two to three times higher than in rich ones. HCAIs can double or quadruple the average length of hospital stay and jack up expenditure on drugs and diagnostics. Hospital staffs and all the health care providers are also at risk. The data available indicate that the burden of HCAI in low and middle income countries like India is high, with an estimated pooled prevalence of 15.5 per 100 patients, more than double the prevalence in Europe and the US [20] Infection prevention and control measures and practices reduce the opportunities for HCAI and multi drug resistant pathogens to spread in healthcare facilities. The burden of HCAI is also much more severe in high-risk populations such as adults housed in IMCUs and neonates, with general infection rates, particularly device-associated infection rates, several-fold higher than in developed countries.

Types of health-care associated infection

HCAIs include central line-associated bloodstream infections (CLABSI), catheter-associated urinary tract infections, and ventilator-associated pneumonia (VAP). Infections may also occur at surgery sites, known as surgical site infections.

The dynamics of disease transmission[19]

Hospital constitutes a special environment where the epidemiology of infection is distinct. The chain of transmission of infection involves six vital links: the causative agent, reservoir of infection, portal of exit, mode of transmission, portal of entry and susceptible

host.Contact transmission is the most common mode. This may occur either as direct contact or indirect contact.

Chain of transmission of infection

Patients constitute a special hazard as they are infectious and they may be unusually susceptible to infection due to their disease condition or treatment with broad spectrum antibiotics and with immunosuppressive agents. Special activities like invasive therapeutic procedure, surgery and extensive use of intravascular devices, life supporting devices also pose constant hazard.

The extensive use of broad spectrum antibiotics, disinfectants and need to reuse the equipments, contaminated environment contribute to the special environment. Certain MDRO like MRSA, ESBL, MDR Pseudomonas and *Acinetobacter spp.* are important agents of HCAI, can survive and persistent in the hospital environment and are difficult to eradicate.

Risk factors of HCAI

There are patient, therapy and environment related risk factors for the development of HCAI. [21]

Patient related risk factors:

- Age more than 70 years
- Shock and Acute renal failure
- Major trauma

- Coma -Therapy related risk factors
- Prior antibiotics
- Mechanical ventilation
- Drugs affecting the immune system (steroids, chemotherapy)
- Indwelling catheters - Environment related risk factors
- Prolonged ICU stay (>3 days).

Infection control and Surveillance of HCAI

Effective functioning of the infection control and prevention program is an essential part of the patient safety and quality improvement programme. The following are the five pillars of IC programme,[19]

- Isolation of patient and use of personal protective equipments,
- Hand hygiene,
- Antibiotic policy,
- Decontamination of equipments & Aseptic technique and
- Environmental issues – cleaning and waste disposal

To monitor the effectiveness of IC practices, periodical surveillance and audits should be carried out.The fundamental aspect of IC and prevention is active search for disease among apparently healthy people. Surveillance has been defined as "the continuous scrutiny of all aspects of occurrence and spread of disease that are pertinent to effective control". The ultimate objective of surveillance is prevention and to detect changes in the trend of occurrence of infection.It is therefore essential for effective control and prevention and includes collection,analysis,interpretation and distribution of relevant data for action.[22]

The hospital IC programme should include surveillance and prevention of HCAI, continuing education of HCPs, control of infectious diseases out break and protection of employees from infection and advice on new products and procedures.Surveillance allow the IC programme to monitor the frequency and type of HCAI, detect out breaks, evaluate compliance with IC guidelines, provide data for policy development and monitor the effect of IC intervention on HCAI rate.

Active HCAI surveillance are accounted with reduction in infection rate, the consequence, morbidity and mortality. Thus systematic s surveillance is the IC programme most common activity.

To accomplish the overall goal to reduce the infection rate the IC programme must provide surveillance data to clinicians as soon as possible; accompanied by suggestions for improvement and reminders of existing IC practices.

As surveillance is resources intensive and time consuming, an effective IC programme must decide on the most efficient surveillance system possible. Various other screening technique too increases surveillance effect. This include, use of Microbiology report, nursing care plans, antibiotic orders, radiology reports, vital science and discharge summary. Most complete and effective surveillance system requires infection control personnel to review case sheet of all hospital patients daily. In lab based surveillance, review of microbiology report is being done to screen large amount of data. The sensitivity and specificity of laboratory based surveillance depends on nature of the quality of specimen and the frequency which were culture done. An optimal surveillance should include data from more than one source.

Process surveillance: The importance of adhering to safest process (Ex HHC, adopting bundle care) can be established by process surveillance. It can help IC personnel to understand the some of the variables in HCAI rate, may improve practices and HCAI rate[14].

Standardized definitions of HCAI

CDC has provided the definition of HCAI (CDC definition of health-care associated infection 2015). The standardized definition helps to decrease subjectivity, improve patient care and optimizes the data consistency.

An Infection is considered as HCAI, when the date of event occurs on or after the 3rd calendar day of admission. The date of Event (DOE) is the first element used to meet National Healthcare Safety Network (NHSN) site specific infection criterion, occurs for the first time within the seven- day infection window period.

National Healthcare Safety Network is the most widely used HCAI tracking system of CDC. NHSN provides facilities wise, regions wise and the nation wise data needed to identify problem areas. It also helps to measure progress of prevention efforts, and ultimately eliminate HCAI.[23]Such international data cannot be generalized, as each hospital has its own risk factors that can influence the rates of HCAI.

Infection Window period is defined as the 7- days during which all site- specific infection criteria is met. It includes the date of first positive Diagnostic test, 3 calendar days before and the 3 calendar days after the positive Diagnostic test.

Repeat infection time frame (RIT)-is a 14 – day timeframe during which no new infections of the same type are reported. It reduces labour of surveillance. If the potential next event is within 14 days of DOE of the previous one, then no need to report the new event and additional pathogens identified are added to the original event.

Secondary BSI attribution period: This period includes the infection window period combined with RIT (depending upon the date of event). Within this period a positive blood culture must be considered as a secondary BSI to primary site infection.

Infection control-Indian scenario

Definite guidelines and policies for appropriate use of antimicrobial for specific national health programmes like RNTCP, National AIDS control programme, National vector borne control programme were available at national level for many years. For other disease and pathogens of public health importance and infection control program such policies were not available.

Guidelines on Prevention and Control of Hospital Associated Infections was published by World Health OrganizationRegional Office for South-East Asia, New Delhi on January 2002. These guidelines included organization of the infection control programme, management of hospital environment, care of high-risk areas and patients, surveillance and outbreak investigation, isolation procedures, standard precautions as well as care of hospital staff.[24]

Publications from India on prevention of infection and control are only a few and on antibiotic stewardship are even fewer (Table) [25]

Publication area	% of publications*	
	USA	India
Prevention of infection and control	21.34	1.45
Antibiotic stewardship	37.60	1.23
Antibiotic policy	16.23	4. 5

*Data as per *www.pubmed.com* (accessed on December 31, 2013)

The Indian Council of Medical Research (ICMR) in its centenary year 2011-2012 planned workshops in thrust areas such as that of antibiotic use,resistance and infection control. This area is unique as it is truly an integrated area covering the disciplines of clinical pharmacology, microbiology and infectious disease.

Under the Antibiotic Stewardship, Prevention of Infection and Control (ASPIC) programme of ICMR 15 microbiologists, four pharmacologists and one physician were trained in 2012.The trained participants from 20 centres across India were expected to start antibiotic stewardship and infection control and ultimately contain antimicrobial resistance in their respective centres.National antibiotic policy or a national policy to contain antimicrobial resistance in India published in 2011 has been put on hold due to non-implement ability of major recommendations.[26]

Medical societies in India came together and organised a symposium - A Roadmap to Tackle the Challenges of Antimicrobial Resistance - in Chennai on August 24, 2012 to discuss the growing problem of antimicrobial resistance and its possible solutions.The Chennai Declaration calls for urgent initiatives to formulate an effective national policy to control the rising antimicrobial resistance, including a ban on over-the-counter sale of antibiotics, and to bring about changes in the medical education curriculum to include training in antibiotic usage and infection control.

The Indian Council of Medical Research (ICMR), New Delhi, India, has launched the Anti Microbial Resistance Surveillance and Research Network (AMRSN) across the country in 2013 with an avowed purpose of rationalizing AMSP in India. Treatment guidelines for important clinical infections and hospital infection control (HIC) guidelines

were prepared.This initiative was in line with the recommendations of Chennai Declaration which coincided with the global initiatives to combat AMR.[27]

Experts from various medical science came together and prepared the National Antimicrobial use guidelines for infectious diseases. **"National antibiotics guideline" released by Indian Ministry of Health**. Union health minister of India released the document during International conference on AMR, New Delhi, organised by MOH and WHO, in Feb 2016.[28]

Although hospital accreditation is not mandatory in India, groups like the autonomous National Accreditation Board of Hospitals and the National Health Mission's National Health Systems Resource Centre have incorporated programmes on infection prevention and control, including surveillance of HCAI, as a core part of the certification process.[29,30] At the national level, there has been growing recognition of the need for policy and guidance documents, and in 2016 the ICMR released guidelines on infection prevention and control.[31] In addition, as part of the national S*wacch Bharat Abhiyan* (clean India mission) the National Health Mission launched *Kayakalp* (clean hospital initiative), which aims to promote and reward cleanliness, hygiene, and infection control practices in public healthcare facilities.[32]

Standard Precautions

Standard Precautions are the minimum infection prevention practices that apply to all patient care, regardless of infection status of the patient, in any healthcare setting. These practices are designed to protect both healthcare personnel (HCPs) and prevent HCPs from spreading infections among patients, especially those due to blood-borne pathogens.

In August 1987, CDC initially introduced the concept of Universal Precautions, stating blood and certain body fluids of all patients are considered potentially infectious for HIV, hepatitis B virus (HBV) and other bloodborne pathogens, regardless of their bloodborne infection status. Thus, Universal Precautions should apply to all patients.

The relevance of Universal Precautions applied to other potentially infectious materials was recognized later, and in 1996, CDC replaced Universal Precautions with Standard Precautions.

Standard Precautions integrate and expand Universal Precautions to include organisms spread by blood, all body fluids, secretions, and excretions except sweat, regardless of whether they contain blood;Non-intact skin and mucous membranes.

These Standard Precautions include:

1) Hand hygiene,
2) Use of PPE such as gloves, masks, eye protection, and gowns, that are intended to prevent the exposure of skin and mucous membranes to blood and other potentially infectious materials.
3) Injury prevention through safe injection practices and safe handling of sharps
4) Proper cleaning and decontamination of patient care equipment.
5) Cleaning and disinfection of environmental surfaces.
6) Sterilization
7) Disinfection
8) Proper Biomedical waste management
9) Adherence to correct hospital sterilization disinfection protocols
10) HBV immunization of HCP at risk.

Normal Bacterial Skin Flora

The superficial part of the skin, the epidermis, has the stratum corneum, as the outermost layer, and is composed of flattened dead cells. From healthy skin, approximately 10^7 particles are disseminated into the air each day, and 10% of these dead cells contain viable bacteria.

Normal human skin is colonized with bacteria; different areas of the body have varied bacterial flora and variable bacterial counts. Total bacterial counts on the hands of medical personnel have ranged from 3.9×10^4 to 4.6×10^6. Bacteria recovered from the hands are divided into two categories: transient flora and resident flora.[33]

Transient flora, which colonize the superficial layers of the skin. They are often acquired by HCPs during direct contact with patients or contact with contaminated environmental surfaces. Transient flora are the organisms most frequently associated with healthcare associated and laboratory associated infections and it can be removed by hand hygiene practices.

Resident flora, which are attached to deeper layers of the skin, are more resistant to removal. In addition, resident flora (e.g., *coagulase-negative staphylococci* and *diphtheroids*) are less likely to be associated with such infections.

Hand Hygiene

Hand washing remain the simplest and most effective methods of preventing transmission of infectious agents from clinicians to patients and among patients. Several hospital-based studies demonstrated that improved hand hygiene techniques significantly reduced infection rates.

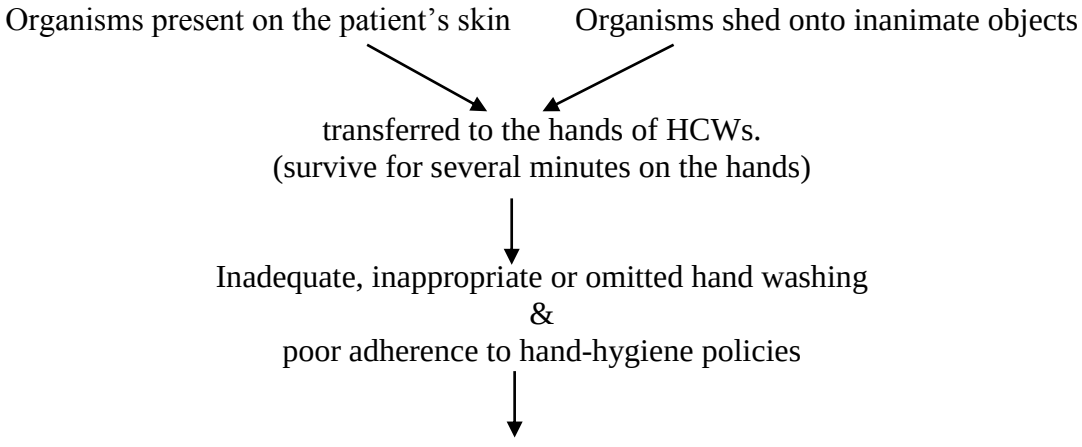
Hand hygiene is an important indicator of safety and quality of care delivered in any health-care setting is emphasized in the WHO Collaborating Centre on Patient Safety Solutions. [34]

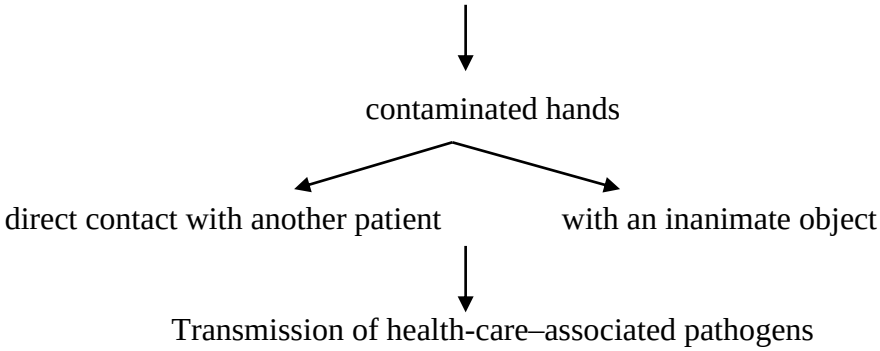
An alcohol handrub, correctly applied to socially clean hands is an acceptable and very effective method of hand decontamination and is now the preferred method of hygienic hand hygiene in most clinical situations. Alcohols effectively reduce bacterial counts on the hands. Typically, log reductions of the release of test bacteria from artificially contaminated hands average 3.5 log10 after a 30-second application and 4.0–5.0 log10 after a 1-minute application.[35]

Health-care–associated pathogens can be recovered not only from infected or draining wounds, but also from frequently colonized areas of normal, intact patient skin. Many studies have documented and proved evidence based the contamination of HCPs hands with potential health-care–associated pathogens.

Events of Transmission of Pathogens on Hands

Transmission of health-care–associated pathogens from one patient to another via the hands of HCPs requires the following sequence of events:





Outbreak investigations have indicated an association between infections and understaffing or overcrowding; the association was consistently linked with poor adherence to hand hygiene. During an outbreak investigation of risk factors for CLABSI,[36] after adjustment for confounding factors, the patient-to-nurse ratio remained an independent risk factor for bloodstream infection, indicating that nursing staff reduction below a critical threshold may have contributed to this outbreak by jeopardizing adequate catheter care. The understaffing of nurses can facilitate the spread of MRSA in intensive-care settings [37] through relaxed attention to basic control measures (e.g., hand hygiene).

Hand hygiene technique

Amount of hand-hygiene solution and duration of hand-hygiene procedure should be as per Manufacturer's instructions. Dispense the required amount of alcohol handrub and vigorously rub hands together for 15 - 30 seconds until dry, ensuring that all areas of the hands and wrists are covered as per the WHO "How to hand rub" process. Alcohol handrubs are only effective when used on socially clean hands and when allowed to dry.

Hand washing

A hand wash using aliquid soap may be used as an alternative to the above method.Soap and water are recommended for visibly soil hands.Rub hands together applying the soap for at least 30 – 40 seconds, covering all surfaces, focussing on fingertips

and fingernails.Rinse under running water and dry with disposable towel. Hand drying is an essential part of hand hygiene.Use towel to turn off the faucet

Steps of hand hygiene - WHO recommends steps given in Figure 1.

1. Rub palm to palm
2. Right palm over left dorsum and left palm over right dorsum
3. Palm to palm finger interlaced
4. Backs of fingers to opposing palms with fingers interlocked
5. Rotational rubbing of rights thumb clasped in left palm and vice versa
6. Rotational rubbing back and forwards with clasped fingers of right hand in left palm and vice versa
7. Rub both wrists in a rotating manner. Rinse and dry thoroughly.

Fig 1 : How to hand wash? - WHO recommended steps.

WHO recommends alcohol-based hand rubs based on the following factors:

1. Evidence-based, intrinsic advantages of fast-acting and broad-spectrum microbicidal activity (excellent in vitro germicidal activity against gram-positive and gram-negative vegetative bacteria, including multidrug-resistant pathogens (e.g., MRSA and VRE),Mycobacterium tuberculosis,various fungiandenveloped lipophilic viruses (e.g., herpes simplex virus, HIV, influenza virus, respiratory syncytial virus, and vaccinia virus) with a minimal risk of generating resistance to antimicrobial agents;
2. Suitability for use in resource-limited or remote areas with lack of accessibility to sinks or other facilities for hand hygiene (including clean water, towels, etc.);
3. Capacity to promote improved compliance with hand hygiene by making the process faster and more convenient;
4. Economic benefit by reducing annual costs for hand hygiene,
5. Minimization of risks from adverse events because of increased safety associated with better acceptability and tolerance than other products

Limitations of alcohol-based hand rubs:

1. Alcohols are rapidly germicidal when applied to the skin,but without appreciable residual activity. Addition of chlorhexidine, quaternary ammonium compounds, octenidine, or triclosan to alcohol-based solutions can result in persistent activity [35]
2. As HCPs may wash their hands from a limited number of times to as many as 30 times per shift, the tendency of products to cause skin irritation and dryness is a substantial factor that influences acceptance, and ultimate usage.[38]
3. The drying effects of alcohol was a primary cause of poor acceptance of alcohol-based hand-hygiene products. However, several studies havedemonstrated that alcohol-based hand rubs containing emollients are acceptable to HCPs.

4. With alcohol-based products, the time required for drying may also affect product acceptance.

Product-selection committees must consider factors that can affect the overallefficacy of such products, including the relative efficacy ofantiseptic agents against various pathogens. In addition to evaluating the efficacy and acceptability ofhand-care products, it shouldinquire about the potential deleterious effects that oilcontaining products may have on the integrity of rubber gloves. Characteristics of a HH product, either soap or alcohol-based hand rub that canaffect acceptance by personnel, include its smell, consistency or "feel", and color. For soaps, ease of lathering also may affect user preference. [39]

The vital component of any successful IC programme is evaluation and repeated monitoring of IC practices and HCPs knowledge and perception of the problem of HCAI and the importance of hand hygiene.

Monitoring hand hygiene compliance is of crucial importance to:

- assess baseline compliance by HCPs
- provide feedback to health-care workers about defective practices as well as improvement,
- evaluate the impact of promotion interventions, and
- Investigate outbreaks.
- Unobtrusive direct observation of hand hygiene practices by a trained observer is considered the gold standard for evaluating compliance. Detailed instructions on this method are included in the Hand Hygiene Technical Reference Manual.[40]The advantage of this method is, it directly links the indication of HH with the

performance of the act and the disadvantage is potential observer bias and Hawthorn effect.

- The WHO observation form exists for both hospitals and outpatient care settings.
- Web-based data collection and entry applications using touch screen and mobile devices have been developed and are being used in a number of countries. (Hand Hygiene Australia – HHCApp)
- Innovative electronic systems for the automatic monitoring of HHC are now available and can significantly facilitate data collection.
- Conducting surveys on HCPs perception, attitude and behavior of theirs and other HCP on HH. Survey of self-reporting is unreliable. A well designed and carefully administered survey can help in achieving reliable and accurate results.
- Consumption of HH products, in particular alcohol-based handrub, is another useful indicator. Data can be calculated easily at any place or at any time and can be correlated with infection trends over time.The disadvantage is, it does not provide any contextual information of non-compliance or product spillage or pilferage.
- Unfortunately there is no single perfect method for monitoring the HHC, each method has its own limitations. Collecting reliable data requires highly structured procedure of observation and documentation of data. Using multiple measurement approach helps in confirming the findings and it gives reliable information on HHC than any single method.

