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Risk Factors of Hospital Acquired Infections among Patients Admitted in A Selected Hospital in Dhaka

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University of Rajshahi

RISK FACTORS OF HOSPITAL ACQUIRED INFECTIONS AMONG PATIENTS ADMITTED IN A SELECTED HOSPITAL IN DHAKA

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DECLARATION

I hereby declare that this PhD thesis entitled **"Risk Factors of Hospital Acquired Infections among patients admitted in a selected Hospital in Dhaka"** was carried out by me for the degree of **Doctor of Philosophy** under the guidance and supervision of Professor Dr. Md. Matiar Rahman, in the Department of Biochemistry & Molecular Biology under the Faculty of Science, University of Rajshahi, Bangladesh.

The interpretations put forth are based on my reading and understanding of the original texts and they are not published anywhere in the form of books, monographs or articles.

For the present thesis, which I am submitting to the University, no degree or diploma or distinction has been conferred on me before, either in this or in any other University.

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CERTIFICATION

This is to certify that PhD thesis entitled **"Risk Factors of Hospital Acquired Infections among patients admitted in a selected Hospital in Dhaka"** conducted in the Department of Biochemistry & Molecular Biology, under the faculty of Science at University of Rajshahi, Bangladesh for the degree of Doctor of Philosophy (PhD) and is submitted by Md. Al Jahidi Hasan Chowdhury, Roll no.- 13202, Registration no.- 1578, as a course for the partial fulfillment of the Degree of Doctor of Philosophy. It is absolutely based on his own work under my close supervision and guidance. His work is genuine and upto the mark.

I wish him every success.

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LIST OF ABBREVIATIONS

APCHE II	Acute Physiology and Chronic Health Evaluation
BIRDEM	Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorder
BSI	Blood Stream Infection
CDC	Centers for Disease Control and Prevention
CI	Confidence Interval
CMH	Combined Military Hospital
COPD	Chronic Obstructive Lung Disease
DMCH	Dhaka Medical College Hospital
EMRSA	Epidemic-Methicillin-Resistant Staphylococcus aureus
EPIC	European Prevention of Infection in Intensive Care Unit
HAI	Hospital Acquired Infection
HAP	Hospital Acquired Pneumoniae
HARI	Hospital Acquired Respiratory Infection
HRN	High-Risk Nurseries
HIV	Human Immunodeficiency Virus
ICDDR'B	International Center for Diarrhoeal Disease and Research, Bangladesh
ICU	Intensive Care Unit
LOS	Length of Stay
LTC	Long Term Care
MDR	Multi-Drug Resistant

MMWR	Morbidity & Mortality Weekly Report
MRSA	Methicillin-Resistant Staphylococcus aureus
MSSA	Methicillin-Sensitive Staphylococcus aureus
NHS	National Health Services
NIPSOM	National Institute of Preventive and Social Medicine
NI	Nosocomial Infection
NICU	Neonatal Intensive Care Unit
NNIS	National Nosocomial Infection Surveillance
OTI	Orotracheal Intubations
NP	Nosocomial pneumoniae
PBP	Penicillin Binding Protein
PICU	Pediatric Intensive Care Unit
RI	Respiratory Infection
S. aureus	Staphylococcus aureus
SCIEH	Scottish Center for Infection and Environmental Health
SSI	Surgical Site Infection
SSTI	Skin and Soft Tissue Infection
UK	United Kingdom
USA	United States of America
UTI	Urinary Tract Infection
VAP	Ventilator Associated Pneumonia
WHO	World Health Organization

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ABSTRACT

This prospective cross sectional observational and analytical study was conducted at United Hospital Ltd. Gulshan, Dhaka at all age and sex during January to July, 2015 with a view to find out the incidence of Hospital Acquired Infection (HAI), patient related risk factors, hospital related risk factor, offending organism caused for HAI and their antimicrobial sensitivity. Out of total 1108 respondents, 104 (9.4%) respondents were found to develop HAI which yielded incidence rate 8.75/1000 hospital days. Respiratory tract infection was the highest 56.7% among the types of HAI followed by urinary tract infection (15.4%). Not any single factor of socio-demographic characteristics was found associated with the development of HAI.

168 (16.7%) respondents of extreme of age group developed infection comparison to around 940 (8.1%) of not of extreme of age develop infection and the association was found statistically significant ($p<0.001$).

An individual who required nursing assistance most of the time had 20 times more risk of developing HAI and those who required some assistance had 6.78times more risk than those who required no assistance. The Odds ratio (OR) for 3 functional categories were: 0.3, 0.9 and 6.1.