Intervention to improve the HHC:

Hand-hygiene promotion has been challenging for more than a century. It involves factors at both the individual and system level. The dynamic of behavioural change is complex and involves a combination of education, motivation, and system change.

- Education is the cornerstone for improvement with HH practices.
- Motivation, or system change.
- Routine observation and feedback,
- alcohol hand rub made available,convenient sink locations
- Signs, verbal reminders to physicians, movies, posters, and brochures,
- dissemination of literature, and results ofenvironmental cultures,
- Performance feedback, policy reviews,
- individual reinforcement technique, appropriate rewarding, administrative sanction, memo, and
- administrative support

Several investigators reported improved adherence afterimplementing various interventions, but the majority of studies had short follow-up periods and did not confirm whetherbehavioral improvements were long-lasting. Other studiesestablished that sustained improvements in hand washing behavior occurred during a long-term program to improveadherence to HH policies. Organisational characteristics, such as leadership, convenient placement of HH products, remainders and staff workload play a big influence on HHC. Strong system to support, monitor and guide is necessary to integrate the HH into the routine practice. Ultimately, adherence to recommended hand-hygiene practices should become part of a culture of patientsafety.

CAUTI

A urinary tract infection (UTI) is an infection involving any part of the urinary system, including urethra, bladder, ureters, and kidney. UTIs are the most common type of HCAI reported to the NHSN.[41]

Standard case definition of CAUTI[42]

Patient who has an indwelling urinary catheter in place > 2 calendar days and catheter still present on the date of event or removed the day before the date of event.

↓

At least 1 of following: Fever > 38 °C, suprapubic tenderness, Costovertebral angle pain or tenderness, urinary urgency, urinary frequency, dysuria

↓

Urine culture ≥ 10^5 CFU/ ml with no more than 2 species

CAUTI is also considered when urine showed pyuria (>10 leukocytes /mL of urine) or > three WBC / high power field in centrifuged organisms seen on Gram stain.

Risk factors for CAUTI

Among UTIs acquired in the hospital, approximately 75% are associated with a urinary catheter and Infection is the most important adverse outcome of urinary catheter use.[43]

Between 15-25% of hospitalized patients receive urinary catheters during their hospital stay. The most important risk factor for developing a catheter-associated UTI (CAUTI) is prolonged use of the urinary catheter. Therefore, catheters should only be used for appropriate indications and should be removed as soon as they are no longer needed. [44]

Other risk factors are female, older age, Diabetes mellitus, Malnutrition failure to use closed drainage system and failure to adhere aseptic technique during insertion and maintenance.

Background—Strategies to Prevent CAUTI

Guidelines incorporating various simple methods and strategies to control HCAI have been published regularly by the CDC and the World Health Organization.

- The CDC published guidelines for prevention of CAUTI in 1981, and these were updated in 2009.[45] These guidelines provide recommendations for catheter use, catheter insertion, catheter care, and implementation of programs to prevent CAUTI.
- The IDSA, together with other professional societies, published international guidelines for the management of CAUTI in 2010.[46]
- In the document, "Strategies to Prevent Catheter-Associated Urinary Tract Infections in Acute Care Hospitals; 2014 update" the guidelines published in 2008 was updated. This expert guidance document is sponsored by the Society for Healthcare Epidemiology of America (SHEA). [47]

A systematic review in hospitalized patients reported that the use of an intervention including a reminder to staff that a catheter was in place and/or a stop order to prompt removal of unnecessary catheters reduced the CAUTI rate by 53%.[48]

A care bundle identifies a set of key interventions from evidence-based guidelines that, when implemented together, are found to be more effective than the sum of its parts.[49]

Recommendation for Surveillance

The CDC/HICPAC system for categorizing recommendations is as follows: each recommendation is categorized on the basis of existing scientific data, theoretical rationale, applicability, and economic impact

Category IA - Strongly recommended for implementation and strongly supported by well-designed experimental, clinical, or epidemiologic studies.

Category IB - Strongly recommended for implementation and supported by certain experimental, clinical, or epidemiologic studies and a strong theoretical rationale.

Category IC - Required for implementation, as mandated by federal or state regulation or standard.

Category II - Suggested for implementation and supported by suggestive clinical or epidemiologic studies or a theoretical rationale.

No recommendation - Unresolved issue. Practices for which insufficient evidence or no consensus regarding efficacy exist.

Standardized methodology for performing CAUTI surveillance –

There is a level 1 B evidence.

1. Examples of metrics that should be used for CAUTI surveillance include:[50]
    a. Number of CAUTI per 1000 catheter-days
    b. Number of bloodstream infections secondary to CAUTI per 1000 catheter-days
    c. Catheter utilization ratio: (urinary catheter days/patient days) × 100
2. Use CDC/NHSN criteria for identifying patients who have symptomatic UTI (SUTI) (numerator data) [51]
3. Routine screening of catheterized patients for asymptomatic bacteriuria (ASB) is not recommended.

Anti-Microbial resistance (AMR)

AMR poses a profound threat to human health and also it threatens the very core of modern medicine and the sustainability of an effective, global public health response to the enduring threat from infectious diseases.

One of the main objective to deal with the crisis of AMR is to strengthen the knowledge and evidence base through surveillance and research. Better hygiene and infection prevention measures are essential to limit the development and spread of antimicrobial-resistant infections and multidrug-resistant bacteria. [52]

Information on: the incidence, prevalence, range across pathogens and geographical patterns related to antimicrobial resistance is needed to be made accessible in a timely manner in order to guide the treatment of patients; to inform local, national and regional actions; and to monitor the effectiveness of interventions and no single or simple strategy will suffice to fully contain the emergence and spread of infectious organisms.

Multi-drug resistant organisms:

(MDRO) are those organisms which are resistant to at least one agent in at least three antimicrobial classes of Cephalosporins, β-lactam/β-lactamase inhibitors, Carbapenems, Fluoroquinolones, Aminoglycosides[39]

Extensive Drug Resistant(XDR):

The isolates will be resistant to carbapenems in addition to the MDR drugs.

Pan Drug Resistant(PDR):

The isolated will be resistant to all the available drugs,includingpolymyxins and tigecycline.

The acquisition and spread of antibiotic resistance in bacteria:

Inherent (natural) resistance: In which bacteria may be inherently resistant to an antibiotic, which is reflected in wild type antimicrobial patterns of all or almost all representatives of a species. *Pseudomonas aeruginosa*is intrinsically resistant to

amoxicillin, ampicillin, ampicillin-sulbactam, amoxicillin-clavulanate, cefotaxime, ceftriaxone, ertapenem, trimethoprim-sulfamethoxazole, tetracycline, and chloramphenicol.

Acquired resistance: may be due tomodification of existing genetic material (chromosomal mediated) or due to theacquisition of new genetic material from another source (plasmid mediated) [35]. Plasmid mediated resistance is usually based on the production of enzymes or change in the target protein. Plasmid mediated resistance is of great clinical importance than the chromosomal mediated resistance as it can be transferred from one bacterium to another. The reason for the acquired resistance may be

- Over use and misuse of an antibiotic and is the most common cause.Evolution of strains among bacteria, is a natural phenomenon, which can occur when an antibiotic is over used.
- Use of particular antibiotic continuously, poses selective pressure in a population of bacteria which promotes resistant bacteria to thrive and the susceptible bacteria to die off.
- Extrinsic mechanisms include acquisition of resistance genes such as extended spectrum beta-lactamases and carbapenemases.

Various mechanisms for MDR include loss of outer membrane protein, over expression of efflux pump (e.g. tetracycline), modification of cell wall protein, production of β-lactam hydrolyzing enzymes such as extended spectrum β-lactamases (ESBL) &AmpCβ-lactamases and carbapenemhydrolyzing enzymes (metallo-β-lactamases, oxacillinase). [53]

The emergence and rapid spread of Multidrug resistant isolates causing HCAI are of great concern worldwide. It poses complex problem to the treating clinician and adversely affects the clinical outcome of the patients.Hence identification of invitro antimicrobial

susceptibility pattern and special resistance pattern is important before treating infections with MDRO.

For ESBL and AmpC producers, Carbapenems remain the drug of choice, however resistance to these drugs is also on the rise.To treat carbapenem resistant strains we are left with tigecycline and polymyxin B and polymyxin E (Colistin) to which many Gram negative bacteria have started developing resistance. Hence the detection of Carbapenem resistance is important in treatment of patients and also preventing the spread of resistant strains.

K. pneumoniae, Pseudomonas aeruginosa and *Acinetobacter spp.* are top of the list of pathogens causing IMCU infections. Itmay spread remarkably well in the hospital environment, and frequently cause HCAI and outbreaks, especially in IMCUs. Medical equipment, the gastrointestinal tract of patients and the hands of HCPs are considered the most important reservoirs for the spread of *Klebsiella species* in the hospital environment.

Mechanisms of β-lactam resistance:

Resistance to β-lactams may be either due to alteration of the target site, (Penicillin Binding Protein-PBP mediated), or caused by production of β-lactamases. Down-regulation orporin loss may cause β-lactam resistance alone, or in combination with β-lactamase production. PBP-mediated resistance may be caused by acquisition of foreign PBPs, e.g. acquisition of the gene encoding PBP2a in methicillin resistant *Staphylococcus aureus* (MRSA).

Destruction or inactivation of β-lactam antibiotics by hydrolysing the amide bond of the β-lactam ring by the enzyme β-lactamase is the most common mechanism of β-lactam resistance among Gram-negative bacteria. They may be classified based on their primary

structure according to Ambler R36, or due to their functional characteristics (i.e. the enzymes abilities to hydrolyse different β-lactam classes) according to Bush-Jacoby-Medeiros.[54]ESBL belongs to Class A beta-lactamase of Ambler molecular classification while AmpC beta-lactamase belongs to Class C.

β-lactamase enzymes hydrolyse penicillin, aztreonam and cephalosporins but not cephamycin (cefoxitin) or carbapenems. In Amp C related resistance, in contrast to ESBLs they hydrolyse Cefoxitin and coxyimino-cephalosporins except fourth generation cephalosporins. Carbapenems, β-lactams and β-lactam inhibitor combinations such as piperacillin-tazobactam are the drugs active against ESBL and AmpC producers.

Carbapenem resistance enzymes belong to Class B β-lactamase of Ambler classification. These enzymes can hydrolyse all classes of β-lactam antibiotics with the exception of monobactams (Aztreonam) and resist neutralization by β-lactamases inhibitor antibiotics. However, for isolates that also co-produce AmpC or ESBL, aztreonam is ineffective.

Risk factors for the MDROs

- Use of broad spectrum antibiotics (second & third generation cephalasporins and quinolones), treatment with previous glycopeptide in VRE patient.
- chronically debilitated patients with severe underlying illness.
- immunocompromisedpatients,critically ill patients with prolonged hospital stay in ICU, oncology and transplantation ward
- Patients with indwelling devices,
- Patients who had intra-abdomonal, cardiothoracic, orthopedic, vascular procedure and surgery

- Contact with health care facility (> 12 continuous hours in the past 12 months) where MDRO is endemic.

Recommended measures to control spread of MDRO:

i) Improved laboratory detection and reporting of MDRO

ii) Enhanced infection surveillance and control in IMCUs

iii) Isolation of patients and prevent spread by barrier precautions: Gowns and gloves

iv) Hand Washing

v) Cleaning and decontamination of patient care equipments and environment.

vi) Implementation of ASP and restricted use of 3rd generation cephalosporins

vii) Education and training

Role of Microbiology laboratory[19]

- The Microbiology laboratory must use internationally accepted methods for prompt and accurate identification and AST of HCAI pathogens.
- Keep updated in the detection methods of resistance in MDROs.
- Microbiology laboratory must follow restricted reporting based on the local guidelines to encourage the use of narrow spectrum antibiotics.
- Establish local laboratory surveillance system and feed data into national surveillance system.
- Surveillance of MDROs with the help of HIC team to monitor the epidemiological trend
- To help the hospital administration to develop Antibiotic guidelines based on the local antibiotic resistance pattern.

METHODOLOGY

PATIENTS AND METHODS

Study design - Prospective interventional study

Study period - 3 years

Plan of study

First year - July 2015 – March 2016

- Extensive review of literature was done.
- Methodology was standardized
- Research proposal was presented to University Scientific committee
- FGD facilitation guide, KAP questionnaire prepared and pilot testing was done

Second year

- Base line evaluation - April 2016 to September 2016.
- Intervention - October 2016 to January 2017
- Post interventional evaluation - February 2017 to July 2017

Third year (August 2017- July 2018)

- Compilation and tabulation of study findings,
- Statistical analysis of the results,
- Synopsis of the study prepared and submitted.

Place of study

Institute of Microbiology and Intensive Medical Care Unit of Rajiv Gandhi Government General Hospital, Madras Medical College, Chennai.

Ethical consideration

The study was approved by the Institutional Ethics Committee of Madras Medical College and an informed written consent (Annexure i) was obtained from the participants before the collection of the samples and before their participation in questionnaire survey, and Assent was obtained from those below 18 years of age.

Statistical analysis

Categorical data were presented as proportions. Normally distributed continuous data were presented as mean with standard deviation. Non-normally distributed continuous data were presented as median with interquartile range. Data were descriptively analyzed using the Statistical Package for the Social Sciences 16.0 (SPSS). Chi square test was used to analyze the strength of association of duration of catheterization and the risk of developing CAUTI. In the post interventional, Knowledge Attitude and Practice (KAP) questionnaire study, mean was calculated for the parameters. Comparison of knowledge to attitude, knowledge to practice and attitude to practice was done by Independent sample t test. p value < 0.05 was considered as significant.

Study population

- Doctors and other Health Care Personnel (HCP) serving in the IMCU.Patients who got admitted in IMCU.

Inclusion criteria

- Doctors and other HCP serving in the IMCU.
- Patients who got admitted and stayed in the IMCU for ≥48 h, were followed prospectively.

Exclusion criteria

- Patients discharged, expired or transferred out from IMCU in < 48 h,
- Patient with symptoms of UTI prior to the catheterization and on suprapubic and condom drainage were excluded.
- Patients undergoing cancer chemotherapy and patients who have undergone bone marrow and solid organ transplantation were excluded from the study.

Operational definition

Hand Hygiene (HH) - A general term referring to any action of hand cleansing. Hand rubbing with an alcohol-based hand rub or hand washing with soap and water aimed at reducing or inhibiting the growth of micro-organisms on hands.[55]

Hand Hygiene Compliance (HHC) - Compliance with hand hygiene is the ratio of the number of performed actions to the number of opportunities. This reflects the degree of compliance by HCP with the requirement to practise hand hygiene during health-care activities in line with the five indications (moments) insofar as they are counted as opportunities.[55]

Catheter associated urinary tract infection - A patient was said to be suffering from catheter-associated urinary tract infection (CAUTI) if he was catheterized and he developed one or more of the following condition that is fever (temp > 38°C) without any other known cause, urgency, frequency, dysuria or suprapubic tenderness with urine culture showing more than 10^5 colony-forming units or more per ml of urine, with not more than two types of organism. [56]

Multi drug resistance organisms (MDRO)

MDR bacteria is defined as non-susceptibility to one or more antimicrobials of three or more Antimicrobial classes.[57]

Sample size- Sample size was 200 per group.

Sample size calculation was done using the below formula.

- Sample size is 200 per group. $n = \frac{[P1\ (100-P1) + P2\ ((100 - P2)]}{(P1-P2)^2}\ (Z_\alpha + Z_\beta)^2$

Anticipated values of the population proportions	=	P1 & P2
Level of Significance	=	100 (1-α) %
Power of the Test	=	100 (1-β) %
Medically Meaningful Difference	=	d

Data collection

Demographic details and other relevant details was collected using standard proforma (Annexure ii) by the investigator.

Methodology - Prospective interventional study plan

Base line or pre interventional phase

To achieve the objectives, in the beginning of the study as Base line or Pre-interventional evaluation of the infection control indicators such as HHC, CAUTI rate and MDRO rate was calculated for a period of six months from April 2016 to September 2016.

Sampling procedure

For calculation of CAUTI rate,urine samples from all the consecutive patients fulfilling the inclusion criteria were included.

For calculation of MDRO rates all the consecutive clinical samples such as blood, urine, tracheal aspirate, sputum, pus and other body fluids collected from symptomatic IMCU patients were included during the study period.

Microbiological methods of processing the samples was done as per the standard procedure .[58,59] This included,

1. Collection of specimen
2. Macroscopic examination
3. Microscopic examination
4. Culture procedure
5. Identification of organisms
6. Antibiogram- antibiotic susceptibility testing
7. Test for detection of special resistant patterns: MRSA, ESBL and Carbapenemase production

Collection of Specimens: Blood

After choosing the venepuncture site the skin was disinfected first with 70% alcohol in circular motion. Allowed to air dry. Then 2% povidone iodine was applied and allowed to dry for one minute

After disinfecting the venepuncture site about 10 mL of venous blood was drawn from 2 different sites using sterile disposable needle and syringe and inoculated into 50 mL of Brain Heart Infusion (BHI) broth.

Urine

Clean catch midstream urine collected in a sterile, wide mouthed, screw capped bottle after thorough preliminary cleaning of external genitalia with soap and water.

In catheterized patient, after disinfecting a portion of the catheter tubing with alcohol, urine sample was collected by puncturing the tubing with sterile syringe and needle.

Sputum

Patients were instructed to have mouth wash and gargle with sterile distilled water and to cough when the sputum is felt in the throat and to spit the material directly in to a wide mouthed sterile container.

Tracheal Aspirate (TA)

The collection of TA by the traditional technique was performed according to standard procedure. The sterile suction tube introduced through the ETT until resistance was encountered (level of the carina in the trachea), and retracted approximately 2cm. This was followed by the release of the vacuum and the suction tube was delicately removed using turning movements, from which the secretion was aspirated into a sterile culture tube or the distal end of the tube was cut and send for the culture under aseptic precaution.[60]

Body Fluids - Pleural fluid, Ascitic fluid, Cerebro Spinal Fluid (CSF)

Collected by aspiration with a needle and syringe under aseptic precaution by trained physician.

Macroscopic Examination Sputum

Sputum was examined for color and consistency and presence of mucus, mucopurulent and frothy material. Urine and other body fluids were examined for color, consistency, turbidity and presence of blood.

Initial processing of the specimen

All body fluid specimens greater than one mL in volume was subjected to centrifugation for 15 minute at 1500 g. Supernatant was transferred to a sterile tube, leaving approximately 0.5 mL of fluid to suspend the sediment before smear examination or culture.

Microscopic Examination

Gram Stain

Smears from sputum, pus and other body fluids were stained by Gram‘s method and examined for the presence of squamous epithelial cells, polymorphonuclear leukocytes, mononuclear leukocytes, Gram positive, Gram negative bacteria and Yeast cells.

Culture procedure to isolate and identify bacteria:

Blood sample

10 mL of blood from 2 sites was inoculated into 50mL of BHI broth and incubated at 37^{o}C. Sub cultures were made at 24 hrs, 48 hrs and 5 days and on 7^{th} day onto Mac Conkey (MAC), Blood agar plate (BAP) and Nutrient agar (NA) plate incubated aerobically. Blood agar plate was incubated in candle jar.

Urine Sample

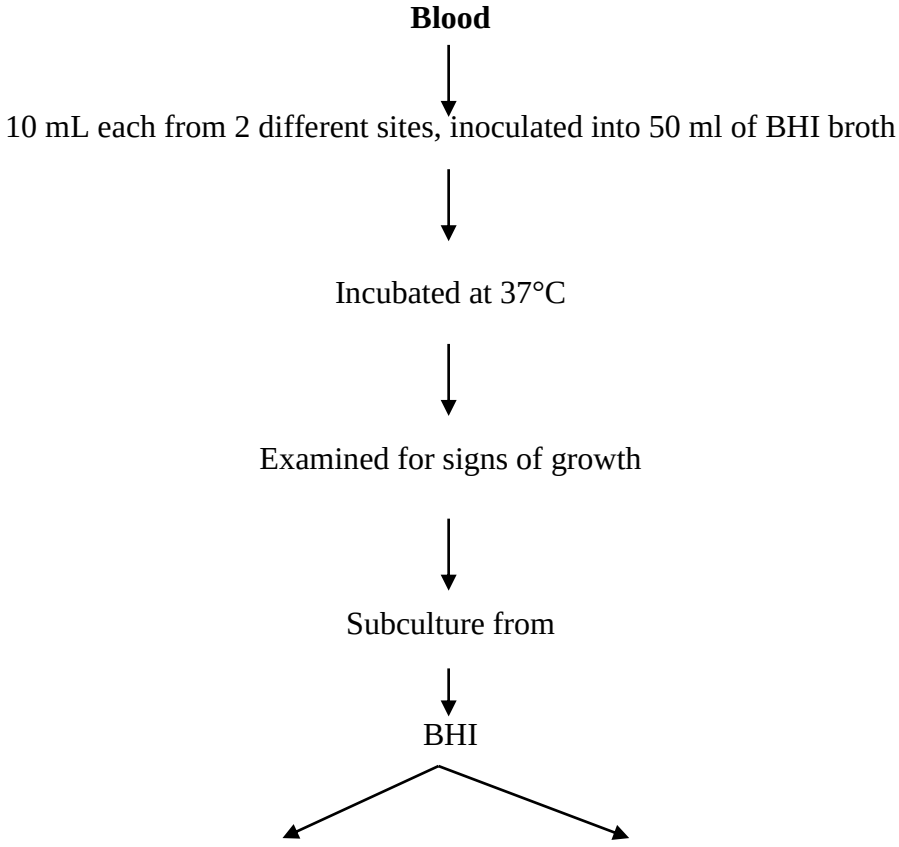
With the calibrated loop urine was cultured on Cystein Lactose Electrolyte Deficient media (CLED) media for quantitative analysis to assess the microbial counts. Colony count of 10^5 was taken as significant. The identification of pathogen was done by standard biochemical tests. Isolate suggestive of the yeast were subcultured on Sabouraud's dextrose agar and further identification was done by demonstration of germ tube; sugar fermentation and CHROM agar.

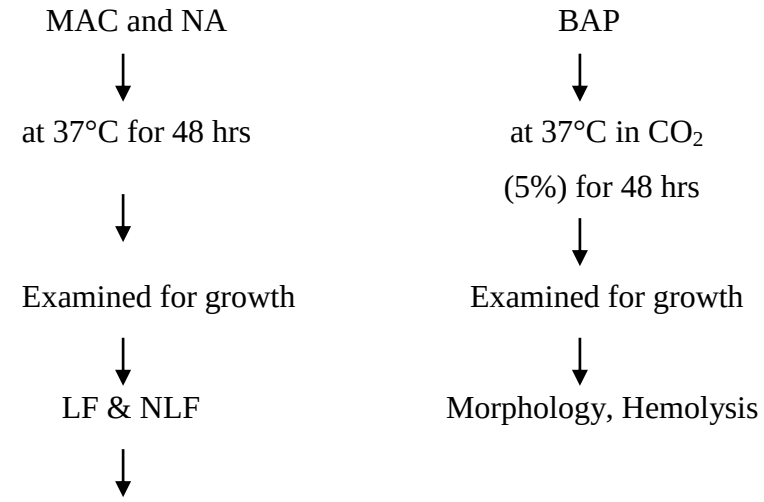
Sputum and Tracheal aspirate

Samples plated onto Mac Conkey, Chocolate agar plate (CAP)and Blood agar plates incubated at 37^{o}C for 24 hrs. Chocolate agar plate was incubated in candle jar. The plates were examined after 24 hrs for presence of growth. Isolates were identified based on colony morphology, Gram stain and by standard biochemical reactions.

Body fluid was inoculated onto Mac Conkey, CAP and BAP incubated at 37^{o} C for 24 hours and observed for growth. Figures: 2 and 3 exhibits the *Klebsiella pneumoniae* colony on MAC plate and the biochemical reactions. Figures 4 shows the Non lactose fermenting colonies of *Acinetobacter boumannii* and Figure: 5 shows its biochemical reactions.

Flow Chart for processing of sample





Sputum, Sterile body fluids

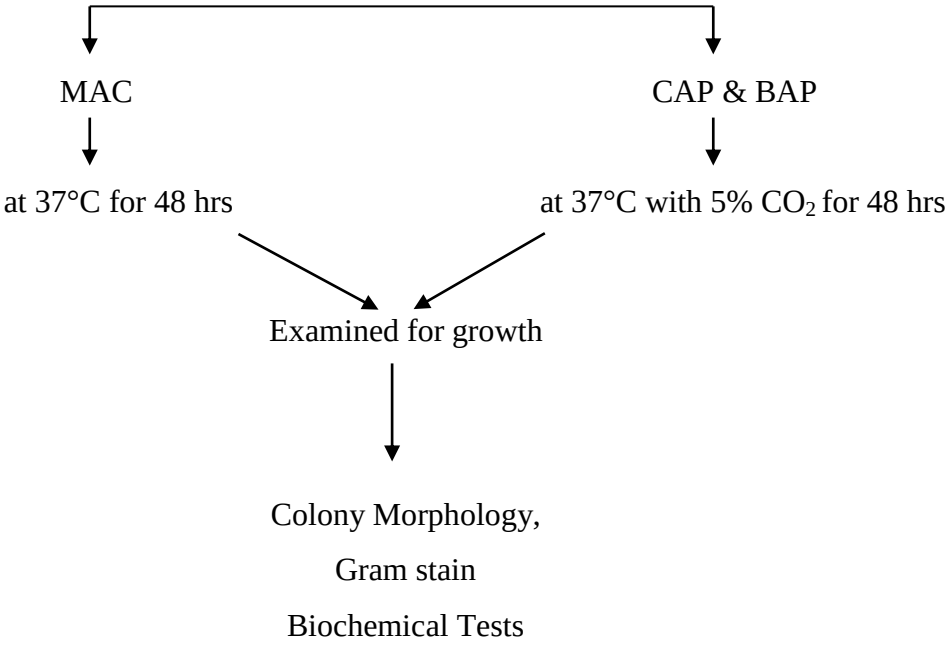


Fig 2 : *Klebsiella pneumoniae* – on MacConkey agar

Fig 3 : *Klebsiella pneumoniae* – Biochemical Reactions

Fig 4 : *Acinetobacter boumannii* – on MacConkey agar

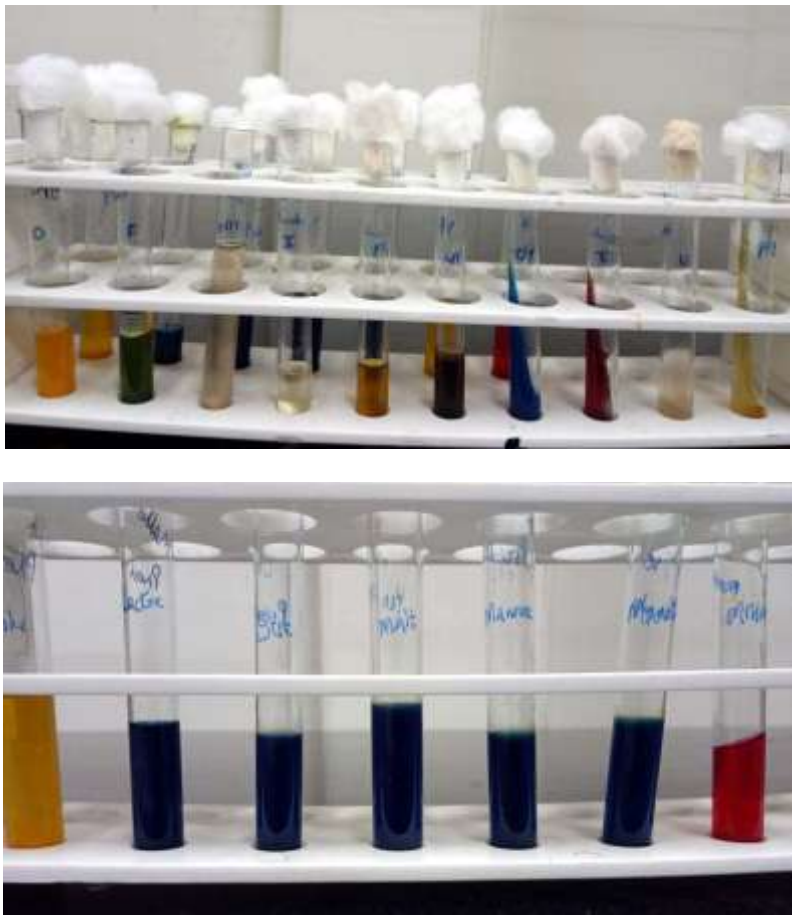


Fig 5 : *Acinetobacter boumannii* – Biochemical Reactions

Antibiotic Susceptibility Testing (AST) [61]

Disc Diffusion Method:

AST was performed for all the isolates by Kirby Bauer disc diffusion method as per Clinical and Laboratory Standards Institute (CLSI) guideline on Mueller-Hinton agar plates. Three to four colonies were inoculated in nutrient broth and incubated for two hours at 37ºC, to bring the organism to logarithmic phase. The turbidity of the suspension was adjusted to 0.5 McFarland standards. Within fifteen minutes of preparation of the suspension, a sterile cotton swab was immersed in the suspension and the excess suspension was removed by rotating the swab against the wall of the test tube. A lawn culture of the inoculum was made by streaking the swab over the surface of the plate in three directions. After about 10 to 15 minutes, the antibiotic discs were placed, five on each plate and incubated at 37 ºC for 20 to 24 hours. Zone of inhibition of bacterial growth around the antibiotic discs were measured using the Himedia scale. Interpretations were made using the CLSI, USA guidelines – January 2016, M100S. Control Strains: *Staphylococcus aureus* – ATCC 25923, *E.coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853.

Phenotypic screening method for Extended Spectrum Beta-lactamase (ESBL) [62] **& Carbapenemase production**

All the gram negative isolates were subjected to ESBL screening test using ceftazidime (30µg) and cefotaxime (30µg) and carbapenemase screening test using imipenem (10µg) and meropenem (10µg) discs by Phenotypic screening method.

Phenotypic confirmatory test for ESBL production- Combined disc method

The isolates which were positive in the screening test were subjected to respective confirmatory tests using appropriate antibiotic discs. The phenotypic confirmation for ESBL production was done by testing the strain against ceftazidime (30µg) and

ceftazidime/clavulanic acid (30µg/10µg) Himedia, which were placed at a distance of 20mm centre to centre on the Mueller-Hinton agar plate, incubated at 37ºC for 20-24 hours. The test isolate was considered to produce ESBL if the zone of inhibition around the ceftazidime-clavulanic acid disc was ≥5mm than the zone around ceftazidime disc alone. (Figure: 6)

Carbapenemase detection by Modified Hodge Test (MHT)[63]

Isolates resistant to carbapenems was further processed by modified Hodge test to detect carbapenemase production. A lawn culture of 1:10 dilution 0.5 McFarland standard suspension of *E.coli* ATCC 25922 was done on to a Mueller Hinton Agar plate and allowed to dry for 3-5 minutes. A 10µg meropenem disc was placed in the center of the test area. In a straight line, the test organism was streaked from the edge of the disc to the edge of the plate and incubated at 37°C for 16-20 hours. Enhanced growth (Clover-leaf indentation) was considered as positive for carbapenemase production. (Figure: 7)

Detection of MRSA-Disc Diffusion Method [64]

To detect Methicillin resistance in *Staphylococcus aureus*, with 0.5 McFarland standard suspension of each isolate, a lawn culture was performed onto Mueller Hinton Agar plate. 30 µg cefoxitin disc was placed in it by Kirby Bauer disc diffusion method and incubated at 37°C for 18 hours. The results are interpreted as per CLSI standards.

Staphylococcus aureus isolate with zone of inhibition ≤ 21mm was considered as MRSA and with inhibition zone size of ≥ 22mm was considered as Methicillin sensitive. For Coagulase Negative *Stathylococci (CoNS)* zone of inhibition of <24mm was interpreted as Methicillin resistant and that of ≥ 25mm was Methicillin sensitive.

Fig 6 : Phenotypic confirmation test for ESBL- Combined disc method

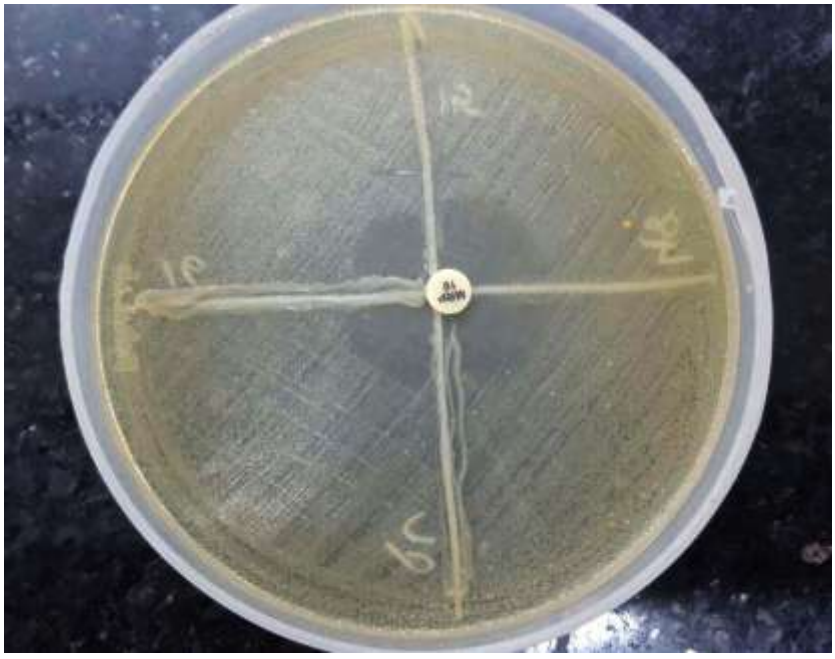


Fig 7 : Modified Hodge Test (MHT)

Surveillance of Hand Hygiene Compliance (HHC) [55]

HHC was measured by direct observation. WHO observation form (indication related compliance with Hand Hygiene) was used as a monitoring tool. The investigator visited the IMCU at various time period and passively observed the hand hygiene behaviour of HCPs. During each 20 minutes period, minimum of 10 HH opportunities were observed. The surveyors counted hand hygiene opportunities and checked HCPs hand hygiene action in each opportunity. HHC was calculated by the below mentioned method.

Compliance with hand hygiene is the ratio of the number of performed actions to the number of opportunities and is expressed by the following formula:

$$\text{Compliance (\%)} = \frac{\text{Performed actions}}{\text{Opportunities}} \times 100$$

Hawthorne effect or the observer effect i.e the alteration of behaviour by the subjects of a study due to their awareness of being observed was carefully avoided by doing practice observations before undertaking the original observation.

Measurement of the Consumption of Alcoholic hand rub products was done in association with the Implementation of WHO Multimodal Hand Hygiene Improvement Strategy.

Intervention of infection control practice in the IMCU was done for a period of four months from October 2016 to January 2017.

The intervention included:

1. Focus Group Discussion (FGD) was conducted to assess the knowledge and attitude of HCPs on infection control and hand hygiene practices.With the help of the practical guide for Good Questions proposed by Richard Kruegar and Mary Anne Casey the prototype facilitation guide (Annexure iii) for FGD was prepared.[65]

   The facilitation guide included the following topics: general awareness and knowledge about standard work precaution, infection prevention and hand hygiene, their attitudes regarding their own and others hand hygiene practice at the site, and their ideas on challenges involved with infection control practices and preparedness for improving infection prevention efforts. Pilot testing, refinement, and validation of the survey questions were conducted.

   Participants were explained about the purpose of the study and ensured that their responses will be kept confidential. Written consent to participation was obtained from each participant.Discussions ranged in length from 30-45 minutes. The discussions were conducted in English and Tamil, recorded, transcribed and translated into English. (Figure:8) While conducting FGD, the facilitator used pre-determined question and established permissive environment. Six focus group discussions were held with 12 nurses, 10 emergency care technicians and 5 doctors. Transcripts were analyzed by thematic content.

2. Training and education of HCPs on infection control practices in the form of interactive educational sessions like demonstration, group discussion, video demonstration were conducted to cover various topics like Hand hygiene, Personal protective equipment (PPE), Health care associated infections and Introduction to Bundle approach, Universal/Standard work precaution, Catheter associated urinary tract infection,

Ventilator associated pneumonia, Central line associated blood stream infection, Multidrug resistant organism-antibiotic policy, Sterilization and disinfection, Biomedical Waste Management.

Each training sessions lasted up to 30 minutes and tailored to the needs of different health care workers. The timing of the session was planned in discussion with the HCPs in such a way that it was conducted within their working hours but without affecting their routine work. (Figure: 9) The HCPs working in all the three shifts participated in the training sessions.

The lecture had three sessions and the first session was for learning the residual and transient flora of hands and the role of HCPs hands in spreading infection. The second session was for understanding the WHO "Five Moments for Hand Hygiene" and the importance of hand hygiene.

In the third session the importance of WHO recommended 'My 5 moments of Hand hygiene' and seven steps of hygienic hand washing was demonstrated with the commercially available training tool (Figure: 10) having fluorescent cream mimicking germs on the hands and a Ultra violet torch to visualize the germs.

After applying the fluorescent cream on hands, the HCPs were asked to wash their hands with water and soap in the way they routinely do and then the hands were checked under fluorescent lamp for the presence of fluorescent particles mimicking germs.The importance of 7 steps of hand hygiene was insisted and HCPs were made to adhere to the steps while washing their hands. The above mentioned same exercise was repeated. After the proper hygienic hand washing presence of very less number of fluorescent particles was demonstrated. (Figure: 11)

3. HCPs were trained and encouraged to participate in the preparation of written documents on procedures and protocols regarding Infection control practices, decontamination and disinfection of common equipment used in the IMCU.

4. All the HCPs working in the IMCU were trained in maintaining charts in the form of monitoring tools(Annexure iv) on CAUTI and MDROs isolated from patients' clinical samples. User friendly monitoring tools were prepared after discussing and gathering inputs from the HCPs for the better compliance.

5. Providing Information Education Communication Charts (IEC), materials at work place. Conducted a discussion with the HCPs on the requirements and usefulness of IEC material on infection control. Collected and compiled the information on end user specification for IEC material. Based on this,concepts for the preparation of posters(Annexure v) were developed. Accordingly posters were designed and displayed in the IMCU.

6. Bundle approach was introduced for CAUTI prevention. Collection of five steps of interventions that have been recommended as best practices, based on evidence, in the prevention of CAUTI were taught to HCPs. Practicing urinary catheter insertion bundle and catheter maintenance bundle (Annexure vi) was emphasized.

Post interventional phase

After the period of intervention, post interventional surveillance of the same infection control indicators was done for six months from February 2017 to July 2017. At the end of the interventional period, Knowledge, Attitude and Practice (KAP) of HCPs regarding Infection control and health care associated infections was assessed by using KAP Questionnaire survey(Annexure vii).

Fig 8 : Focus group discussion

Fig 9 : Bed side training session

Fig 10 : Hand hygiene teaching tool

Fig 11 : HH- practical demonstration using the teaching tool

RESULTS AND ANALYSIS

RESULTS

Table: 1 Age profile of study participants.

S.No	Age (Years)	No. of Participants	
		Pre Interventional phase (%)	Post Interventional phase (%)
1	12 – 20	77 (21)	47 (13)
2	21 – 30	65 (18)	100 (28)
3	31- 40	78 (22)	52(15)
4	41-50	53 (15)	50 (14)
5	51-60	47 (13)	47 (13)
6	61-70	31 (9)	36 (10)
7	71-86	8 (2)	21 (7)
Total		359	353

Majority of the patients for both the pre interventional phase (n=142, 40%) and for the post interventional phase (n=147, 42%) were from the age group 12-30 years.

Table: 2 Age and Sex wise stratification of study participants.

S.No	Age (Years)	No. of patients			
		Pre Interventional		Post Interventional	
		Male	Female	Male	Female
1	12 – 20	38	39	22	25
2	21 – 30	29	36	37	63
3	31- 40	48	30	24	28
4	41-50	27	26	24	26
5	51-60	30	17	26	21
6	61-70	13	18	24	12
7	71-86	2	6	17	4
Total		187	172	174	179

male: female ratio was 1.01: 1.

Table: 3 Nature of specimen.

S.No	Nature of specimen	No. of specimen	
		Pre Interventional phase (%)	Post Interventional phase (%)
1	Urine	168 (38)	130 (29)
2	Blood	165 (38)	157 (36)
3	Tracheal Aspirate	53 (12)	89 (20)
4	Sputum	28 (6)	29 (7)
5	CSF	12 (3)	26 (6)
6	Ascitic Fluid	7 (2)	4 (1)
7	Pleural Fluid	6 (1)	6 (1)
	Total	439	441

No significant difference in the nature of distribution of specimen except that there was a 68% increase in Tracheal aspirate sample in the post intervention phase.