60% HAI had >3 visitors followed by 39.6% were 3 visitors while 2.1%, 2.9% visited by 1 & 2 visitor respectively. For the development of HAI, visitors were found statistically markedly significant ($p<0.001$). An individual who was visited by more than three visitors had around 118 times more risk of developing HAI of respondents than who had no or one visitor. The Odds ratio for 4 visitor categories were: 0.2, 0.2, 9.4 and 23.6.

96 (11.9%) with antibiotic therapy during hospitalization showed HAI while 8(2.6%) found HAI with no antibiotic ($p<0.001$). Regarding application of antimicrobial use up to 5 days, 16respondents (5.7%), 28 (7.6%) of 6-10 days, 32 (28.1%) of 11-15 days, 10 (45.5%) of 16-20 days and 14 (70.0%) of duration more than 20 days developed infection. The association of duration of antimicrobial use and development of HAI was found statistically highly significant ($t=9.675$, $p=0.000$).

Around 24% respondents with underlying illness developed HAI in comparison 6.5% respondents without illness and the association was found statistically highly significant ($p<0.001$). 20.8% respondents with invasive device application developed HAI compare to 2.8% without device and statistically highly significant ($p=0.000$). 3.3% of respondents developed HAI who had the application of invasive device up to 5 days, while 21.8% by 6-10 days, 38.9% by 11-15 days, 21.4% by 16-20 days and 50% by more than 20 days. The association of developing

HAI with duration of use of invasive device was statistically highly significant (t=12.063, p=0.000).

31.8% respondents having immunosuppressive therapy developed HAI on the contrary to 7.5%without such therapy which showed association statistically highly significant (p<0.001). 24.5% (80) respondents representing immunosuppressive condition developed HAI where 3.1% (24) had infection did not present such condition and association was found statistically highly significant (p=0.000).

The mean hospital days for development of HAI group was 19.96±13.11 whereas hospital days on discharge without infection group was 9.77±7.13. The association between hospital days and development of infection was found statistically highly significant (t=7.845, P=0.000).

Routine operation 47 (20.2%) and emergency 19 (26.8%) respondents having HAI established no statistically significant (p>0.05). On the other hand respondents having post operative showed HAI, 55(18.1%) and non-operative 49 (6.1%) infection. The association found statistically significant (p<0.001).

16 (14.5%) respondents found frequent transfer developed HAI comparison to 88 (8.8%) without transfer and association was statistically not significant (p>0.05). Regarding general cleanliness of ward/department, 9% had HAI satisfactory group contrary to 10.4% HAI from dirty group of respondents. No statistically significant association was found (p>0.05).

The Logistic regression predicting independent risk factors revealed functional state (OR=22.067, p=0.001), number of visitor/patients/day (OR=71.000, p=0.000), underlying illness (OR=4.602, p=0.000), duration of device use (OR=19.000, p=0.011 and duration of antimicrobial use (OR=1.079, p=0.001) were found as independent risk for developing HAI.

Gram negative Enterobacteriaceae as a group were most predominant pathogens. The highest infective agents were 33% HAI from *Klebsiella pneumoniae* followed by 17% *Acinetobacter baumannii* and both *Esch.coli* and *Pseudomonas aeruginosa* each 14%.Only colistin sulphate was reported sensitivity range from 76 to 100% while almost all other isolates were observed multi drug resistance (MDR).

Measured aimed at increasing awareness of hospital staff, a large scale study, formulation of antibiotic policy, controlling of visitors, appropriate device handling procedure, establishing a strong surveillance programme through infection control and prevention department for minimize or control hospital acquired infection. Epidemiological studies are strongly recommended in order to detect source of infection.

Chapter-1

INTRODUCTION

INTRODUCTION

STATEMENT OF THE PROBLEM

1.1.1 Preamble

There is no hospital however small, airy or well ventilated where the epidemic ulcer is not to be found at times and thus no operation dared to be performed. Every cure stands still, every wound becomes a sore and every sore is apt to run into gangrene. But in great hospitals specially, it prevails at all times and is a real gangrene. It has been named the Hospital Gangrene and such were the ravages at Hotel Dieu of Paris the great storehouse of corruption and disease that the surgeons did not dare call it by its true name.

JOHN BELL (1801) on: Hospital Infections

Patients are no doubt better treated in hospitals than anywhere else; however congregating a large number of sick under a single roof could easily facilitate the transmission of infectious disease from one patient to another. One must remember that infections in hospitals have existed since the very inception of hospitals themselves. To say that Hospital acquired infections are of great importance in hospitalized patients is to state the obvious. Hospital acquired infections, even in this modern era of antibiotics, continue to remain an important and formidable consequence of hospitalization. It has been estimated that about 3.5% of patients leave the hospital after having acquired infections, depending on the case, hospital size and multiple other factors.