Table: 4 Pattern of Bacterial isolates from various clinical specimens - Baseline data

Organisms	Urine (%)	Blood (%)	Tracheal aspirate (%)	Sputum (%)	Sterile Fluid specimen (%)	Total(%)
Klebsiella pneumoniae	4 (13)	5 (16)	14 (45)	7 (23)	1 (3)	31 (36)
Acinetobacter spp.	2 (12.5)	2 (12.5)	10 (63)	1 (6)	1 (6)	16 (18)
Pseudomonas spp.	1 (8)	0	6 (46)	6 (46)	0	13 (15)
E.coli	5 (71)	2 (29)	0	0	0	7 (8)
Klebsiella oxytoca	4 (100)	0	0	0	0	4 (5)
P. mirabilis	1 (100)	0	0	0	0	1 (1)
Citrobacter koseri	0	0	0	1 (100)	0	1 (1)
Enterococcus spp.	3 (50)	3 (50)	0	0	0	6 (7)
Staphylococcus epidermidis	0	6 (100)	0	0	0	6 (7)
Staphylococcus aureus	0	0	2 (100)	0	0	2 (2)
Total	20 (23)	18 (20.6)	32 (36.7)	15 (17)	2 (2.2)	87

Klebsiella pneumoniae 31 (36%) was the predominant pathogen followed by *Acinetobacter spp.* 16(18 %).

Table: 5 Pattern of Bacterial isolates from various clinical specimens – post intervention data

Organisms	Urine (%)	Blood (%)	Tracheal aspirate (%)	Sputum (%)	Sterile Fluid specimen (%)	Total (%)
Acinetobacter spp.	2 (7)	6 (20)	16 (53)	6 (20)	0	30 (36)
Klebsiella pneumoniae	2 (8)	4 (16)	12 (48)	6 (24)	1 (4)	25 (30)
Pseudomonas spp.	1 (6.2)	0	13 (81)	1 (6.2)	1 (6.2)	16 (19)
E.coli	4 (80)	0	0	1 (20)	0	5 (6)
Klebsiella oxytoca	1 (50)	0	1 (50)	0	0	2 (2.3)
Enterococcus spp.	1 (50)	1 (50)	0	0	0	2 (2.3)
Citrobacter koseri	1 (100)	0	0	0	0	1 (1)
Staphylococcus epidermidis	0	2	0	0	0	2 (2.3)
Staphylococcus aureus	0	1(100)	0	0	0	1 (1)
Total	12 (14)	14 (17)	42 (50)	14 (17)	2 (2)	84

Acinetobacter spp. 30(36%) was the predominant pathogen followed by *Klebsiella pneumoniae* 25(30%).Tracheal aspirate is the major source for the isolation of *Acinetobacter spp.* in both the phases

Table: 6 Spectrum of microorganisms isolated in the study

Organisms	Baseline data (%)	Post intervention data (%)
Klebsiella pneumoniae	31 (28)	25 (26)
Acinetobacter spp.	16 (14)	30 (31)
E.coli	7 (6)	5 (5)
Pseudomonas spp.	13 (12)	16 (17)
Klebsiella oxytoca	4 (4)	2 (2)
P. mirabilis	1 (1)	0
Citrobacter koseri	1 (1)	1 (1)
Enterococcus spp.	6 (5)	2 (2)
Staphylococcus epidermidis	6 (5)	2 (2)
Staphylococcus aureus	2 (2)	1 (1)
Candida non albicans	19 (17)	10 (10)
Candida albicans	5 (5)	2 (2)
Total	111	96

There was no significant difference between infection rate between base line and the post interventional phase. p =0.218.

Fig: 12 Bacterial Profile of both the phases of the study

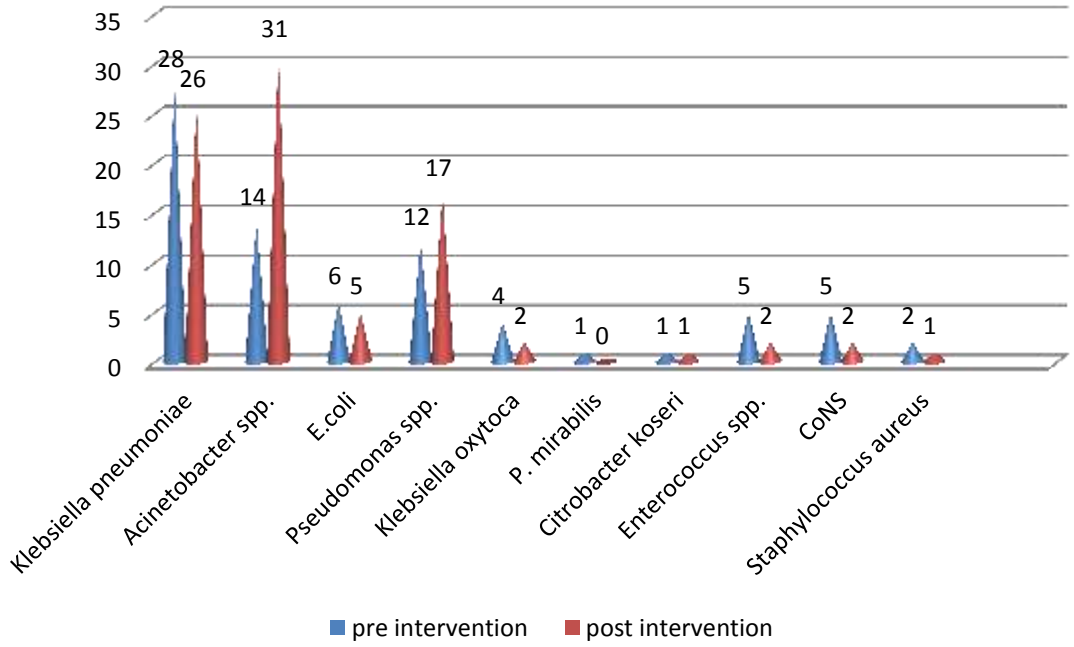


Table: 7 Distribution of Gram Positive organisms among various clinical specimens

Organisms	Base line			Post interventional			Total
	Urine	Blood	Tracheal Aspirate	Urine	Blood	Tracheal Aspirate	
Staphylococcus aureus	0	0	2	0	1	0	3
Enterococcus feacalis	3	2	0	0	1	0	6
Enterococcus feacium	0	1	0	1	0	0	2
Staphylococcus epidermidis	0	6	0	0	2	0	8
Total	3	9	2	1	4	0	19

In the pre interventional phase, 14(16%) Gram positive organisms were isolated out of 87 and in the post interventional phase, 5(6%) Gram positive organisms were isolated out of 84 bacterial isolates.

Table: 8 Spectrum of microorganisms isolated from CAUTI – Baseline surveillance

Organisms	Number (%)
E.coli	5 (11)
Klebsiella oxytoca	4 (9)
Klebsiella pneumoniae	4(9)
Acinetobacter spp.	2 (5)
Pseudomonas spp.	1 (2)
P. mirabilis	1 (2)
Enterococcus feacalis	3 (7)
Candida non albicans	19 (43)
Candida albicans	5 (11)
Total	44

Bacterial pathogen was identified in 17 (41 %) of patients and in 24 (59 %) patients *Candida* species were isolated. Out of 17 patients 3 patients had 2 bacterial isolates each with significant count.

Table: 9 Spectrum of microorganisms isolated from CAUTI – post interventional surveillance

Organisms	Number (%)
E.coli	4 (17)
Klebsiella pneumoniae	2 (8)
Acinetobacter spp.	2 (8)
Klebsiella oxytoca	1 (4)
Pseudomonas spp.	1 (4)
Citrobacter koseri	1 (4)
Enterococcus feacium	1 (4)
Candida non albicans	10 (42)
Candida albicans	2 (8)
Total	24

Candida non albicans was the predominant isolate followed by *E.coli* in both the phases among the CAUTI specimen.

Table: 10 Descriptive analysis of catheter days – Baseline surveillance

Days of urinary catheterisation	No of patients	No of UTI detected	Total No of Device Days	Infection rates (%)	Mean duration of catheter use
≤3	29	3	84	1.7	2.8
4 - 7	56	11	344	6.5	6.15
>7	83	27	1420	16.07	17.10
Total	168	41	1848	24.40	11

The rate of development of CAUTI was higher as the duration of catheterization increased. p value 0.033946, Chi square value 6.766

Fig:13 CAUTI isolates Pre & Post interventional analysis

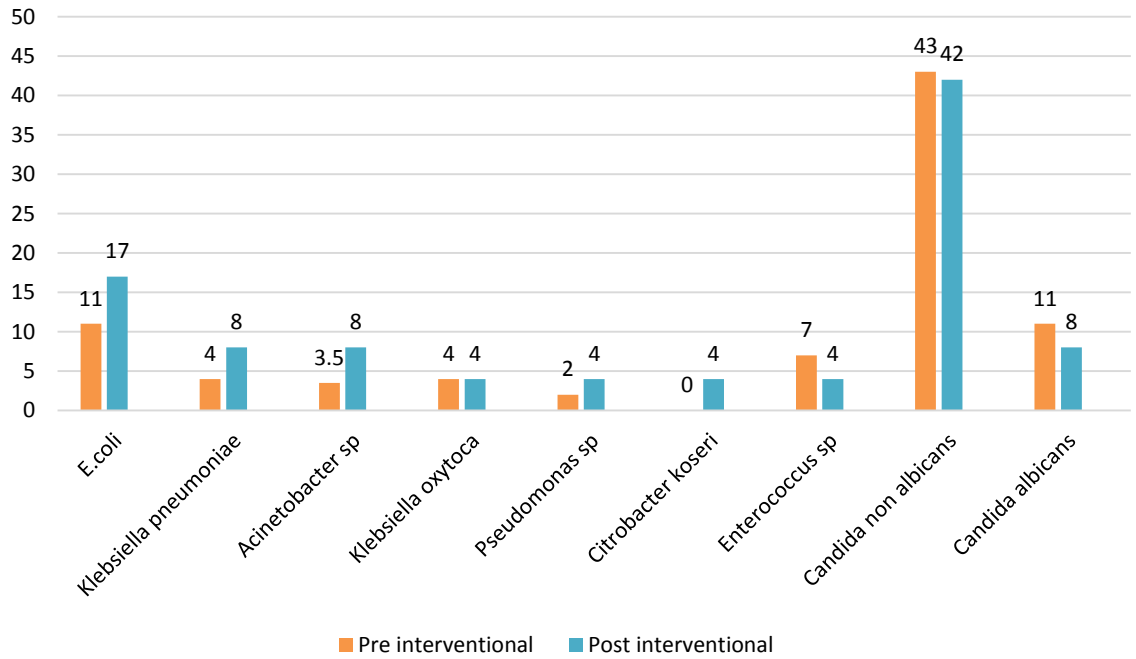


Fig:14 Comparison of Catheter use and Infection rate

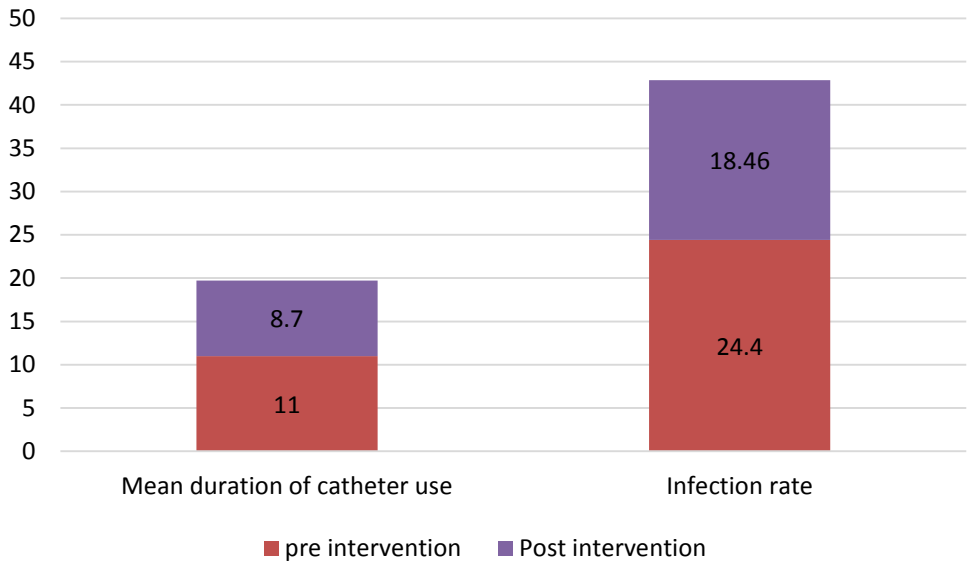


Table: 11 Descriptive analysis of catheter days - post interventional surveillance

Days of urinary catheterisation	No of patients	No of UTI detected	Total No of Device Days	Infection rates (%)	Mean duration of catheter use
≤3	20	0	44	0	1.4
4 - 7	47	7	242	14.8	5.1
>7	63	17	850	27	13.49
Total	130	24	1136	18.46	8.7

CAUTI rate was calculated as 22 and 21 per 1000 catheter days for pre interventional phase and post interventional phase respectively. There was no statistically significant difference between infection rates of both the phases. p=0.127.

Table: 12 Trend analysis of CAUTI rate during the Pre and Post interventional phases.

Phase	CAUTI rate	
	Apr & May	June & July
Pre intervention 2016	28.04	34.78
Post intervention 2017	16.32	9.52
p value	0.184	0.012

Trend analysis of CAUTI rate was done by comparing 4 data i.e April, May, June and July in 2016 and 2017, found to be statistically significant. (p value was 0.012 for the months June, July of 2016 and 2017).

Table: 13 Baseline and Post interventional evaluation of Tracheal Aspirate specimen.

Nature of specimen	Baseline		post interventional	
	Total no. of patients	No. of culture positives (%)	Total no. of patients	No. of culture positives (%)
Tracheal Aspirate	53	32(60)	89	42(48)

Number of Tracheal aspirate specimen has increased in the Post interventional evaluation by 68%.

Table: 14 Baseline and Post interventional evaluation of infection rate in the study group.

	Urine specimen		Blood specimen		Respiratory & fluid specimen	
	Total no. of patients	No. of culture positives (%)	Total no. of patients	No. of culture positives (%)	Total no. of patients	No. of culture positives (%)
Baseline data	168	41(24)	165	18(11)	106	49(46)
Post interventional data	130	24(18)	157	14(9)	154	58(38)
p value	0.114		0.550		0.858	

The difference in the infection rate of urine, blood and respiratory and fluid specimen between pre interventional phase and post interventional phase was not statistically significant.

Table: 15 Trend analysis of Blood stream infection rate among the study population.

Phase	Blood stream infection rate	
	Apr & May	June & July
Pre intervention 2016	10	10.5
Post intervention 2017	11.1	6.8
p value	0.829	0.591

Table: 16 Trend analysis of culture positivity of respiratory specimen during the study period.

Phase	Infection rate- Respiratory specimen	
	Apr & May	June & July
Pre intervention 2016	64.1	70
Post intervention 2017	47.6	41.11
p value	0.32	0.15

Table: 17 Distribution of MDR pathogens.

Specimen	Baseline		Post interventional	
	Total no. of organisms	No. of MDR organisms (%)	Total no. of organisms	No. of MDR organisms
Tracheal aspirate	32	13 (32.5)	42	18 (54.5)
Blood	18	8 (20)	14	6 (18)
Urine	20	9(22)	12	5(15)
Sputum	15	9 (22.5)	14	3 (9)
Body fluids	2	1 (2.5)	2	1 (3)
Total	87	40	84	33

Tracheal aspiration was the predominant specimen from which majority of the MDR pathogens were isolated.

Fig:15 Trend analysis of CAUTI rate

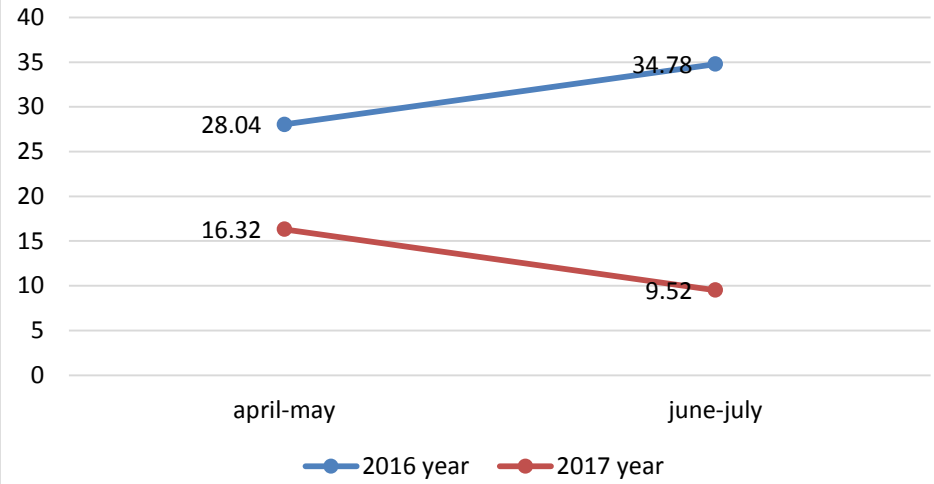


Fig:16 Trend analysis - respiratory specimen

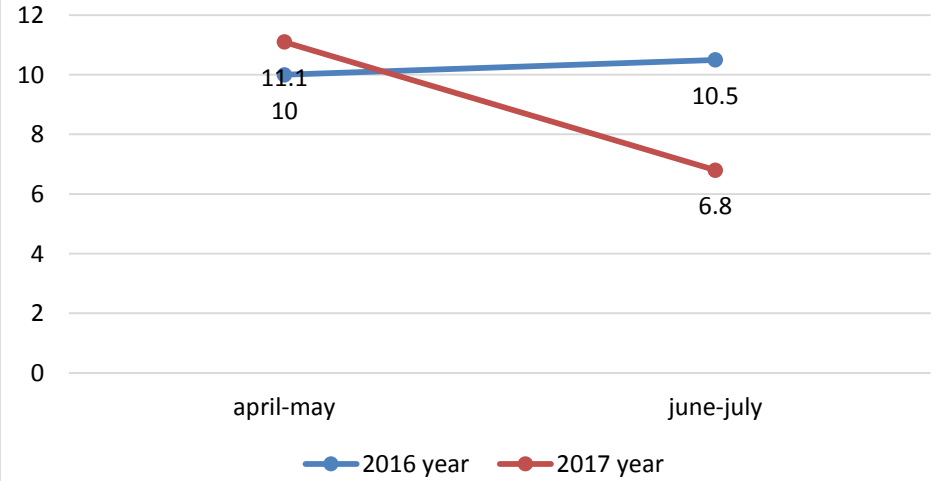


Fig: 17 Trend analysis of infection rate in blood specimen

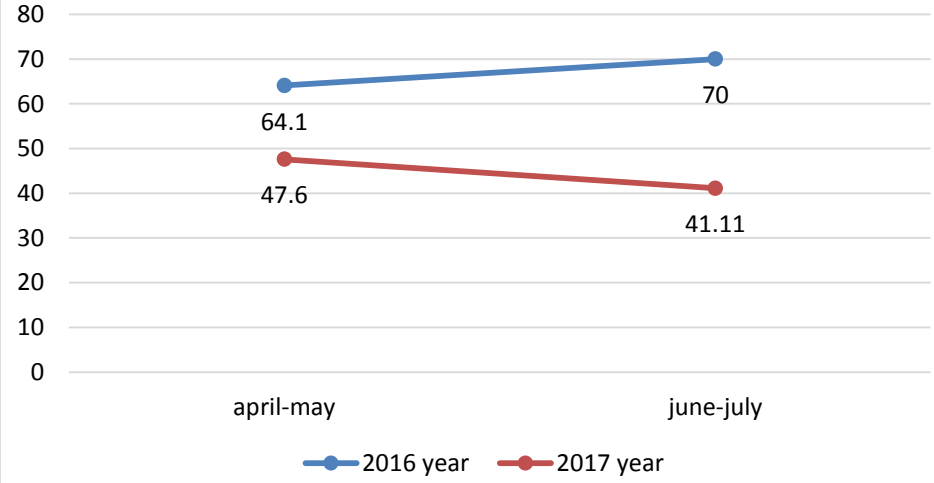


Fig:18 Comparison of MDR isolates

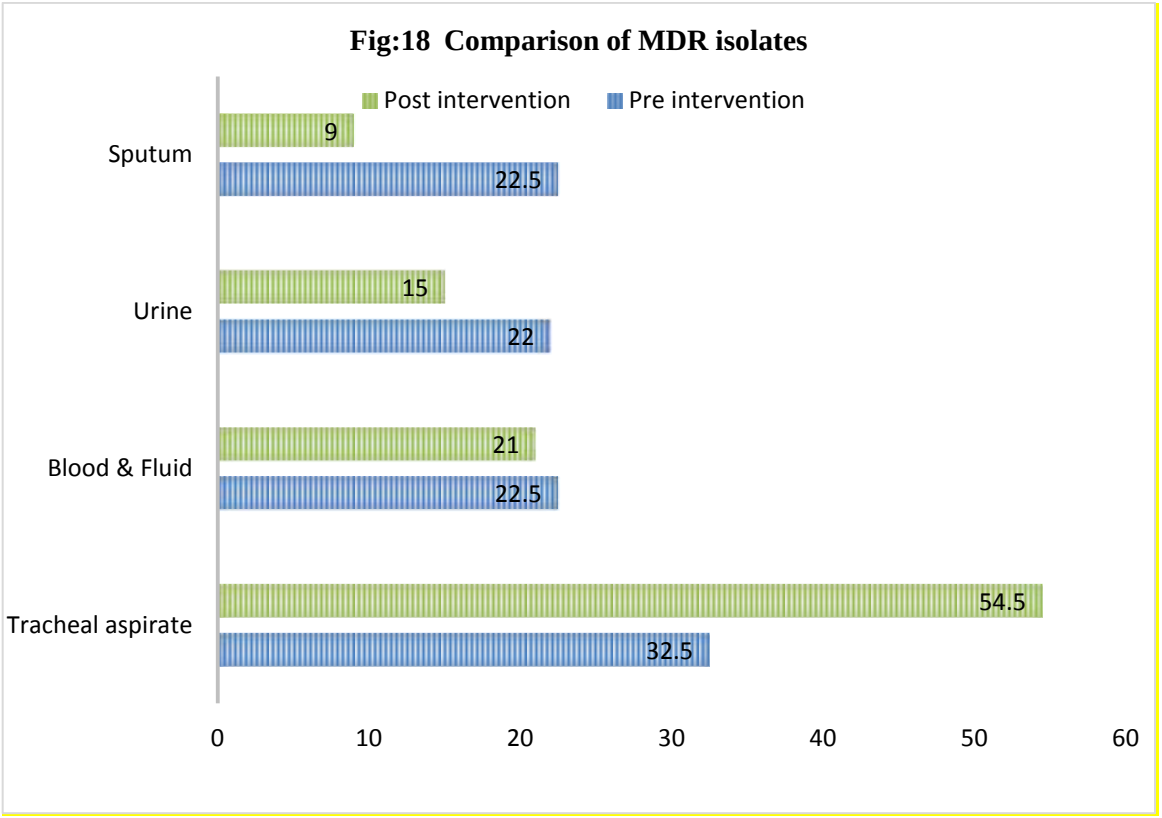


Table: 18 Nature of distribution of MDR pathogens.