Despite progress in public health and hospital care, infections develop in hospitalized patients without any concession. Patient care is rendered in facilities, which range from highly equipped clinics technologically advanced university hospitals to frontline units with basic facilities. The effect of hospital- acquired infections are among major causes of death and increased morbidity in developed and developing countries resulting to significant burden both for patients as well as public health[1].

Although medical and nursing care is expected to be safe, hospital have always been hazardous place until 20th century. Similarly, modern medicine practiced in large urban hospitals in the 19th century, opened up many avenues of hopes, overcrowding and ignorance added a significant risk of developing hospital-acquired infections in patient undergone many procedures ranged from childbirth to amputation[2].

The triumph of antibiotic over disease-causing bacteria was the greatest success stories. The drugs which were widely used in World War-2 era saved countless lives and blunted serious

complications of many infections. Many antibiotics after 50 years widespread use cannot pack the same punch they once did[3].

In early 1970, the belief, that all bacterial infections are treatable, was shaken by the emergence of resistant microorganism to multiple antibiotics. *Staphylococcus aureus* perhaps the greatest concern[4]. It remained as a versatile and dangerous pathogen in humans even after more than 100 years later of its description by Ogstan as an agent of sepsis and abscess formation. The frequency of hospital-acquired infection has increased steadily with little change in overall mortality. Treatment of the infections has become more difficult with the emergence of multi-drug resistance (MDR) bacteria[5]. The mortality remains approximately 20-40% despite the availability of effective antimicrobials and continues to be the leading cause of hospital-acquired infections. The patients when released from hospitals may also carry the infections which pose a greater concern in the community[4].

During 1950s, most Staphylococcal infection were penicillin-sensitive. However, at the beginning of the new millennium not almost all Staphylococcal infections are only resistant to penicillin but also increasingly impervious to each newer drug developed to breach the gap. As soon as new drugs are developed against the unbeatable infectious agents newer strains of more virulent bacteria emerged[6].

The advancing age of patients along with the greater prevalence of chronic diseases, mean increased use of diagnostic and therapeutic procedures. This may affect the host defenses and results in hospital-acquired infections in the future. Organisms hospital-acquired infections can be transmitted to the community through discharged patients, staff, and visitors where multidrug-resistant organism in the community may cause significant diseases and can produce a havoc situation[1].

Presently, about 60% of hospital-acquired infections are caused by aerobic Gram negative rods and about 30% by Gram positive cocci. Many Gram-negative bacilli such as P*seudomonas aeruginosa* are opportunists capable of causing infection in immune-compromised patient[19]. In recent years, groups of micro-organisms, which formerly played no recognized part in hospital infection, have emerged. These include the Coagulase-negative *Staphylococci* present in normal skin flora. Viral or fungal infection, particularly of the immune-compromised patient has become more important[20].

1.1.2 Hospital- Acquired Infection: An avoidable Situation becoming a Growing Threat

Hospital- acquired infections (HAI) have been documented as a global threat of major cause

of morbidity and mortality and its high frequency means a poor quality of health care services which may lead to avoidable costs. Despite rapid advances of medical science in both therapeutic and diagnostic arena, HAI persists as a bane in hospitals throughout the world[1].

1.1.2.1 Global Scenario

WHO carried out a study in 2002 in 55 hospitals of countries and found an average of 8.7% of hospital patients with HAI. The situation worst in Eastern Mediterranean and south-east Asia Region and accounted for figures 11.8 and 10.0% respectively. However, figures for European and western pacific Region were found 7.7 and 9.0% respectively[1].

In UK, hundred thousand cases of HAI occur annually and five thousand of them die each year which renders a financial involvement amounting to one billion pound[7]. In 1980 the first national prevalence study of infection in England and Wales showed that 19.1% of the patients were infected. Half of these (51.9%) were community acquired infection and the rest (48.1%) were hospital acquired infections[8].

In America, the nationwide nosocomial infection rate was approximately 5.7 per hundred admissions.[9] At Ottawa general hospital the overall infection rate was 13.5% of which 5.6% was community acquired while 7.9% was nosocomial origin. It also showed that Urinary Tract Infection (UTI) accounted for 44.8% of all the nosocomial infection and clearly dominated the picture. The postoperative wound infection rate was 3.9% and accounted for only 18% of nosocomial infection. The risk of hospital acquired infection was increased three fold by carrying of an operative procedure[10]. The prevalence rates of nosocomial infection in many countries ranged from 9.2% to 21.4%[11]. In England, prevalence rate of nosocomial infection was 11%. Nosocomial infections develop in at least 5% of patient admitted to hospital[15].