Specimen	Organisms	Baseline		Post interventional	
		Total no. of organisms	No. of MDR organisms	Total no. of organisms	No. of MDR organisms
Urine	*E.coli*	5	2	4	0
	Klebsiella pneumoniae	4	1	2	1
	Klebsiella oxytoca	4	2	1	1
	Acinetobacter spp.	2	0	2	2
	Pseudomonas spp.	1	1	1	1
	Proteus mirabilis	1	0	0	0
	Citrobacter koseri	0	0	1	0
	Enterococcus spp.	3	3	1	0

Blood	*Klebsiella pneumoniae*	5	3	4	2
	E.coli	2	1	0	0
	Acinetobacter spp.	2	1	6	2
	Enterococcus spp.	3	1	1	0
	Staphylococcus aureus	0	0	1	1
	Staphylococcus epidermidis	6	2	2	1
Tracheal Aspirate	*Klebsiella pneumoniae*	14	7	12	5
	Klebsiella oxytoca	0		1	0
	Acinetobacter spp.	10	5	16	6
	Pseudomonas spp.	6	0	13	7
	Staphylococcus aureus	2	1	0	0
Sputum	*Klebsiella pneumoniae*	7	3	6	1
	E.coli	0	0	1	0
	Acinetobacter spp.	1	1	6	0
	Citrobacter koseri	1	1	0	0
	Pseudomonas spp.	6	4	1	2
Body Fluid	*Klebsiella pneumoniae*	1	0	1	1
	Acinetobacter spp.	1	1	0	0
	Pseudomonas spp.	0	0	1	0
Total		87	40 (46%)	84	33 (39%)

The difference in the distribution of MDR pathogens between Baseline and Post interventional was not statistically significant. p=0.376.

Table: 19 Distribution of Carbapenemase producing organisms among the study group - Baseline data.

Nature of Specimen	Total number of gram negative isolates	Carbapenemase Producing Organisms	Number
Tracheal Aspirate	30	*Acinetobacter spp.*	4
		Klebsiella pneumoniae	1
Urine	17	*Klebsiella pneumoniae*	2
Sputum and Fluid specimen	17	*Klebsiella pneumoniae*	1
		Pseudomonas spp.	1
Blood	9	*Acinetobacter spp.*	1
Total	73		10

Table: 20 Distribution of Carbapenemase producing organisms among the study group – post intervention data.

Nature of Specimen	Total number of gram negative isolates	Carbapenemase producing Organisms	Number
Tracheal Aspirate	42	*Acinetobacter spp.*	4
		Klebsiella pneumoniae	2
Sputum and Fluid specimen	16	-	-
Urine	11	*Acinetobacter spp.*	1
Blood	10	*Acinetobacter spp.*	2
Total	79		9

In both the phases of this study *Acinetobacter spp.* was the predominant Carbapenemase producer. (p =0.667 not significant)

Table : 21 Distribution of resistant pattern among isolates.

Resistant pattern	Baseline (%)	Post interventional (%)	p value
MDR	40 (46)	33 (39)	0.376
ESBL	57 (78)	55 (70)	0.236
Carbapenemase production	10 (13.6)	9 (11.3)	0.667

Table: 22 Evaluation of Hand Hygiene Compliance.

Observations	No. of opportunity	No. of performed action	Percentage
Baseline	200	44	22
Post interventional	200	68	34

Table: 23 Thematic content of focus group discussion

S.no	Major Theme	Sub Category
1	**Challenges with practice of infection control**	*Heavy work load *Knowledge of core concepts * Complacency
2	**Interventions to improve**	*Need for training * Designated infection control personnel * Monitoring

Table: 24 Outcome analysis of post interventional KAP questionnaire study.

	Knowledge (8 marks)	Attitude (4 marks)	Practice (8 marks)
Mean(+/- STD deviation)	6.5 (1.33)	3.1 (0.727)	4.6 (1.40)

Table: 25 Summary table of population and Study findings.

Data	Pre interventional phase	Post interventional phase
No. of patients	359	353
Male	187	174
Female	172	179
No. of urine specimen	168	130
No. of blood specimen	165	157
No. of respiratory & fluid specimen	106	154
No. of Gram negative isolates	73	79
No. of Gram positive isolates	14	5
No. of fungal isolates	24	12

Data	Pre interventional phase	Post interventional phase
Organisms isolated in CAUTI	44	24
Total catheter days	1848	1136
Mean duration of catheterization(days)	11	8.7
CAUTI rate per 1000 catheter days	22	21
CAUTI rate-Trend analysis of 4 data points	34.7	9.5(p=0.012)
No. of MDR pathogens	40 (46%)	33(39%)p=0.376
No. of ESBL producers	57(78%)	55(70%)p=0.236
No. of Carbapenemase producers	10(14%)	9(11%)p=0.667
Hand Hygiene Compliance	22%	34%p=0.007

ANALYSIS

In this prospective interventional study, 78(22%) patients enrolled were in the age group between 31- 40 years, followed by 77(21%) in the age group 12 – 20 years in the pre interventional phase. For the post interventional phase, 100 (21%) patients were from the age group 21-30 years. On the whole the observation showed that majority of the patients for both the pre interventional phase (n=142, 40%) and for the post interventional phase (n=147, 42%) were from the age group 12-30 years. [Table 1]

Age and sex wise stratification of the study participants is depicted in Table 2. There was no significant variation in male: female ratio (1.01: 1) among the participants.

A total of 439 consecutive specimen for the pre interventional phase and 441 consecutive specimen for the post interventional phase were included during the study period, each phase lasted for six months. Nature and distribution of the specimen is discussed in Table 3.

Pattern of microorganisms isolated from various clinical specimens for the pre interventional phase is tabulated in Table 4 and the post interventional phase is tabulated in Table 5.

Out of the 87 bacterial isolates obtained from clinical specimen in the pre interventional phase, 32 (37%) isolates were from tracheal aspirate and 20 isolates (23%) were from urine. In the post interventional phase, 84 bacterial isolates were cultured; of this 42(50%) were from tracheal aspirate and 12 (14%) were cultured from urine specimen. Fig: 12 depict the Bacterial Profile of both the phases of the study.

Table 6 compares the spectrum of microorganisms isolated in both the phases of the study. There was no significant difference in infection rate between base line and the post interventional phase. $p = 0.218$.

Klebsiella pneumoniae 31 (36%) was the predominant pathogen isolated in pre interventional phase followed by *Acinetobacter spp.* 16(18 %). Majority of the *Klebsiella pneumoniae was* grown from Tracheal aspirate (45%) followed by sputum (23%), blood (16%) and urine specimen (13%).

In the post interventional phase, *Acinetobacter spp.* 30(36%) was the predominant pathogen isolated followed by *Klebsiella pneumoniae* 25(30%). Tracheal aspirate was the major source for the isolation of *Acinetobacter spp.* in both the phases.

By the phenotypic characteristics, such as glucose oxidation, beta hemolysis and growth at 37^{o}C & 42^{o}C the *Acinetobacter* isolates were speciated. Of the total 46, catalase positive, oxidase negative non-fermenter isolates, 36(78%) were *Acinetobacter boumannii*, 10(22%) were *A.lwoffii* and one isolate was *A.hemolyticus*.

Distribution of Gram Positive organisms among various clinical specimens is shown in Table 7. In the pre interventional phase, 14(16%) Gram positive organisms were isolated out of 87 and in the post interventional phase, 5(6%) Gram positive organisms were isolated out of 84 bacterial isolates. *Enterococcus* isolates were speciated by sugar fermentation (arabinose, raffinose, sorbital) tests, and *Enterococcus feacalis* 6 in number and *Enterococcus faecium* 2 in number were identified.

A total number of 41(24.40%) patients out of 168 clinically diagnosed CAUTI patients were culture positive with significant colony count in the pre interventional phase. Bacterial pathogen was identified in 17 (41 %) of patients and in 24 (59 %) patients *Candida* species were isolated. [Table 8]. Out of 17 patients 3 patients had 2 bacterial isolates each with significant count. So, 20 bacterial pathogens were isolated from 17 patients.Among the fungal isolates *Candida non albicans* was the predominant organism isolated in 19 (79.2%) patients while *Candida albicans* was isolated only in 5(20.8%) patients. Among *Candida non albicans*, *C. tropicalis* 09(47%) was the predominant species followed by *C. glabrata* 05 (26%) *C. krusei* 03(15.7%) and *C.parapsilosis* 2(10.5%).

Spectrum of microorganisms isolated from clinically diagnosed CAUTI patients in the post interventional surveillance is given in the Table 9. *Candida non albicans* was the predominant organism isolated in 10 patients (42%) followed by *Escherichia coli* 4(17%). Infection rate was 18.4% Fig: 13 depict the comparison of spectrum of CAUTI isolates in Pre and Post interventional phases.

The descriptive analysis of catheter days in the pre interventional phase shows that the rate of development of CAUTI was higher as the duration of catheterization increased. p value 0.033946, Chi square value 6.766.Table 10. Comparison of mean duration of catheterization and infection rate in given in Fig: 14.

The total urinary catheterization day calculated for 168 patients in the pre interventional phase was 1848 days. The same was calculated as 1136 days for 130 patients in the post interventional phase[Table 11]. CAUTI rate was calculated as 22 and 21 per 1000 catheter days for pre interventional phase and post interventional phase respectively. There was no statistically significant difference between infection rates of both the phases. p=0.127.

Trend analysis of CAUTI rate was done by comparing 4 data points' i.e CAUTI rate during the pre-interventional phase (April, May, June and July in 2016) and the same months in the post interventional phase 2017. It was found to be statistically significant (p value was 0.012 for the months June, July of 2016 and 2017). [Table 12]

Baseline and Post interventional evaluation of Tracheal Aspirate specimen number and culture positivity is discussed in Table 13. Number of Tracheal aspirate specimen has increased in the Post interventional evaluation by 68%.

The difference in the infection rate of urine specimen (p=0.114), blood specimen (p=0.550) and respiratory and fluid specimen (p=0.858) between pre interventional phase and post interventional phase was not statistically significant. [Table 14]

Table 15&16 discusses the trend analysis of Blood stream infection rate and the culture positivity of respiratory specimen between Pre and Post interventional phases during the study period. Line diagram for the Trend analysis of infection rate of urine, respiratory and blood specimen is given in Fig: 15, 16, 17.

Table 17& 18 depicts the nature and distribution of MDR pathogens among study isolates. The difference in the distribution of MDR pathogens between Baseline and Post

interventional was not statistically significant. p=0.376. The rate of isolation of MDR pathogens both in pre and post interventional phases compared in Fig: 18.

Distribution of Carbapenemase producing organisms among the study group, Baseline data and Post interventional data is presented in Table 19 and Table 20 respectively. In both the phases of this study *Acinetobacter spp.* was the predominant Carbapenemase producer and Tracheal aspiration was the predominant specimen from which it was isolated. p =0.667 not significant.

Distribution of resistant pattern among isolates is compiled in Table 21.Though there was a difference in number of ESBL isolates between two phases of study it was not significant. Among the gram positive organisms, Methicillin Resistant was diagnosed in 3 out of 8 *Staphylococcus epidermidis* isolates in this study. Among the *Staphylococcus aureus,* one out of 3 was Methicillin resistant.

Evaluation of Hand Hygiene Compliance showed a statistically significant difference p=0.007. [Table 22]

Thematic content of focus group discussion is illustrated in Table 23. Two major themes evolved were Challenges with practice of IC and Interventions to improve.

Table: 24 discusses the outcome analysis of post interventional KAP questionnaire study. T test value for knowledge to attitude, knowledge to practice and attitude to practice is 2.04. p value <0.001.

Only 44% (7 out of 16) of participants were aware about the major infection control related problem of their work place.

Practising universal precautions was protective as per 75% of participants, it was a compulsory affair according to 25% of participants.

According to 69% of participants inadequate supply of alcoholic hand rub was the major barrier to HHC. Heavy work load (19%) and lack of accessible place of hand rub (12%) were the other barrier for poor HHC.

As per the statement by 37% of participants HH was not adequately practiced by other staff members while 63% of them expressed their satisfaction about HH practice of other staff members.

Summary of the study population and the study findings of both the phases is given in Table: 25.

DISCUSSION

The study was conducted in a 22 bedded IMCU of a tertiary care hospital, which also included 5 bedded high dependency unit.

There were 5 medical officers and 2 head nurses with 20 staff nurses posted in 3 shifts round the clock. The staffs were not exclusively posted in IMCU, they were also catering the adjacent 22 bedded toxicology intensive care unit. Two Medical post graduate students and two interns per shift were posted on monthly rotation. Apart from this, 4 student nurses and 4 emergency care technician students, 2 injection staff and one lab technician were posted regularly in the day time shifts. Four sanitary workers were also posted in 3 shifts.

Allied health care personnel like physiotherapist, hemodialysis technician, dietician and Anesthetist, ENT surgeon and many other qualified medical persons from various speciality departments were the floating population catering the IMCU patients on call.

The present study was designed as non-randomized, quasi-experimental which is commonly used in hospital epidemiology: i.e. interrupted time series without control groups.The interrupted time series is the predominant study design for infectious disease epidemiology, especially in the hospital setting. The ORION statement: guidelines for transparent reporting of Outbreak Reports and Intervention studies Of Nosocomial infection emphasizes thoroughness in reporting: as well as the usual what was done and when it was done, for such quasi-experimental research.[18]

Base line or Pre-interventional evaluation of the infection control indicators such as HHC, CAUTI rate and MDRO rate were calculated for a period of six months from April 2016 to September 2016. This was followed by 4 months intervention, from October 2016

to January 2017, then Post interventional surveillance of the same indicators were done for a period of six months from February 2017 to July 2017.

There was no significant difference in the number, age and sex distribution of patients in both the phases (pre and post intervention) of this study. [Table 1&2]Also there was no significant difference in the nature of distribution of specimen and pattern of microorganisms isolated from the various clinical specimen except that there was a 68% increase in Tracheal aspirate sample in the post intervention phase. [Table3, 4&5]

In this study, among the bacterial isolates, 14(16%) were Gram positive organisms and 73(84%) were Gram negative organisms in the pre interventional phase and in the post interventional phase 5(6%) were Gram positive , 79(94%) were Gram negative [Table 6&7]. This is similar to other hospital based studies.[2] In an Indian study conducted in a tertiary care centre, by Jaggi et al., among the study isolates, Gram-negative (80.8%) showed a clear preponderance than Gram-positive pathogens (19.9%). [66]

In the WHO Global priority list of Antibiotic resistant bacteria to guide research, discovery and development of new antibiotics, the organisms causing HCAI are grouped under priority 1 critical list. In that list, 9 out of 12 families are of the "gram-negative" type and are MDROs. Top of the list is *Escherichia coli*, the leading cause of urinary tract infections. [67]

In this study the difference in the spectrum of bacterial isolates in pre and post interventional phase was not significant. p value 0.218.[Table 6] Among the Gram-negative isolates, *K.pneumoniae* (36%) was the predominant bacterial isolate in the pre interventional phase followed by *Acinetobacter spp.* (18%) and *Pseudomonas spp.* (15%). In the post interventional phase *Acinetobacter spp.* (36%) was the predominant followed by

K.pneumoniae (30%) and *Pseudomonas spp.* (19%). This spectrum is similar to nosocomial pathogens isolated in other Indian studies.[68, 69]

In the present study, among the CAUTI specimen, a total number of 41(24.40%) patients out of 168 were culture positive with significant colony count. Bacterial cause was identified in 17 (41 %) patients and in 24 (59 %)patients, Candida species were isolated, in the pre interventional phase. In the post interventional phase, 24 (18%) patients out of 130 had significant bacteriuria and bacterial cause was identified in 12(50%) of them.

Candida non albicans was the predominant isolate[70] followed by *E.coli* in both the phases among the CAUTI specimen.[Table 8&9]Among the bacterial isolates, Gram-negative bacilli represented the most common (85% in pre intervention and 91% in post interventional phase).

The descriptive analysis of catheter days in the pre interventional phase shows that the rate of development of CAUTI was higher as the duration of catheterization increased. p value 0.033946, Chi square value 6.766.[Table10]

The mean duration of catheterization in this study was 11 days and 8.7 days in pre and post interventional phases respectively. The mean duration of catheterization decreased by 27%, resulting in 2.30 fewer days of catheterization per patient in the post intervention group. [Table 10 &11]

In a hospital-based prospective study on risk factors of CAUTI, the mean duration of catheterization was 4.8 days and 28/125 (22.4%) of patients developed a symptomatic urinary tract infection during the period of follow up. [71]

CAUTI rate in the present study calculated at the end of the pre interventional and the post interventional phase was 22 and 21 per 1000 catheter days respectively. But the trend analysis of data points in the months of June and July in both the phases showed decrease in the urinary infection rate from 34.78 to 9.52 which was significant. [Table12] It was not the same with April and May months of both the phases. This explains the phase of reluctance and the time period required by HCPs to adapt to the newly introduced CAUTI bundle concepts.

The decrease in mean catheterisation rate and CAUTI rate leads to decrease in IMCU stay and in turn decreases the use of broad spectrum antibiotics. Practising the IC methods such as HH and CAUTI bundle approach ultimately leads to cost effective patient care and patient safety. Studies proved that patients who had longer ICU stays had higher rates of infection, especially infections due to resistant *Staphylococci, Acinetobacter spp., Pseudomonas species, and Candida species*.[72]

Inadequate infection prevention and control practices provide greater opportunities for new drug resistant infections to emerge in healthcare settings. In turn, a high incidence of such infections results in an increased demand for broad spectrum and reserve antibiotics, which also contributes to increased drug resistance.[73]

The difference in the infection rate of blood specimen (p=0.550) and respiratory and fluid specimen (p=0.858) between pre interventional phase and post interventional phase were not statistically significant. [Table13&14] Also the trend analysis of data points for the blood stream infection rate and culture positivity rate of respiratory specimen in the pre and post intervention phase were not significant.[Table15&16] However the significant reduction in the CAUTI rate in the trend analysis explains the importance of effective introduction of bundle approach for the prevention of device associated infections.