In Thailand, prevalence rate was 11.7%, in Ethiopia 17%, UK 9.2% and in Norway it was 9%. As for the site of infection urinary tract infection (UTI) was the commonest infection (60%) followed by pneumonia and surgical site infection[12].

Despite advances in operative techniques better understanding of pathogenesis of wound infection and widespread use of prophylactic antibiotics, postoperative surgical site infections continued to be major causes of morbidity and mortality for patients undergoing operative procedures. It was estimated that surgical site infection developed in 2-5% of the 16 million patients undergoing surgical procedures each year[13]. In the last two hundred years it has emerged as a matter of great concern with the rapid advancement of medical

science. In the 1800s as many as 80% of all operations ended in infection[196].

The extent of problems and the consequences of HAI have been documented after several studies in USA where nearly two million patients are infected each year in hospitals. Ninety thousand die each year as result of complication infections and more than 70% of bacteria causing HAI and resistant to at least one of the drugs most commonly used to treat them. Persons infected with drug resistant organisms are more likely to have longer hospital stays and treated with 2nd or 3rd choice drugs that may be less effective more toxic and more expensive[3]. The Institute of medicine reports that HAI is responsible for 44000-98000 deaths per year at a cost of $17-29 billion (US) per year in USA[16]. In USA, an estimated 500,000 patients suffer from postoperative infections each year which are often unnecessary and can be quite expensive[17].

Urinary tract infection (UTI) is the most commonly encountered hospital-acquired infection and the major risk factor is urinary catheterization[48.] According to reports from Turkey, 21-49% of hospital-acquired infections are urinary tract infections[49]. The importance of nosocomial infections has increased in the last decade and establishment of hospital infection committees and surveillance of nosocomial infections have become mandatory since 2005 for all the hospitals in Turkey[50]. A study from Scotland on urinary tract infection by nosocomial infection has found a significantly higher prevalence in ICUs 27.1%[51]. The most common reason of this higher prevalence is the application of catheters[52]. Another study on Hospital-acquired urinary tract infection point prevalence in Turkey: Differences in risk factors among patient groups disclosed the most common risk factors were the use of antibiotics in the preceding three months, urinary catheter, UTI in the preceding year and diabetes, in concordance with previous studies[53].

The prevention of ICU acquired infections demands knowledge of the infection rates and of the sources, the pathogens involved as well as the common risk factors for infection. The incidence of nosocomial infections varies according to the setting, that is, the type of hospital or ICU, the patient population and the precise definition and surveillance techniques used to identify a nosocomial infection[54]. A large cohort multicentric international study has reported at least one ICU acquired infection in 18.9% of patients with an incidence ranging from 2.3% to 49.2% across the centers[55]. In 1-day point prevalence study involving 1265 ICUs from 76 countries (extended prevalence of infection in intensive care [EPIC II] study), 51% patients were found to have nosocomial infection. However, the rates of infections varied considerably according to the country with Greece and Portugal having the highest and Switzerland and Germany and the Netherlands having the lowest infection rates.[56]

In the study by Rosenthal *et al.*,[57] crude mortality rate for patients with device associated infections ranged from 35.2% (for central venous catheter associated blood stream infection) to 44.9% (for VAP). Another study [58-59] has reported incidence rates between 9% and 37% depending largely on the populations studied. Invasive device utilization like central venous or urinary catheterization, intubation, tracheostomy and mechanical ventilation have been reported as significant risk factors for infection in many studies.[56, 61, 62, 63].

In 2012, Sugata Dasgupta et al., [60] showed the nosocomial infection rate was 11.98% (95% confidence interval 7.89–16.07%). Pneumonia was the most frequently detected infection (62.07%), followed by urinary tract infections and central venous catheter associated bloodstream infections. Prior antimicrobial therapy, urinary catheterization and length of ICU stay were found to be statistically significant risk factors associated with nosocomial infection. Nosocomial infection resulted in a statistically significant increase in length of ICU and hospital stay but not in mortality.

Hospital-acquired infections are most commonly associated with invasive medical devices or surgical procedures. Lower respiratory tract and bloodstream infections are the most lethal; however, urinary tract infections are the most common. Recent data from the U.S. National Healthcare Safety Network indicate that gram- negative bacteria are responsible for more than 30% of hospital-acquired infections, and these bacteria predominate in cases of ventilator-associated pneumonia (47%) and urinary tract infections (45%)[64].