In a study by Amira Ezzat Khamis Amine et al., to evaluate the intervention program to prevent CAUTI, the presence of a statistically significant strong negative correlation between the adherence to the urinary catheter care maintenance bundle elements and the CAUTI rate, suggests their strong role in the prevention of CAUTI. Adherence to recommended CAUTI preventive practices (bundle) should become part of a culture of patient safety. [74]

According to a study by Jaggi and Sissodia conducted in the year 2012 in India, the most common labour and cost effective CAUTI prevention measures were adherence to the urinary catheter bundle components (indication for catheter insertion and change, asepsis maintenance during and after the catheter insertion and avoiding urine reflux) and hand hygiene practices. [75]

In a Taiwan study, the rate of overall HAI decreased from 3.7% to 3.1% ($P < .05$), urinary tract infection rate decreased from 1.5% to 1.2% ($P < .05$), and respiratory tract infection rate decreased from 0.53% to 0.35% ($P < .05$) after the implementation of WHO multimodal hand hygiene improvement strategy. [76] In the present study, reduction in CAUTI rate was significant however the reduction in the infection rate of respiratory specimen was not significant. $p= 0.858$

HCAI caused by MDR pathogens and extensively drug-resistant Gram-negative pathogens represent a major threat worldwide.[57] In general, MDRO are those organisms which are resistant to at least one agent in at least three antimicrobial classes of Cephalosporins, β-lactam/β-lactamase inhibitors, Carbapenems, Fluoroquinolones, Aminoglycosides [77]and are considered to be epidemiologically important as these organisms are associated with treatment failure and increased morbidity.[78]

Methicillin-resistant *Staphylococcus aureus* [MRSA], Vancomycin resistant *Enterococcus* and Carbapenem-resistant Enterobacteriaceae are some of MDROs. MDR is also common and increasing among non-fermenting Gram-negative bacteria. The ESKAPE microorganisms, -*Enterococcus faecium*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa* and *Enterobacter spp*., point out the 'eskape' effect from the action of antibacterial agents.[79]

According to a study conducted by Puneet Butt et al., most resistant MDR isolates were obtained from acute wards (42.9) and ICU (29.5) followed by other wards.[80]In that study the most common specimen in which these resistant isolates were obtained was urine followed by tracheal aspirate. [80]

In the present study, approximately 40% of isolates in the pre intervention phase and 39% in the post intervention phase were MDR. This is in contrast to a study by Giang M et al., in which 85% were found to be multiple-drug resistant.[82] Among the MDR pathogens, maximum number were isolated from Tracheal aspirate specimen both in pre-interventional phase (32.5%) and in post interventional phase (54.5%). [Table 17] *K.pneumoniae* (33%) was the most common MDR pathogen followed by *Acinetobacter spp.* (25%) and *Pseudomonas spp.* (20%). Rate of isolation of MDR pathogen decreased from 46% in the pre-interventional to 39% in the post interventional phase.p value is 0.376. [Table 18] In a south Indian study conducted by Kailash et al., 55.7% of IMCU isolates were MDR and the most common organism isolated was *Pseudomonas* spp. (19.1%) followed by *Acinetobacter spp*. (17.5%) from tracheal aspirate.[81]

Among the MDR Gram negative isolates, highest resistance was observed to Ampicillin, lowest resistance was observed to Amikacin, Cefaperazone/Sulbactam,

Piperacillin/Tazobactam and Imipenem. Among the Gram negative Enterobacteriaceae isolates, 80% were susceptible to Amikacin, 72% to Cefaperazone/Sulbactam, 68% to Ciprofloxacin and 50% to Gentamicin. Only 20% of them were susceptible to Cefotaxime and 8% to Ampicillin.

The non-fermenter isolates were found to be susceptible to Amikacin (70%)Piperacillin/Tazobactam (60%), Ciprofloxacin (52%), Gentamicin (48%) and only 24% of them were susceptible to Ceftazidime. This is similar to studies conducted in various parts of the globe, in which the highest susceptibility rates recorded for *K.pneumoniae, P.aeruginosa* and *Acinetobacter* species were to Amikacin and Imipenem while the lowest susceptibility rates were to ampicillin, ceftriaxone, ceftazidime, ciprofloxacin and gentamicin. [83,84]

Amikacin was the most effective antibiotic against both Enterobacteriaceae isolates (80%) *and* non-fermenter isolates (70%) followed by Imipenem. This is similar to an Indonesian study in which Amikacin was the most effective (84.4%) antibiotic against *P. aeruginosa* followed by Imipenem (81.2%).[85]

The susceptibility rates to Piperacillin/Tazobactam and Cefaperazone/Sulbactam were on average about 60% and 72% respectively. This may be due to increase usage of the antibiotic.[86]

In this study, among the Gram positive organisms, all the MRCoNS (37.5%)isolates and 33% of MRSA were obtained from blood. This is similar to a study conducted in Intensive Care Units of a Tertiary Care Hospital in Southern India, in which about (40.6%) of *Staphylococcus aureus* were found to be MRSA.[81]

Both MRSA and MRCoNS exhibited higher resistance to Penicillin-G (91%), Ampicillin (81%), Ciprofloxacin (64%) and all were sensitive to Vancomycin and Linezolid. All the *Enterococcus spp.* isolated from CAUTI patients were found to be multidrug resistant and were found to be sensitive to Vancomycin. Since the number of Gram-positive isolates was < 16%, this may not be the true picture to be considered as significant. All the *Staphylococcus epidermidis* isolates were obtained from blood culture and pathogenicity of the isolate was confirmed by isolating the same organism with the consecutive blood samples collected from the patient and by clinical correlation.

In an Indian study conducted by Gopalakrishnan et al., over an 8 year period in a tertiary care hospital, on antimicrobial susceptibility and hospital acquired infections, the overall MRSA prevalence was 40-50% and 17% of *Staphylococcus aureus* was isolated from catheter related blood stream infections (CRBSIs) in that centre. [87]

A high proportion of *Acinetobacter spp.* (50%) in the pre intervention and in the post intervention phase (33%) was multidrug resistant. For *Klebsiella pneumoniae* 45% and 40% were multidrug resistant in the pre and post intervention phase respectively.This is similar to another hospital based study conducted in Delhi, in which high rates of multidrug resistance were observed in *Acinetobacter spp., Klebsiella spp.* and *Escherichia coli* isolates.[88]

Among the Carbapenemase producing organisms, *Acinetobacter spp.*(63%) was the predominant pathogen followed by *K.pneumoniae* (32%). In a study by YanlingXu et al., stably escalating trend of resistance rates to imipenem and meropenem was reported in *Enterobacteriaceae*.[89]

In both the phases of this study, *Acinetobacter spp.* was the predominant Carbapenemase producer and Tracheal aspiration was the predominant specimen from which it was isolated. p =0.667 not significant.[Table19&20] This is similar to a study on MDR pathogens, in which the prevalence of Carbapenem resistance in *Acinetobacter spp.* was found to be 85%. [90]

In a 4 year study conducted in western India on trends of *Acinetobacter spp.*, a high proportion of MDR and ESBL producing non susceptible *Acinetobacter spp.* were isolated from respiratory specimen.[91]

The ESBL producing Gram negative isolates were 78% and 70% in the pre-interventional phase and in the postinterventional phase. [Table 21] In a study by Pottahilshinu et al., the incidence of ESBL-producing organisms among clinical isolates of urinary tract infections and wound infections was found to be 72.41%.[92] In another study, among the 150 non repetitive Gram negative isolates, 102 (68%) were found to be ESBL producers and prevalence of ESBLs was maximum in ICU (34.2%). [93]

Hand washing is the easiest and oldest strategy to prevent nosocomial infections. Moreover, scientific evidence suggests that the compliance of hand hygiene by HCP with alcohol based hand rub reduces the HCAI rate and is more acceptable and easier to use.[94] In spite of all the aforementioned facts, poor compliance with HH recommendations among HCP is a worldwide problem.The results of researches conducted in the public sector, even in developed countries, also showed poor performance of nurses and other health workers in hand hygiene.[95,96]

In the present study, HHC rate in pre interventional phase was 22% and it increased to 34% in the post interventional phase. (p <0.010). [Table 22] Also there was a 40% increase in the requirement of alcohol based hand rub in the post intervention phase.

Many studies claim that HHC improvement is temporary after educational interventions.[97,98] In a study by Huang et al,[99] 4 months post-education, HHC significantly improved (P<0.001) for the nurses in the experimental group compared to the control group which is similar to this study. HHC was found to be highest among nurses (63%) followed by other staff (56%) and doctors (48%). This is similar to a study conducted in a tertiary care hospital in which nurses were found to be more compliant to HH practice than doctors.[100]

In an another study by Jui-Kuang Chen et al , overall HHC increased from 62.3% to 73.3% after 1 year of intervention (P < .001).[76] In contrast, Gould et al found that 3 months after the education intervention, there was no significant improvement in the number of essential hand hygiene episodes in the intervention.[101]

In this study, 69% of participants stated that the inadequate supply of alcoholic hand rub was the common barrier to HH compliance. Heavy work load (19 %) and lack of easy access to hand rub (12 %)were the other reasons for poor compliance.

In an article reviewing the reported barriers to appropriate hand hygiene and factors associated with poor compliance, the author has stated that in high-demand situations, hand rub with an alcohol-based solution appears to be the only alternative that allows a decent compliance.[102] Easy access to hand hygiene product is also a necessary prerequisite for appropriate hand-hygiene behaviour.

In a two-arm cluster randomised controlled trial, the MRSA prevalence in the intervention arm dropped in the initial phases than control arm and became steady afterwards. Though the HHC improved significantly, the difference in MRSA prevalence and transmission between the two arms was not statistically significant.[103]

This is very similar to the present study with significant improvement in HHC (p=0.010) though the improvement in other infection control indicators was not statistically significant except the CAUTI rate.

Challenges to the infection control

According to recommendation by European society of intensive care medicine working group, 3 level of care (LOC) is proposed. Patients with 2 or more acute vital organ failure are categorized in LOC III (highest), patients requiring monitoring and device related support with one vital organ failure are grouped in LOC II, and LOC I (lowest) represents patients with signs of organ dysfunction necessitating continuous monitoring with minor device support. For different LOC, appropriate minimum nurse/patient ratio proposed is, LOC III - 1/1, LOC II - 1/2 and for LOC I is 1/3. [104]

The typical nurse to patient ratio in this study was 1:4 at morning and 1:6 at afternoon and night shifts. This is similar to other studies in which, insufficient funding and human resources, hospital overcrowding, and low nurse-to-patient ratios even in intensive care units were reported as important challenges in successful implementation of infection control and prevention practices in Indian hospitals.[2, 105]

Understanding the perspectives of infection control practices among HCPs is essential in planning interventions in a health care setting. With this background, in the beginning of the interventional phase, a focus group discussion was carried out to assess the

knowledge and attitude of HCPs on infection control and hand hygiene practices. Thematic analysis came out with two major themes: Challenges with practice of IC and Interventions to improve. In challenges, the major sub category emerged was job related, heavy work load and emergency situations.[Table23]This is similar to other studies conducted in developing countries.[106,107,108]

In interventions to improve the IC practices, availability of hand hygiene product at the point of care was suggested by many participants. As noted by other studies [109,110] providing point of care hand hygiene products facilitates integration of hand hygiene in to the natural workflow patterns of HCPs and can contribute to HHC.

In answering to the question relating to the adequacy of practice of infection control by other staff members, only 63% of participants endorsed that all are adequately practicing infection control. 37% of participants reported that the infection control practice by other members was not adequate.Only 44% of participants were aware about the major infection control related problem of their work place.

Major barriers to Infection control, recognized in this study related lack of administrative support leading to inconsistent and inadequate supply of alcoholic hand hygiene products. Under staffing and overcrowding of patients causing increased work load to nursing staff was another major barrier.Administrative support is critical and it plays a pivotal role in effective implementation of infection control practices. Similarly a qualitative study by Anna K, concludes that, institutional support for infection control and prioritizing resources to recruit and retain trained, experienced nursing staff are critical to the effective implementation of infection control practices.[111]

The outcome analysis of post interventional KAP questionnaire study showed T test value for knowledge to attitude, knowledge to practice and attitude to practice is 2.04, which was statistically significant (p value <0.001). [Table24]This implies that there is a significant conversion of knowledge to attitude and attitude to practice. HHC improved and trend analysis of CAUTI rate were reduced significantly.Even after this, the other IC indicators, like infection rate of respiratory samples and blood stream infection, MDRO rate, ESBL and Carbapenemase rate between pre and post interventional phases were not significantly reduced. This reflects the lack of organized infection control programs with a well-trained infection control team and an institutional climate that prioritizes infection control in the public sector hospital.

Two other similar interventional studies conducted from India also reports on the role of person and organizational level factors in improving the implementation of infection control and prevention measures.[112,113] Furthermore, a recent international survey of infection prevention practices in thirty countries concludes that limited trained staff, inadequate infrastructure, and supplies were major barriers in preventing MDRO transmission.[114]Also following infection control practices and HHC involves, emotional sensitization and cultural transformation than acquiring knowledge and attitude. Behavioural change takes time to emerge.Infection control measures have to be given priority with recruitment of more personnel and with more budgetary allocation.

SUMMARY

Setting:

Intensive Medical Care Unit (22 beds) of adult wards in a tertiary care hospital.

Study design:

Prospective interventional

Population characteristics:

Both male and female adult patients' age ranging from 12 to 86 years consecutive IMCU admissions during the study period. Doctors and other HCPs serving in the IMCU.

Major infection control interventions during the study:

Focus Group Discussion, Training and education of HCPs on hand hygiene and infection control practices, Bundle approach was introduced for CAUTI prevention, maintaining charts in the form of monitoring tools on CAUTI and MDROs isolated from patients' clinical samples, and Providing Information Education Charts (IEC), ready reckoner materials at work place.

- A total of 359 patients in the pre intervention and 353 patients in the post intervention phase were included in the study.
- There was no significant variation in the male:female ratio.(1.01:1)
- Various clinical samples with suspected infection, a total of 439 specimen in the pre intervention and 441 specimen in the post intervention were collected and subjected to culture in the study period.

- The most common isolates were gram negative pathogens. There was no significant difference between infection rate between base line and the post interventional phases. p =0.218.

- In catheterised patient with clinically suspected CAUTI, 168 urine specimen in the pre intervention phase and 130 urine specimen in the post intervention phase were collected and subjected to culture.

- The rate of development of CAUTI was higher as the duration of catheterization increased. p value 0.033946, Chi square value 6.766.

- CAUTI rate calculated at the end of the pre and post intervention phase 22 and 21 per 1000 catheter days respectively.

- The mean duration of catheterisation was 11 days and 8.7 days in the pre and post intervention phases respectively.

- Trend analysis of CAUTI rate was done by comparing 4 data points' showed significant reduction in infection rate. p= 0.012

- In this study, maximum number of MDR pathogens were isolated from Tracheal aspirate specimen. *K.pneumoniae* (33%) was the most common MDR pathogen followed by *Acinetobacter spp.* (25%) and *Pseudomonas spp.* (20%).

- ESBL rate was 78% and 70% in the pre and post intervention phases respectively.

- There was no significant difference in the carbapenemase production (p= 0.667) in both the phases of the study.

- After the intervention, there was a vast improvement in the HHC (p=0.007) and CAUTI rate was reduced significantly.

- Even after this the other IC indicators, like infection rate of respiratory samples and blood stream infection, MDRO rate, ESBL and carbapenemase rate between pre and post interventional phases were not significantly reduced.

- This reflects the lack of organized infection control programs with a well-developed infection control team and an institutional climate that prioritizes infection control in the public sector hospital

CONCLUSION

- HCAI is a major threat to the safety of patient care and it is a growing problem all over the world especially public sector hospital in a developing country.
- In an IMCU setting, the urinary tract of catheterized patients is highly susceptible to infection by MDR pathogens.
- HCAI associated with varied microbiological etiology and 39-46% of them was MDROs.
- As the rate of development of CAUTI is significantly associated with the duration of catheterization emphasis should be made on reducing the duration of catheterization.
- Intervention by training and education of HCP in infection control and HH significantly increased HHC.
- Introduction of Bundle concepts in the prevention of CAUTI was very much beneficial with decrease in mean duration of catheterization by 2.3 days and CAUTI rate was significantly reduced in the post intervention phase.
- Practising the IC methods such as HH and CAUTI bundle approach ultimately leads to cost effective patient care and patient safety.
- MDRO rate and infection rate of Blood, tracheal aspirate, sputum and sterile fluid specimen were not significantly decreased.
- CAUTI prevention bundle approach was successful as it was specific and focused.
- Problems associated with infection prevention and control in a public sector hospital is multifactorial involving infrastructure, environmental and personnel. Comprehensive infection control intervention should not only involve training and education but should address all these factors.

- Major barriers to Infection control, recognized in this study related to lack of administrative support leading to inconsistent and inadequate supply of alcoholic hand hygiene products and under staffing and high bed occupancy of patients.
- Understanding the perspectives of infection control practices among HCPs is essential in planning interventions in a health care setting.
- Epidemiological Surveillance of HCAI is essential to understand the nature and extent of problem also it supports the clinicians in treating infections and helps in planning the prevention strategies to ensure a quality health care in any hospital.
- Administrative support is critical and it plays a pivotal role in effective implementation of infection control practices.

RECOMMENDATIONS

- The prevention, control and treatment of HCAI is a concern of all health care professionals working in a hospital including microbiologists, clinical specialists from various disciplines of medicine and surgery, medical and nursing administrators.
- By this structured intervention study, involving assessment, education and surveillance as components, HCAI rate was monitored.
- The risk factors and local determinants for acquiring HCAIs were revealed and the outcome will be extremely useful.
- Also such study unveils the challenges in implementation of infection control program in a resource constraint setting.
- This study recommends the surveillance of HCAI which is very important to understand the nature and extend of problem which helps in planning the prevention strategies to ensure a quality health care in any hospital.
- Thus it becomes important to undertake such studies at Institutional level and to share the knowledge, experience and quality improvement and research findings.

LIMITATIONS

- The study analyzed the effectiveness of IC practices using only three indicators. Many factors should be involved for improving IC in IMCU, as it is very difficult and complicated to improve IC.

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Annexure (i)

PATIENT CONSENT FORM & INFORMATION SHEET

TITLE OF THE STUDY: "A study on assessment of challenges and effectiveness of infection control measures in a tertiary care hospital using specific infection control indicators."

Name	:	Date	:
Age	:	OP No	:
Sex	:	Project Patient No	:

Documentation of the informed consent

I _____ have read the information in this form (or it has been read to me). I was free to ask any questions and they have been answered. I hereby give my consent to be included as a participant in **"A study on assessment of challenges and effectiveness of Infection control measures in a tertiary care hospital using specific infection control indicators."**

I have read and understood this consent form and the information provided to me.

1. I have had the consent document explained to me.
2. I have been explained about my rights and responsibilities and about the nature of the study by the investigator.
3. I have been advised about the risks associated with my participation in this study.
4. I agree to cooperate with the investigator and I will inform her immediately if I suffer unusual symptoms.
5. I have not participated in any research study within the past _____ month(s).
6. I am aware of the fact that I can opt out of the study at any time without having to give my reason and this will not affect my future treatment in this hospital.
7. I am also aware that the investigator may terminate my participation in the study at any time, for any reason, without any consent.
8. I hereby give permission to the investigators to release the information obtained from me as result of participation in this study to the sponsors, regulatory authorities, Govt. agencies, and IEC. I understand that they are publicly presented.
9. I have understood that my identity will be kept confidential if my data are publicly presented.
10. I have had my questions answered to my satisfaction.
11. I have decided to be in the research study.

I am aware that if I have any question during this study, I should contact the investigator. By signing this consent form I attest that the information given in this document has been clearly explained to me and understood by me, I will be given a copy of this consent document.

For participants:

Name and signature / thumb impression of the participant (or legal representative if participant incompetent/for age 10-17 yrs-Name& signature of the parent/guardian.)

Name _____ Signature_____

Date_____

Name and Signature of impartial witness (required for illiterate patients):

Name _____ Signature_____

Date_____

Address and contact number of the impartial witness:

Name and Signature of the investigator or his representative obtaining consent:

Name _____ Signature_____

Date_____

Patient Information Sheet in Regional Language (Tamil)

தகவல் படிவம்

ஆராய்ச்சி தலைப்பு:

தீவிர சிகிச்சை பிரிவின் நோய்த்தடுப்பு நடவடிக்கைகளை மதிப்பீடு செய்தல் மற்றும் அந்நடவடிக்கைகளை நடைமுறைப்படுத்துவதில் உள்ள சிக்கல்களை கண்டறிவதற்கான ஆராய்ச்சி.

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மருத்துவமனை,
சென்னை.

தீவிர சிகிச்சைப் பிரிவில் அனுமதிக்கப்பட்டு கவனிக்கப்படும் நோயாளிகள் அவர்களின் நோயின் தன்மை, வீரியமிக்க மருந்துகள், பல்வேறு உபகரணங்கள், உபயோகிப்பது போன்ற பல காரணங்களினால் மருத்துவமனை சார்ந்த நோய்த்தொற்றுக்கு (Healthcare Associated Infectious) ஆளாக நேருகிறது. பல மருந்துகளாலும் கட்டுப்படுத்த முடியாத வீரியமிக்க கிருமிகளின் தாக்கமும், இந்த கிருமிகள் ஒரு நோயாளியிடம் இருந்து சுகாதாரத்துறை ஊழியர்களின் (Health Care Workers) கைகள் மூலமாகவும், சுற்றுப்புற சூழல் மூலமாகவும் அடுத்த நோயாளிகளுக்கு பரவுவதும் நிரூபிக்கப்பட்டுள்ளது. இத்தகைய நோய்த்தொற்று விகிதம் வளரும் நாடுகளில் அதிகமாக இருப்பதாகவும் கண்டறியப்பட்டுள்ளது.