Infections caused by gram-negative bacteria have features that are of particular concern. These organisms are highly efficient at up-regulating or acquiring genes that code for mechanisms of antibiotic drug resistance especially in the presence of antibiotic selection pressure. Furthermore, they have available to them a plethora of resistance mechanisms often using multiple mechanisms against the same antibiotic or using a single mechanism to affect multiple antibiotics. Com- pounding the problem of antimicrobial-drug resistance is the immediate threat of a reduction in the discovery and development of new antibiotics.[65] Several factors have contributed to this decline, including the increasing challenges of screening for new compounds, the high capital costs and long time required for drug development, the growing complexity of designing and performing definitive clinical trials and the concern about reduced drug longevity due to the emergence of resistance. As a consequence, a perfect storm has been created with regard to these infections: increasing drug resistance in the absence of new drug development.

1.1.2.2 Regional Scenario

In India, 10 to 30% of patients admitted in HAI according to members of Hospital Infection Society (HIS), India. The involvement of high cost as an outcome of antibiotic intake, prolonged hospital stay and loss of work affect the health and weaken the economy too. In a few situations, HAI lead to septicemia having a mortality rate of 80%[18]. In another study in Lahore, Aman (1982) found that the predominating causative organism was *Staphylococcus aureus* (28.65), followed by *Escherichia coli* (24.7%) and *Pseudomonas* spp.(23.7%)[25].

1.1.2.3 Bangladesh Scenario

Today surveillance programs estimate the rate of this infection as 5-10% of hospital admissions all over the world[190]. Bangladesh is no exception. Systematic studies on the magnitude and extent of the problem are lacking but a study conducted in 2004 in BIRDEM hospital excluding burn, neonatal and adult intensive care units has documented the rate of hospital acquired infection as 2.4%[191].

In Bangladesh, a few studies have been conducted in this field. A limited single study has recorded the mean duration of hospital stay is significantly long (20 to 26 days) for cases who acquired hospital infection compared to non-infected cases (9.5 days)[192]. In a multi-center study involving four geographic divisions of Bangladesh, the rate of isolation of MRSA from hospital patients ranged between 32-63%[193]. Another study conducted in a referral hospital of Dhaka city reported 43.2% and 39.5% of *Esch. coli* and *K. pneumoniae* as ESBL phenotypes respectively[194]. The situation is even dismal in high risk areas of the hospital like intensive care units (ICU). All the isolates from an ICU of BIRDEM hospital were highly resistant (>80%) to cephalosporin's and fluoroquinolones[195]. This entire scenario invites the urgent need for initiation of a systematic infection control program in all hospitals of the country.

The extent and pattern of resistance to different antimicrobials are largely unknown. However, in 1990, the rate of HAI was found 30% at Dhaka Medical College Hospital (DMCH) which is quite high. It was found that increased frequency was due to overload of the wards by patients, overcrowding by visitors and breach of aseptic measures[21]. In 2003, the rate of infection was found as 11.34% in the same hospital which reflects a better situation than before. However, the study result revealed that 38.2% patients with HAI had to bear the burden of extra cost (10001-20000 taka) because of longer hospital stay[22].

In 2002, a study was conducted to determine the microorganisms responsible for HAI in different hospitals of Bangladesh where *Staphylococcus aureus* was found as the most common pathogen and 70% of which was resistant to methicillin[23]. In an earlier study in

Bangladesh, mohiuddin (1999) found that majority of the organisms responsible for nosocomial infection was *Escherichia coli* (55.9%) followed by *Pseudomonas* spp. (33.3%) and *Proteus* spp. (12.7%)[24]. A cross sectional study in the surgical wards of Dhaka medical college hospital (1991) showed that out of 240 patients, 72(38.0%) suffered from nosocomial infection of which maximum number i.e. 26 (36.1%) suffered from surgical wound infection followed by 17(23.6%) urinary tract infection. Prevalence of nosocomial infection was found to be higher (49%) in postoperative patient than preoperative patients (15.9%) in this study[14].

1.1.3 Consequences of Hospital Acquired Infections

The patients with HAI suffer from functional disability and emotional stress leading to disabling conditions that reduce quality of life. It is not only cause of death but economic costs are also enormous. The increased length of hospital stay, increased use of drugs, the need for isolation and the use of additional laboratory and other diagnostic studies contribute to costs. HAI add to the imbalance between resource allocation for primary and secondary health care by diverting scarce fund to the management of potentially preventable conditions. Prolonged hospitalization of infected patient also results in decrease availability hospital facilities for other patients and has a significant impact upon hospital practice. The antibiotic resistance problem is global confronting communities and countries. The cost of antibiotic resistance continues to rise with increased mortality and length of hospital stay.

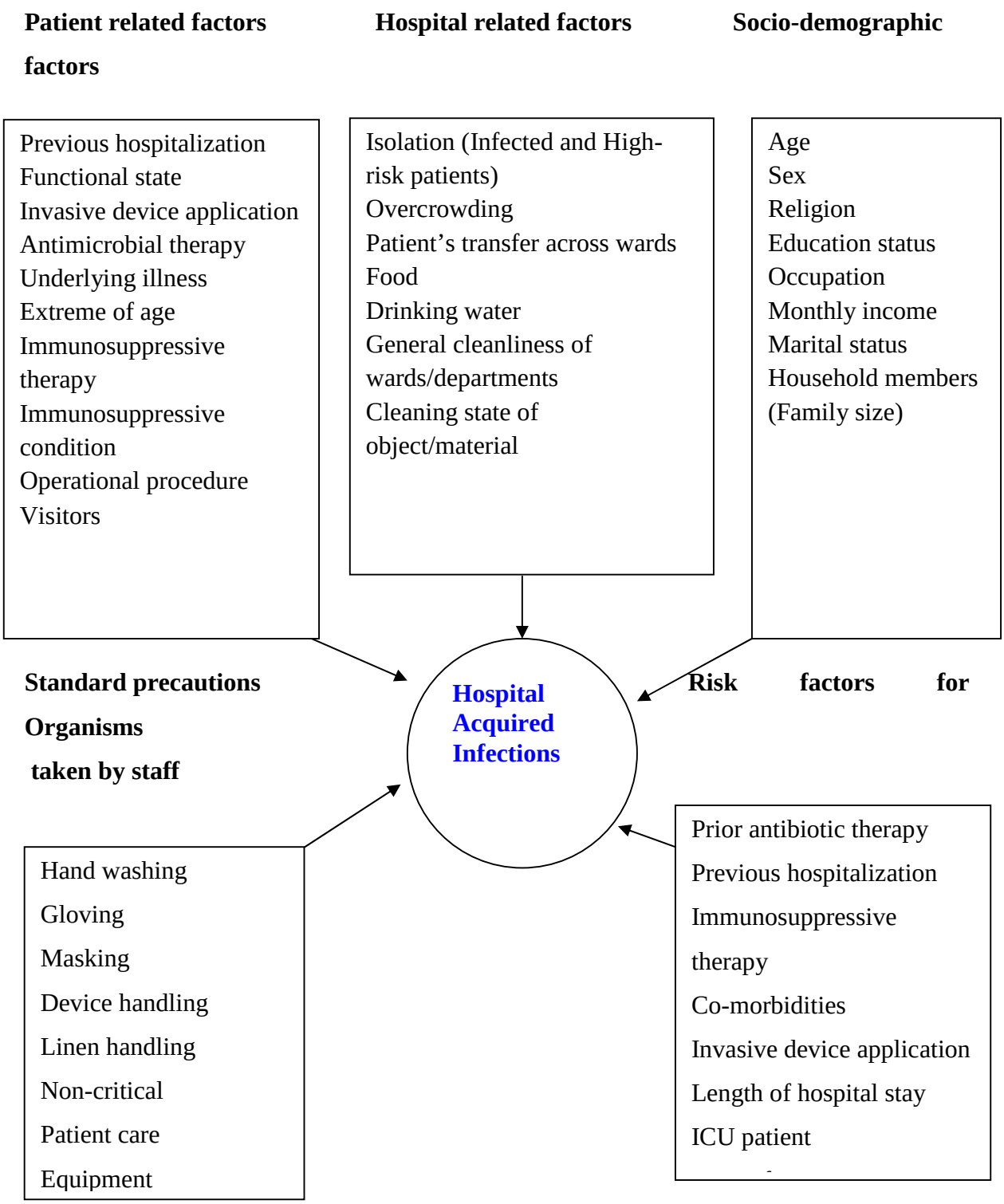
So the consequences of hospital infection are several, both for the patient and for the community which may summarized as follows:

- result in serious illness or death:
- prolong hospital stay, which costs money and results in loss of earnings and hardship foe patient and his /her family:
- require additional anti microbial therapy which is costly, exposed the patient to additional risk of toxicity and increases selective pressure for resistance to emerge among hospital pathogens;
- results in the infected patient becoming a source from which other may become infected both in hospital and community[81].