முறையான நோய்த்தடுப்பு நடவடிக்கைகளினால் இத்தகைய நோய்த்தொற்று தாக்கத்தை வெகுவாக குறைக்க முடியும் என உலகசுகாதார நிறுவன ஆய்வரிக்கை கூறுகிறது.

இதன் பின்னணியில், நமது மருத்துவமனையின் தீவிர சிகிச்சைப் பிரிவல் தற்போதைய நோய்த்தடுப்பு நடவடிக்கைகளை மதிப்பீடு செய்வது, அனைத்து சுகாதாரத்துறை ஊழியர்களுக்கும் பயிற்சி அளித்து, நோய்த்தடுப்பு நடவடிக்கைகளுக்கு ஊக்கமளித்தல் மூலம் அதை நடைமுறைப்படுத்துவதில் உள்ள சிக்கல்களை கண்டறிவது இவையே இந்த ஆராய்ச்சியின் நோக்கமாகும்.

இதன் ஒரு பகுதியாக, தங்களின் இரத்தம், சிறுநீர், சளி மற்றும் உடல் திரவங்கள் நுண்ணுரியல் ஆய்வுக்கு உட்படுத்தப்படும். தங்களின் நோய்க்கண்டறிதல் மற்றும் சிகிச்சையின் ஒரு பகுதியாகவே இந்த பரிசோதனை மேற்கொள்ளப்படும்.

தங்கள் சுயவிருப்பத்துடன் இந்த ஆராய்ச்சியில் பங்கேற்கலாம். விருப்பம் இல்லாவிடில் விலகிக்கொள்ளலாம்.

ஏதேனும் வினா இருந்தால் மரு. K. உஷா கிருஷ்ணன், **9884824617** அவர்களை கேட்கலாம்.

Annexure (ii)

PROFORMA

Date __ __ __ __ __ __

Patient Name : _____ Age /Sex : M / F I.P.No:---------

Admitted on - | | | | | | | | ----- Unit / Ward : ------- / ---------

Discharged | | | | | | | | on No of Days of Hospital stay :

Transfers if any : From : To:

Diagnosis : Provisional ----------

Final ----------

Tt outcome : 1.Discharged ☐ 2.Expired ☐ 3. DAMA ☐

Risk factors DM HT CKD CLD

Presenting complaints

Duration of illness

Previous history of similar illness or treatment

Personal history

Family History

Clinical Examination- General Examination

Systemic Examination

Details of urinary catheterization Indication:

Functional status: Conscious/ Unconscious:

Date of insertion of urinary Catheter: Date of removal of urinary Catheter:

Date of Development of CAUTI:

Daily monitoring for signs of inflammation

E – elevated **N –** normal **P –**present

Date												
Temperature												
X-ray												
IA line												
IV line												
Urinary catheter												

Investigations: Blood routine, urine routine and culture report

Treatment: Antibiotics **Signed By:**

Annexure (iii)

FACILITATION GUIDE FOR FOCUS GROUP DISCUSSION AMONG HEALTH CARE PROVIDERS

Domains	Universal precautions (UP) including use of PPE & vaccination	Guidance for facilitator
Knowledge	What is Universal precaution (UP) in health care setting?	The facilitator needs to explore the opinion of each and every participant.
	Who should follow UP?	Keep it opens ended and explore whether they are able to list out all cadres of hospital staff.
	Why should HCP follow UP?	Keep it open ended and explore whether they are able to list out the possible risk of acquiring infections.
	When should HCP follow UP?	Keep it open ended and explore whether they are able to list out the time when staff need to follow UP (In terms of emergency/ICU/OT/IMCU/Spl patient/etc).
	How should HCP follow UP?	Keep it open ended and explore whether they are able to list out the techniques of UP.
	What else need to be done by HCP to protect themselves from acquiring infection?	Assess whether the participants are able to discuss about vaccines and PPE.
	What are the vaccines mandatory for HCP &What is the regimen for administration?	Explore about HBV, & Typhoid vaccines for HCP & food handlers
	How much does it cost for getting a complete course of vaccines?	Explore whether the participant is aware about the total cost involved in getting a full course of vaccine
Attitude	Do you think whether it is essential for health care providers to follow UP?	Explore the common opinion about the topic
	Do you think it is a costly affair to follow UP	Explore the opinion on whether the participants feel it costly to follow UP in all settings (from IMCU to OPD) & (From Infectious diseases to non infectious cases)
	Do you think it is a time consuming affair to follow UP?	Explore the opinion on whether the participants feel it time consuming to follow UP in all settings (from IMCU to OPD) & (From Infectious diseases to non infectious cases)
Practices	Do the HCP team in your ward/ department follow UP?	Explore the current practices of other health workers (last 3 months) in their ward/ theatre, etc
	Do you follow UP?	Explore the current practices of the

		participant (last 3 months) in their ward/ theatre, etc If yes- whether it is followed at all times & all sites? If no - where & when it is not followed?
	Hospital Infection Control including Hand hygiene	**Guidance for facilitator**
Knowledge	What is Health care associated infection (HCAI)?	Keep it open ended and explore every ones opinion
	What are the ways and means of preventing HCAI?	Explore whether able to list out the methods.
	Who are getting benefits of good HIC procedure?	Explore whether able to list everyone
	Are you aware of WHO recommended 5 moments of hand hygiene?	Keep it open ended and explore every ones opinion
	What are surveillance data you collect, to assess the HAI?	Explore the current practices
	What are the pre-planned nursing care plan available at IMCU? Are everyone working in IMCU aware about that? How do you ensure?	Keep it open ended and explore every ones opinion & Explore the current practices
Attitude	Who is responsible for HIC?	Keep it open ended and explore every ones opinion
	Do you feel is it necessary to collect ward surveillance data on HCAI?	Explore the common opinion about the topic
	What do you think are the major infection problems in your facility?	Explore the common opinion about the topic.
Practices	How often you wash your hands? Like every 10 minutes,30 minutes etc	Explore the current practices of HCPs (last 3 months) in their ward/ theatre, etc
	How many times on an average you do hand hygiene in your shift duty of 8 hours?	Explore the current practices of HCPs (last 3 months) in their ward/ theatre, etc
	What is the average duration of hand washing? Like 10 sec/20sec/40sec	Explore the current practices of HCPs (last 3 months) in their ward/ theatre, etc
	How do you ensure that every HCP posted in IMCU is aware of IC procedures?	Explore the current practices

Barriers in implementation	What are the common barriers stated by your HCP team for implementing UP or to hand hygiene compliance/ IC practices	Explore the common barriers which they face as a team in implementation of UP. Explore the common barriers like lack of knowledge/ awareness -inadequate supply of hand rub/PPE. -heavy work load. -lack of accessible place to wash hand
	What are the common barriers you feel for implementing UP in your work place	Explore the common barriers which they face as individuals in implementation of UP.
	How does address these barriers? Suggestion	Ask about the suggestions they would provide for Hospital administrators, department heads, Doctors, trainees, Nursing & other paramedical faculty, Sanitary workers
	If the barriers are removed will it be easy for them to practice UP?	Explore if participants say “yes”– How frequently would they need support(training, monitoring/ mentoring by superiors) If they say“no” – What would still prevent them from following it

Annexure (iv)

MONITORING OF DIVICES

NAME : AGE /SEX : IP NO: DOA:

DATE	Temperature		Urinary Catheter		Venflon		Ryle's Tube	Ventilator		ET/TT		Central line		Others
	N	I	Day	Care	Day	Care	Day	Day	Care	Day	Care	Day	Care	

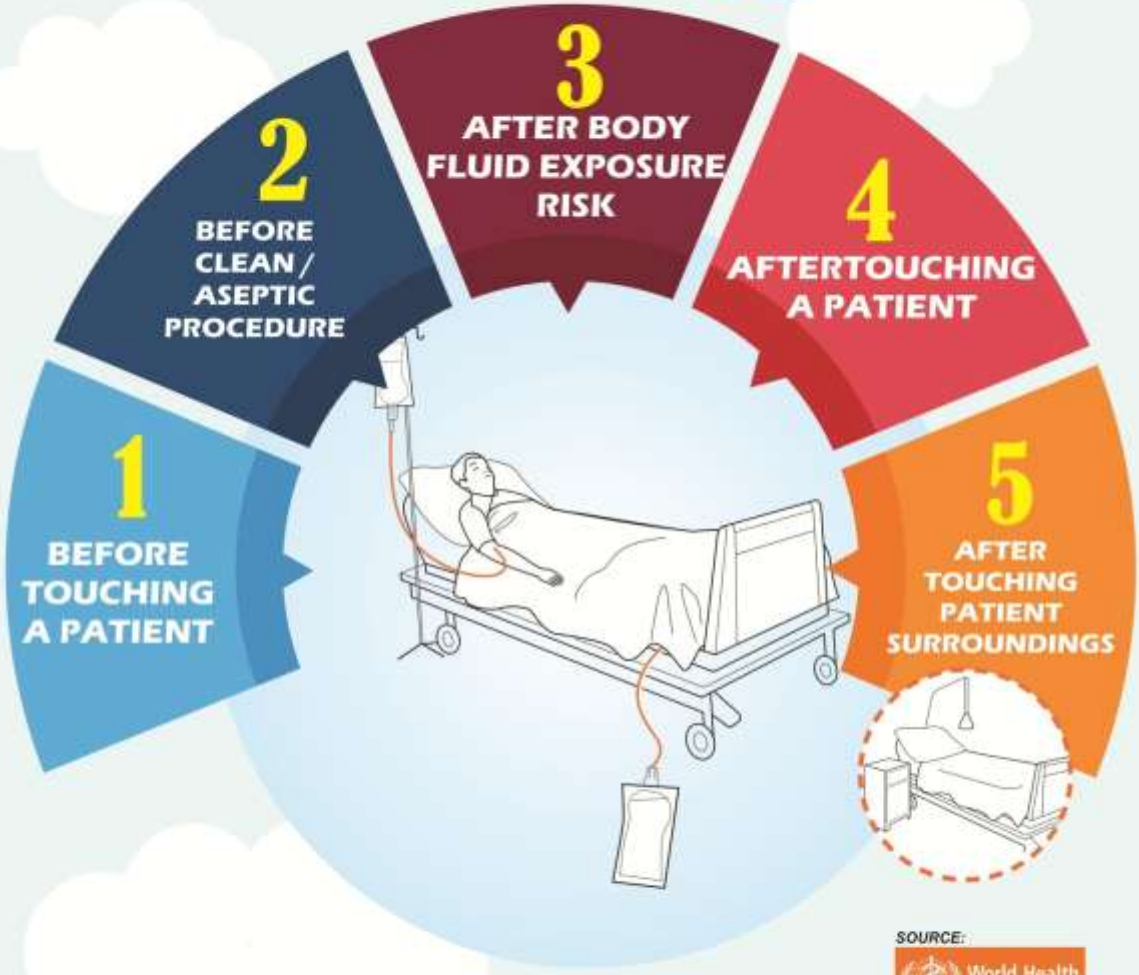
N-normal, I- increased, ET – endotracheal tube, TT – Tracheal tube

Annexure (v)

INFORMATION EDUCATION COMMUNICATION – POSTERS


CARING HANDS
HEALING HANDS
Are the clean hands
SERVING HANDS
NURSING HANDS
CLEAN HANDS ARE WORKING HERE
Composed and designed by
Dr. Usha Krishnan M.D.,
Institute of Microbiology
Rajiv Gandhi Government General Hospital, Chennai

Your 5 Moments for Hand Hygiene



SOURCE: World Health Organization

1	BEFORE TOUCHING A PATIENT	WHY?	Clean your hands before touching a patient when approaching him/her To protect the patient against harmful germs carried on your hands.
2	BEFORE CLEAN/ ASEPTIC PROCEDURE	WHEN? WHY?	Clean your hands immediately before performing a clean/aseptic procedure. To protect the patient against harmful germs, including the patient's own, from entering his/her body.
3	AFTER BODY FLUID EXPOSURE RISK	WHEN? WHY?	Clean your hands immediately after an exposure risk to body fluids (and after glove removal). To protect yourself and the health-care environment from harmful patient germs.
4	AFTER TOUCHING A PATIENT	WHEN? WHY?	Clean your hands after touching a patient and her/his immediate surroundings, when leaving the patient's side. To protect yourself and the health-care environment from harmful patient germs.
5	AFTER TOUCHING PATIENT SURROUNDINGS	WHEN? WHY?	Clean your hands after touching any object or furniture in the patient's immediate surroundings, when leaving – *even if* the patient has not been touched. To protect yourself and the health-care environment from harmful patient germs.

Composed and designed by **Dr. Usha Krishnan M.D.,**
Institute of Microbiology, Rajiv Gandhi Government General Hospital, Chennai

7 STEPS OF HANDS HYGIENE

Rub palms together

Rub the back of both hands

Interlace fingers and rub hands together.

Interlock fingers and rub the back of fingers of both hands

Rub thumb in a rotating manner followed by the area between index finger and thumb for both hands.

Rub fingertips on palm for both hands

Rub both wrists in a rotating manner. Rinse and dry thoroughly.

Composed and designed by Dr. Usha Krishnan M.D.,
Institute of Microbiology, Rajiv Gandhi Government General Hospital, Chennai

உடல்நலம் காக்க கைசுத்தம் பேணுங்கள் !
கையை சுத்தம் செய்யுங்கள் !

உணவு உண்பதற்கு முன்பு

கழிப்பறையை உபயோகித்த பிறகு

உயிரி மருத்துவக் கழிவை கையாண்ட பின்பு

நோயாளிக்கு சேவை செய்வதற்கு முன்னும், பின்னும்

நோயாளியின் சுற்றுப்புறத்தை தூய்மை செய்த பின்

பணிநேரம் முடிந்து வீடு திரும்பும் முன்

Source: Google

Composed and designed by Dr. Usha Krishnan M.D.,
Institute of Microbiology, Rajiv Gandhi Government General Hospital, Chennai

Bundle Care - For Catheter-Associated Urinary Tract Infections (CAUTI)

CAUTI

1. 
closed drained system

2. 

daily review

3. 
early removal

4. 
hand hygiene

5. 
Aseptic precautions

6. 
secure the catheter

7. 

uro bagbelow the bladder level

Composed and designed by
Dr. Usha Krishnan M.D.,
Institute of Microbiology
Rajiv Gandhi Government General Hospital, Chennai

Annexure (vi)

URINARY CATHETER CARE BUNDLE - INSERTION BUNDLE

-Insert only for specific reasons
• Urinary output in critically ill
• Bladder outlet obstruction or neurogenic bladder dysfunction
• prevent contamination of sacral wounds.
•Terminal care
- Competent HCP to insert
- Aseptic technique
- Closed system with bag below bladder

URINARY CATHETER – MAINTENANCE BUNDLE

OBSERVATION	**ELEMENTS**					
Date/Days	Hand Hygiene	Catheter Hygiene	Aseptic Sampling	Drainage bag position	Catheter Manipulation	Catheter Needed
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Annexure (vii)

KAP QUESTIONNAIRE

Infection Control Training – IMCU.

Do you know the order of donning of PPE?

1. How to perform FIT CHECK for a respirator?

2. What is the Sequence for Removing PPE?

3. Where to remove the PPE?

4. While practicing standard work precautions the HCW should assume that an infectious agent could be present in the patient's blood or body fluids, including all secretions and excretions except ---------- and ----------
5. What is Health care associated infection?

7. What are the types of Health care associated infections (HAI)?

8. What are the Denominator data to collect for device-associated HAI incidence density rate calculation?

9. What is an outbreak?

10. What is the commonest HAI?

11. What is Daily Defined Dose (DDD)?

12. What is a multi drug resistance organisms (MDROs)?

13. Name few MDROs

14. To identify MRSA carriers which body sites should be tested?

15. What is the quantity of biomedical waste generated per bed per day?
16. As per the Bio-Medical Waste Management Rules 2016, BMW is classified under how many categories?

17. What is the **Legal Implication of any violation of BMWM rules?**

18. Name few indications for urinary catheterisation:

19. How will you collect urinary sample in a catheterized patient?

20. Name any 2 steps in ongoing catheter care:

21. Why the urinary catheter should be properly secured after insertion?

22. What are the situations where you can use unsterile gloves?

23. What is the recommended disinfectant for environmental cleaning?

24. How will you store the thermometer?

25. How will you clean blood spill?

26. What are Critical, Semi-critical, Non-critical instruments?

27. What is the shelf life and contact time for Glutaraldehyde?

28. How will you handle Mucosal exposure e.g. splash into eyes?

29. What is the method of **Preparation of skin** preferred before attempted insertions of central intravenous catheters, catheters requiring cutdowns, and arterial catheters?

30. What is the recommendation for the Replacement of Peripheral IV Catheters:

31. What is the recommendation for the Replacement of central IV catheters:

32. How will you remove **Catheter line when suspecting central line Infection?**

33. What is the water used for rinsing the reusable semicritical reapiratory equipment and devices?

34. How often you need to change heat and moisture exchanging filter (HMEF)?

35. What are the few steps need to be followed while doing suctioning of endotracheal / tracheostomy tube?

36. How you prevent aspiration associated with enteral feeding?

Annexure (viii)

ETHICS COMMITTEE APPROVAL

INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE, CHENNAI 600 003

EC Reg.No.ECR/270/Inst./TN/2013
Telephone No.044 25305301
Fax: 011 25363970

CERTIFICATE OF APPROVAL

To

Dr.Usha Krishnan.K.
Assistant Professor of Microbiology
Madras Medical College
Chennai 600 003

Dear Dr.Usha Krishnan.K.

The Institutional Ethics Committee has considered your request and approved your study titled **" A STUDY ON ASSESSMENT OF CHALLENGES AND EFFECTIVENESS OF INFECTION CONTROL MEASURES USING SPECIFIC INFECTION CONTROL INDICATORS"** NO.26032015.

The following members of Ethics Committee were present in the meeting hold on 03.03.2015 conducted at Madras Medical College, Chennai 3

1. Prof.C.Rajendran, MD	:Chairperson
2. Prof.R.Vimala,MD.,Dean,MMC,Ch-3	: Deputy Chairperson
3. Prof.B.Kalaiselvi,MD.,Vice Principal,MMC,Ch-3	: Member Secretary
4. Prof.R.Nandini,MD.,Inst.of Pharmacology,MMC	: Member
5. Prof.K.Ramadevi, Director ,Inst.of Bio-Chem.MMC	: Member
6. Prof.Saraswathy,MD.,Director,Pathology, MMC	: Member
7. Prof.S.G.Sivachidambaram,MD.,Director I/c Inst.of Internal Medicine,MMC	: Member
8. Thiru S.Rameshkumar, B.Com., MBA.	: Lay Person
9. Thiru S.Govindasamy, BA., BL.,	: Lawyer
10.Tmt.Arnold Saulina, MA., MSW.,	: Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

27/3/15

Member Secretary – Ethics Committee

Sys 2

27 MAR 2015

Annexure (ix)

PLAGIARISM DIGITAL APPROVAL

URKUND

Urkund Analysis Result

Analysed Document:	Thesis consolidation -Final.docx (D39284840)
Submitted:	5/27/2018 4:37:00 PM
Submitted By:	manimaran_usha@yahoo.com
Significance:	4 %

Sources included in the report:

complete thesis 10.10.docx (D31315954)
sathi dissertation final..docx (D31028713)
plag check.docx (D31681268)
A STUDY ON THE BACTERIOLOGICAL PROFILE AND ROLE OF BIOFILM FORMING ORGANISMS IN CATHETER ASSOCIATED URINARY TRACT INFECTIONS IN A TERTIARY CARE HOSPITAL.docx (D30343735)
NIDHI PAL full thesis 18-2-18.pdf (D38814179)
http://journals.plos.org/plosone/article?id=10.1371%252Fjournal.pone.0189621
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31

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Original Article

The Epidemiology and Microbiological pattern of Catheter Associated Urinary Tract Infection in a Tertiary Care Hospital- A Surveillance Study

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Abstract

Background: *Among the Health care associated infections, Urinary tract infections are the most common, accounting for up to 40% of infections reported by acute care hospitals. Also, 70 - 80% of urinary tract infections are associated with the presence of an indwelling urinary catheter. So, a periodical surveillance system is essential to establish effective infection control and prevention program.*

Aims

1. *To determine the rate of Catheter Associated Urinary Tract Infection (CAUTI),*
2. *To isolate and identify the antibiotic sensitivity pattern of the isolates.*

Setting: *This study was undertaken in patients admitted in the Intensive Medical Care Unit (IMCU) for ≥48 hrs and on Foley's catheter.*

Methodology: *In a catheterized patient, urine sample were collected aseptically. Total 168 catheterized patients were included for a period of six months. Standard proforma was used to collect all the demographic details. Colony count of 10^5 was taken as significant. p value of <0.05 is considered significant.*

Results: *The mean age of patients was 37 ± 19 years. A total number of 41(24.40%) patients were culture positive. Bacterial cause was identified in 17 (41 %) and in 24 (59 %) patients Candida species were isolated. The most common bacteria isolated was Escherichia coli. The rate of Extended-spectrum β-Lactamase production was 78%. In the present study, the rate of development of CAUTI was higher with longer duration of catheterization. p value 0.033946.*

Conclusions: *In an IMCU setting, the catheterized patients are highly susceptible to infection. As the rate of development of CAUTI is significantly associated with the duration of catheterization emphasis should be made on reducing the duration of catheterization.*

Keywords: *Escherichia coli, infection control and prevention, Intensive Medical Care Unit, Health care associated infections.*

Introduction

Health Care Associated Infections (HCAI) are a major public health problem for patient safety and its impact can result in prolonged hospital stay, long-term disability, increased resistance of microorganisms to antimicrobial agents, a massive additional financial burden for the health care system, high costs for patients and their families, and increased mortality [1].[2].