The problem as described above has been genuinely defined to determine the incidence of HAI and its risk factors which might fill the gap and answer the unexplained questions.

1.2 CONCEPTUAL FRAMEWORK OF PROBLEM ANALYSIS

Conceptual Framework Illustrating Factors Associated with Hospital- Acquired Infections (HAIs)



1.3 JUSTIFICATION/RATIONAL OF THE STUDY

Bangladesh is of least developed countries suffering from the curse of population explosion with a growth rate 1.48%. A densely populated country with average household size 5.5, living with economic status which is much bellow subsistence level. Most of them can hardly afford to consume a minimum food while quite a large number of people are deprived of having a regular two square meals[26].

In such a condition, we can very well guess the miserable condition of a person when has to spent a major portion of his earning for health care. These problems become evident when he develops HAI which are preventable. This problem of HAI during his treatment in hospital which are preventable. This problem of HAI has been recognized since the time the sick were housed together for treatment. Despite spectacular advance in life support technology, the management of patients with severe infection continues be a significant health care challenge because of associate morbidity, mortality and health economic implications[27].

In our country, the hospital bed ratio is 1:3083. More over, in tertiary level of health care, bed utilization rate is more than 100%. Therefore, it is easily understood what a tremendous pressure of patients in government hospitals with high constraints of resources. Although good number of private clinic and hospitals has to some extensively reduce this load but it is not possible for most of the poor people to get access to this costly facility[26].

Approximately 1 in 10 hospitalized patients will acquire an infection after admission which results in substantial economic cost. The primary cost is that patients with hospital-acquired infections have their stay prolonged, during which time they occupy scarce bed-days and require additional diagnostic and therapeutic interventions. Estimates of the cost of these infections, in 2002 prices, suggest that the annual economic costs are $6.7 billion per year in the United States and £1.06 billion (approximately US $1.7 billion) in the United Kingdom[28].

In addition, HAI caused by resistant microbes resulting prolonged illness and greater risk of death. Treatment failure leads to longer infectivity which increases the number of infected people moving in the community and thus general people to the risk of contracting a resistant strain of infection. When infection becomes resistant, treatment of which is nearly always much more expensive and sometimes toxic as well[29].

Once individual develop HAI, bed utilization by the maximum number of patients decreases due to over stay. This situation demands increase number of beds for optimum health care

facilities for other patients which is difficult to ensure due to economic implication.

Antibiotic resistance is a major contributor to the disease, death and cost resulting from HAI proved to be a growing threat to public health. Unfortunately we don't have precise numbers.

One report placed the annual cost of antimicrobial resistance among a single pathogen at $122 million in USA[30]. Therefore, it is of utmost importance for studies in this area to improve our knowledge on HAI and its impact on patient's sufferings and cost involvement.

Considering the economical constraints and lack of resources, optimization of the existing health facilities is to be ensured. Therefore, there should be reduction of rate of HAI which will ultimately reduce the average length of stay of patients and thus contribute maximum utilization of limited resources.

At present, the exact proportion of hospital acquired infections in United Hospital is not known clearly. Although HAI with *Acinetobacter sp., Pseudomonas sp*. have been reported but its risk factors and antimicrobial resistance pattern yet to unfold. The absence of information has made it difficult to access the impact of HAI, their influence on overall increase of infection rate or change of pattern of resistance. Does it increase the morbidity and mortality associated with HAI? All these questions need to be explained in time before the condition deteriorates further or goes out of control.

In Bangladesh, infection control program in hospitals has been recognized only in early 2000. Only few hospitals of the country have designated infection control programs and probably none has an antibiotic policy. There is also no established infection control policy and surveillance system in district and tertiary care hospitals. Recently, provision for infection control nurse has been made in few teaching public hospitals of the country. There is little in the undergraduate curriculum about infection control and its importance. Our medical and nursing students are taught very little about nosocomial infection and ways of reducing its spread. They graduate without an adequate knowledge on how to reduce infections. It is time to include infection control in our undergraduate and postgraduate curricula. Hospitals should have strict guidelines and review measures. In addition, efforts should be made to establish and strengthen microbiology laboratories to support management and control of health-care associated infections. This will not only reduce patient morbidity, but also reduce the use of antibiotics and health care costs of the country. If we do not act today, we are destined to pay the price tomorrow in the form of increased sufferings of the patients, unwanted drainage of meager resources and turning successful treatment into failures. Therefore, "an effective infection control program will relief

patients from unwarranted sufferings and grant medics to enjoy pride in their endeavor."