The WHO Report on the burden of endemic HCAI worldwide, states that the incidence of Intensive Care Unit (ICU) acquired infection among adult patients in low- and middle-income countries ranged from 4.4% up to 88.9%. [3] As per a systematic review, pooled overall HCAI density in adult ICU was 47.9 episodes per 1000 patient-days which are at least three times as high as densities reported in developed countries. [2]

Among the HCAI, Urinary tract infections are the most common, accounting for up to 40% of infections reported by acute care hospitals [4, 5]. Also, 70 - 80% of urinary tract infections are associated with the presence of an indwelling urinary catheter. [6]

Antibiotic resistance in Gram-negative uropathogens is a major global concern, bacterial resistance particularly in relation to Catheter-Associated Urinary Tract Infections (CAUTI)has major implications [7]leading to increased hospital cost and increased morbidity [8] and mortality. [5]. [9]

Up to 69% of CAUTIs are considered to be avoidable, provided that recommended infection-prevention practices are implemented. [10]

A periodical surveillance system for health-care-associated infection which is virtually nonexistent in most low- and middle-income countries is essential to record the size of this infection burden and the effect of interventions. Moreover, many studies have stated that by itself, surveillance can lead to reduction in health-care-associated infection. [2]. [11]

On this background this study was undertaken to determine the epidemiology and rate of CAUTIs, risk factors, microbiological profileand their antimicrobial susceptibilities.

Material and methods

This surveillance study was undertaken in an Intensive Medical Care Unit of a tertiary care hospital. Total 168catheterized patients were included for a period of six months from April 2016 to September 2016. Standard proforma was used to collect all the demographic details like name of the patient, age, sex, diagnosis also details regarding catheterization indication, type, date and days of catheterization were noted.

Patients who got admitted and stayed in the IMCU for ≥48 hrs and catheterized on Foley's catheter were included in this study. Patient with symptoms of UTI prior to the catheterization and on suprapubic and condom drainage were excluded. The study was approved by the institutional Ethics Committee and an informed written consent was obtained from the patients before the collection of the samples.

In a catheterized patient, urine sample (3 mL) were collected as per the guidelines for culture and sensitivity with aseptic precautions using a sterile needle and syringe from the distal edge of catheter tube into a sterile universal container [12] and was transported immediately to the laboratory. For those patients who were admitted more than a week, the repeat samples were collected in the second week. With the calibrated loop urine was cultured on CLED media for quantitative analysis to assess the microbial counts. Colony count of 10^5 was taken as significant while confirmation as CAUTI. The identification of pathogen was done by standard biochemical tests. Isolate suggestive of the yeast were subcultured on Sabouraud's dextrose agar and further identification was done by demonstration of germ tube; sugar fermentation and CHROME agar. Antimicrobial susceptibility testing was done by Kirby-Bauer disk-diffusion method on Muller-Hinton agar as recommended by CLSI guidelines.[13]

All the gram negative isolates were subjected to Extended Spectrum Beta-lactamase (ESBL) screening test using ceftazidime (30µg) and cefepime (30µg) by Phenotypic screening method and carbapenemase screening test using imipenem (10µg) and meropenem (10µg) discs. The isolates which were positive in the screening test were subjected to respective confirmatory tests using appropriate antibiotic discs. The phenotypic confirmation for ESBL production was done by testing the strain against ceftazidime (30µg) and ceftazidime/clavulanic acid (30µg/10µg) *Himedia, were placed at a distance of 20mm centre to centre on the Mueller-Hinton agar plate, incubated at 37ºC for 20-24 hours. The test isolate was considered to produce ESBL if the zone of inhibition around the ceftazidime-clavulanic acid disc was ≥5mm that the zone around ceftazidime disc alone.[14]

Isolates resistant to carbapenems was further processed by modified Hodge test to detect carbapenemase production. A lawn culture of 1:10 dilution 0.5 McFarland standard suspension of E.coli ATCC 25922 was done on to a Mueller Hinton Agar plate and allowed to dry for 3-5 minutes. A 10µg meropenem disc is placed in the center of the test area. In a straight line, the test organism was streaked from the edge of the disc to the edge of the plate and incubated at 37°C for 16-20 hours. Enhanced growth (Clover-leaf indentation) was considered as positive for carbapenemase production.[15]

Statistical analysis

Categorical data are presented as proportions. Normally distributed continuous data are presented as mean with standard deviation. Non-normally distributed continuous data are presented as median with range. Chi square test was used to analyse the strength of association of longer duration of catheterization and the risk of developing CAUTI. McNemar test was used to analyse development/outcome of CAUTI with the duration of catheterization.p value of <0.05 is considered significant.

Results

A total of 168 patients were included in the study. The mean age of patients was 37 ± 19 years. Male to Female ratio was 1:1.15.

Majority n =36 (21%) of them were in the age group of 31 – 40 years, followed by the age group 12 -20,and 21 -30 years (18%). [Table 1]

A total number of 41(24.40%) patients out of 168 were culture positive with significant colony count. Bacterial cause was identified in 17 (41 %) of patients and in 24 (59 %) patients *Candida* species were isolated.

Out of 17 patients 3 patients had 2 bacterial isolates each with significant count. So, 20 bacterial pathogens were isolated from 17 patients. [Table 2]

Candida non albicans was the predominant organism isolated in 19 (79.2%) patients while *Candida albicans* was isolated only in 5 (20.8%) patients. Among *Candida nonalbicans*, *C. tropicalis* 09 (47%) was the predominant species followed by *C. glabrata* 05 (26%) *C. krusei* 03 (15.7%) and *C.parapsilosis* 2 (10.5%).

A total urinary catheterization day calculated for 168 patients was 1848 days.The descriptive analysis of catheter days is given in Table: 3. CAUTI rate was calculated as 22%.

Among patients who were culture negative on 1st week, 70% turned to be culture positive on repeat culture. On the other hand among patients who were culture positive on the 1st week, 85.7% continued to be culture positive on the repeat samples. It was not statistically significant (McNemar test p value 0.07) which could be because of the low sample size.

Table 4 discusses the Antibiotic Susceptibility Pattern of bacterial isolates causing CAUTI. Seven uropathogens including 3 *Enterococcus* spp isolated from CAUTI cases were found to be multidrug resistant. The rate Extended-Spectrum β-Lactamase (ESBL) production was 78%. Carbapenemase-producing *Klebsiella pneumoniae* 2 have been isolated.

Table: 1 Age and sex distribution of participants. (n=168)

S.no	Age (Years)	Male	Female	Total
1	12 – 20	13	17	30
2	21 – 30	11	19	30
3	31- 40	19	17	36
4	41-50	13	12	25
5	51-60	11	9	20
6	>61	11	16	27
Total		78	90	168

Table: 2 Spectrum of microorganisms isolated from CAUTI

ORGANISMS	NUMBER
Klebsiella oxytoca	4
Klebsiella pneumoniae	4
Acinetobacter sp	2
E.coli	5
Pseudomonas sp	1
P. mirabilis	1
Enterococcus sp	3
Candida non albicans	19
Candida albicans	5
Total	44

Table: 3 Descriptive analysis of catheter days

Days of urinary catheterisation	No of patients	No of UTI detected	Total No of Device Days	Infection rates (%)	Mean duration of catheter use
≤3	29	3	84	1.7	2.8
4 - 7	56	11	344	6.5	6.15
>7	83	27	1420	16.07	17.10
Total	168	41	1848	24.40	11

Table: 4 Antibiotic Susceptibility Pattern of Pathogen Causing CAUTI

Name of the antibiotic	Antibiotic Susceptibility(%) of Gram negative bacteria	Antibiotic Susceptibility(%) of Enterococcus
Amikacin	41	0
Gentamicin	35.2	0
Cefotaxime	23.5	-
Cephaperazone Sulbactum	82.35	-
Norfloxacin	47	0
Imipenem	82.35	-
Nitrofurantoin	7.6	33.3
Amoxicillin	-	0
Vancomycin	-	100
Penicillin	-	0

Discussion

The diagnosis of CAUTI was done as per the CDC guidelines. The patient was labelled as a case of CAUTI, when a catheterized patient developed one or more of the following conditions after 48 hours admission to IMCU: fever (>38.0°C), urgency, suprapubic tenderness, dysuria, turbidurine and burning micturition.[16]

Duration of catheterization is the most important determinant of bacteriuria. When an indwelling catheter is in situ the daily risk of acquisition of bacteriuria is 3–7%.[17]

CAUTI is usually deemed present if there are at least 10^5 colony-forming units (cfu)/mL of 1 or 2 micro-organisms identified by urine culture

CAUTI incidence density is defined as the Number of CAUTI episodes per 1000 patient-days or device-days and in this study the CAUTI rate was calculated as 22 per 1000 catheter days. Another prospective observational study describes the rates of nosocomial urinary tract infection as (24%) which is very similar to this study.[18]

The most common (54.5%) etiological agents of CAUTI were *Candida spp.*[19]

The predominance of *Candida non albicans* spp (19) over *C. albicans* (5) was noted. This is similar to other study.[20]

Compared to bacterial CAUTI patients, *Candida* CAUTI patients had more intensive healthcare exposure, longer durations of indwelling urinary catheters, and more frequently had co-infections at the time of CAUTI diagnosis.

Gram-negative bacilli represented the most common (85%) CAUTI isolates among bacteria. A recently-published review of microbiological patterns of HCAI from 28 studies conducted in developing countries 3 reported gram-negative rods as the most common nosocomial isolates, both in mixed patient populations and in high-risk patients. [2]

The most common organisms isolated were *Escherichia coli* (29.4%), *Klebsiella pneumoniae* (23.5%), *Acinetobacter* sp (11.7%), and *Enterococcus* species (15%). The microbiological profile in our study is similar to other studies.[21] [22] [23]

Among organism causing CAUTI extended spectrum beta lactamase (ESBL) resistance seen in nearly 78% of isolates. In a study the prevalence of ESBL producers among *K. pneumoniae* and *E. coli* isolates was 56% (14/25) and 78.6% (11/14), respectively.[24]

Carbapenemase-producing *E. coli* 2 and *Klebsiella pneumoniae* 1 have been isolated.

In the WHO Global priority list of Antibiotic resistant bacteria to guide research, discovery and development of new antibiotics, the organisms causing CAUTI are grouped under priority 1 critical list. In that list, 9 out of 12 families are of the "gram-negative" type. Top of the list is *Escherichia coli* the leading cause of urinary tract infections.[25]

Prolonged catheterization is one of the significant risk factors for the development of CAUTI.[26]. [27]. In the present study, the rate of development of CAUTI was higher as the duration of catheterization increased. p value 0.033946, Chi square value 6.766. [Table 3]

Conclusion

In an IMCU setting, the urinary tract of catheterized patients is highly susceptible to infection by multi drug resistant pathogens. This infection is associated with varied microbiological etiology. This infection along with the underlying comorbid condition increases hospitalization, medication and morbidity. As the rate of development of CAUTI is significantly associated with the duration of catheterization emphasis should be made on reducing the duration of catheterization. Hospital-wide infection control and prevention program and appropriate catheter care bundles can be developed and implemented from evidence-based surveillance study.

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Original article

A qualitative study on perception of health care workers of intensive care unit on infection control in a tertiary care hospital

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Abstract

Background: Health system today is very dynamic and patients admitted in intensive medical care unit (IMCU) are under the greater risk of morbidity and mortality due to health care-associated infections (HAIs). Rates of HAIs and bacterial resistance in developing countries are 3 to 5 times higher than international standards. Many studies reveal that, Organized infection control (IC) programs have been successful in reducing the HAI with subsequent improvement in the hand hygiene compliance.

Understanding the perspectives of infection control practices among health care workers (HCWs) is essential in planning interventions in a health care setting. On this background this qualitative study was carried out.

Aims : To explore perceptions of HCWs of intensive care unit, on infection control and hand hygiene using focus group discussions (FGDs) in a tertiary care hospital in India.

Methods and Materials: The prototype facilitation guide for focus group discussion was prepared. Six discussions were conducted in English and Tamil, were recorded, transcribed verbatim, translated into English and analysed using content analysis. Discussions ranged in length from 30-45 minutes.

Results and conclusion: On thematic analysis two major themes emerged. They are 1.Challenges with practice of infection control and2. Interventions to improve. The participants acknowledged the value of Standard Precautions and infection control practices as a means for reducing HAI but perceived practical problems with implementation.

Awareness and preparedness were satisfactory whereas clarity on basic concepts and current updates appeared lacking.

Key words: Focus group discussions, hand hygiene, health care-associated infections, Intensive care unit, Infection control, qualitative study, standard precautions.

Introduction

Health system today is very dynamic and patients admitted in intensive medical care unit (IMCU) often requires a persistent intensified therapy. More serious underlying illnesses makes the patients susceptible to infections.[1] Also increased use of invasive procedures in modern, sophisticated medicine creates new sources of risk for infection.[2]

So, health care-associated infections (HAIs) with greater risk of morbidity and mortality are common in IMCU patients.[3]

Many studies reveal that, rates of HAIs and bacterial resistance in developing countries are 3 to 5 times higher than international standards. [4, 5]

Infections today requires highly individualized treatment, sometimes with multiple therapies, based on the antibiotic susceptibility pattern of the infecting

organisms, condition of the patient and which organ system is affected. The emerging multi drug resistant organism further complicates the picture causing prolonged antibiotic therapy and prolonged hospital stay. The economic, clinical, and social expenses to patients and hospitals are overwhelming.[6]

Since its recognition by Semmelweis in the 18th century[7] hand hygiene is judged the most important measure and it is the corner stone for prevention of microbial transmission during patient care. However, hand hygiene is in irregular practice in resource constraint settings, historically reported at rates of less than 20%, [8-10] -40%. [11, 12]

Organized infection control (IC) programs have been successful in reducing the HAI with subsequent improvement in the hand hygiene compliance to 50%. [13]

Hence to limit the incidence of IMCU-acquired infections aggressive infection control measures must be implemented and enforced.Understanding the perspectives of infection control practices among health care workers (HCWs) is essential in planning interventions in a health care setting. On this background this qualitative study was carried out to assess the knowledge and attitude of HCWs on infection control and hand hygiene practices.

Objectives

- To understand the perspectives of HCWs working in IMCU, on infection control.

-To assess the knowledge and attitude of infection control among HCWs.

-To explore the problems and challenges involved with infection control practices.

Methodology

With the help of the practical guide for Good Questions proposed by Richard Kruegar and Mary Anne Casey [14] the prototype facilitation guide for focus group discussion (FGD) was prepared.The facilitation guide included the following topics: general awareness and knowledge about standard work precaution, infection prevention and hand hygiene, their attitudes regarding their own and others' hand hygiene practice at the site, and their ideas on challenges involved with infection control practices and preparedness for improving infection prevention efforts. Pilot testing, refinement, and validation of the survey questions were conducted.

This study was approved by the Institutional ethics committee. Participants were explained about the purpose of the study and ensured that their responses will be kept confidential. Written consent to participation was obtained from each participant.

Discussions ranged in length from 30-45 minutes. The discussions were conducted in English and Tamil, recorded on tape, transcribed, and, translated into English. Facilitator participated only to keep the discussion active and focused. On the day of FGD, the facilitator used pre-determined question and established permissive environment. An assistant moderator handled logistics, taken careful notes and monitored recording equipment. After the welcome and the introduction the participants were high lightened about the agenda of the discussion and the guidelines of the FGD were told. The facilitator guided the discussion with the help of the facilitation guide.

Six focus group discussions were held with 12 nurses and 10 emergency care technicians. Transcripts were analyzed by thematic content.

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Results

Table: 1 Thematic content of focus group discussion

S.no	Major Theme	Sub Category
1	Challenges with practice of infection control	*Heavy work load *Knowledge of core concepts * Complacency
2	Interventions to improve	*Need for training * Designated infection control personnel * Monitoring

Thematic analysis came out with two major themes 1. Challenges with practice of IC and

2. Interventions to improve. (Table 1)

In challenges, the major sub category emerged was job related, work load and emergency situations. It was evident by the following statements.

"In pressing situations, I rush to attend the patient than to pause for the hand hygiene."

"Yes. It is good to do surveillance of health care associated infections. But we are afraid to commit this because it will bring more work to us."

In addition, essential knowledge of core concepts of infection prevention practices seemed lacking and was revealed in terms of beliefs and adaptation to the setting.

Most of the participants felt that following the standard work precaution was a costly affair. One staff nurse stated that, "I do not feel my hands are dirty often to do hand rub."

Complacence due to prolonged work experience was another challenge. Many admitted that, "We all do correctly by our experience….."

"We were told to document the number of times the catheter changed. It was hard to follow. We changed the catheter correctly but not documenting."

In barriers to practice IC, people trafficking in IMCU were another challenge. The following statements revealed this.

"The lab technician and dialysis technician need to be told and trained on IC practices"

"Patient attendees' are a constant problem to us. Sometimes we may also depend on them for patient care."

The second major theme emerged was on interventions to improve the IC practices.

All appreciated the administrator for the adequate availability of personal protective equipments. They also insisted on point of care availability of hand rub. The importance of the designated IC nurse and monitoring was insisted by all.

The importance of training to foster behavior change emerged throughout the discussions. Need for training and updating on current guidelines was felt and voiced by everyone.

"Whatever we are doing is by our basic nursing knowledge. We need to have regular training on IC guidelines."

"The interns are not aware and updated on IC practices"

"We are willing to get trained and practice…"

All of the participants expressed their willingness to change and their preparedness to adapt HH practices. Their openness to accept the change and to evolve out of their perceived preconception was evident by the statement that, "This discussion made us think…"

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Discussion

To improve the infection control practices of any setting the first step is to understand the challenges to establish the one. So the perspectives of health care workers will be vital in developing interventions most appropriate to the local context.

In this study, the participants acknowledged the value of Standard Precautions as a means for providing protection against occupational exposure to microorganisms and cross contamination. To practice the IC the major challenge observed was job related factors like heavy work load and emergency situations. Many participants described an emergency situation as a major obstacle in following precautions. This is similar to other studies. [15, 16]

Also in a qualitative study conducted at Vietnam the HCWs expressed frustration with high workload.[17] Forgetful-ness and lack of time was the reason for poor adherence of infection control practices in other studies. [18, 19]

When nurses gain enough experience, they are very confident about their capabilities. Therefore, they lull themselves to skip certain steps in a guideline, in a study as argued by a nurse with considerable clinical experience: "...the more capable I feel, the less preventive measures I may take."[15]

In interventions to improve the IC practices, availability of hand hygiene product at the point of care was suggested by many. As noted by other studies [20, 21] providing point of care hand hygiene products facilitates integration of hand hygiene in to the natural workflow patterns of health care providers and can contribute to higher hand hygiene compliance.

Lack of knowledge, training and education was one of the challenges with the practice of IC. As reported by a study, education had a positive impact on retention of knowledge, attitudes and practices in all the categories of staff.[22] Similarly, in a study by Naggar RA, emphasis was given for educational and motivational intervention on infection control to target nursing students. [23] As per a report by WHO, staff education is a key element and basic principles of IC should be included in curricula of doctors, nurses and other health care professions.[24] So there is a need to develop a system of continuous education for all the categories of staff.

Conclusion

This study provides an insight into what the hospital staff perceives about IC and their current practices, how do they act and react, what are their training and other needs. Awareness and preparedness were satisfactory whereas clarity on basic concepts, current updates, involvement, and performance appeared lacking which necessitates the system change. The results can be used by nurses, administrators, policymakers, and nurse educators as a means of strengthening the IC practices among nursing personnel.

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