In view of the above, the present study is a timely attempt to explore the rate/incidence of hospital acquired infections, risk factors, type of hospital acquired infections, antimicrobial resistance pattern responsible for causative agents and its overall magnitude in this hospital. The out come of this study may provide important information for future in depth study as well as ideas to formulate proper interventions for better control and prevention.

1.4 EPIDEMIOLOGY OF HOSPITAL-ACQUIRED INFECTION

1.4.1 Introduction

An understanding of the epidemiology of hospital acquired infection is necessary for effective control and preventive measures. One uses of epidemiological methods to define all the factors related to the occurrence of diseases, including the relationship among the agent, its reservoirs and source, the environment, the route of transmission and the host. Once all these relationships have been defined for a specific disease, the most appropriate and effective means of control and prevention would become apparent. An understanding of epidemiological aspects of HAI is necessary for effective surveillance to estimate the changing pattern of disease from time to time.

1.4.2 Hospital-acquired infection (HAI)

1.4.2.1 Hospital-acquired infection (HAI) is defined as an infection occurring in a patient while in a hospital or other or other health care facility in which the infection was not present or incubating at the time of admission. Infection is usually considered as HAI when it is developed more than 48 hours after admission.[1]

1.4.2.2 Hospital-acquired infection is also called Nosocomial infection. The term nosocomial comes from two Greek words: nosus meaning disease + komeion means to take care of. Hence, nosocomial should apply to any disease contracted by a patient while under medical care.

In our country, the extent and morbidity and mortality due to hospital-acquired infection is not clear but in USA, they are among the 10 leading cause of death[31].

1.4.2.3 Hospital-acquired infections may involve not only patients but also anyone else, who has contact with a hospital including members of the staff, visitors and volunteers. The majority of HAI become clinically evident while the patients are still in hospital; however, the onset of the infection can happen after a patient is discharged. In this scenario, the patient becomes colonized or infected while in hospital; but the incubation period was longer than the patient's hospital stay. This sequence is generally seen in some

infection of newborns and in most breast abscesses of new mothers. Hepatitis B is an example of HAI with along incubation period and its clinical onset usually becomes apparent long after the patient is discharged from the hospital[32]. The following criteria will distinguish hospital-acquired infections from community-acquired infections[33].

a. The infection is not present or incubating during admission and not an extension of infectious process at the time of admission.

b. The infection manifests itself after discharge within a defined period of time (Infection, 30 days unless an implant is present then up to 1 year). Readmission is not required.

c. When a mother is free from infection upon admission delivers an infection (not transmitted transplacentally) infant 48 to 72 hours later.

1.4.2.4 Forms of hospital-acquired infections

Endogenous infection, self-infection or autoinfection

The causative agent of the infection is present in the patient during admission but there is no sign of infection. The infection develops during the stay in hospital because the patient's altered resistance[34].

Cross-contamination followed by cross-infection

During the stay in hospital the patient comes in contact with the new infective agent becomes contaminated and subsequently develops an infection[34].

Transmission from contamination to infection

Whether or not a tissue will develop an infection after contamination depends upon the interaction between the contaminating organisms and local host. Local resistance of the tissue to infection also plays an important role: the skin and mucous membrane act as barrier in contact with the environment. Infection may follow when these barriers are breached. Local resistance may also be overcome by the long term presence of an irritant such as a cannula or catheter, the likelihood of infection increases daily in a patient with an indwelling catheter. The most important determinants of infection however are the nature and number of organisms. Microorganisms range from the completely innocuous to the extremely pathogenic: the former will never cause an infection even in immune-compromised individuals while latter will cause an infection in any case of contamination[35].

1.4.2.5 Common sites of hospital-acquired infections

Surgical Site Infection (SSI)

Any purulent discharge, abscess or spreading cellulites at the surgical site during the month after the operation. The incidence varies from 0.5% to 15% depending on the type of

operation and underlying patient status[1].

Urinary Tract Infection (UTI)

Positive urine culture with at least 10^5 cfu/ml with or without clinical symptoms. This is most common site of HAI are associated with the use of an indwelling bladder catheter. Urinary infections are associated with less morbidity than other HAI's but can occasionally lead to bacteraemia and death[1].

Respiratory Tract Infection (RTI)

Respiratory symptoms with at least two of the following signs appearing during hospitalization: cough, purulent sputum, new infiltrate on chest radiograph consistent with infection[1].

Hospital-Acquired Pneumoniae (HAP)

One of the common infections acquired in hospital when the patients are on ventilators in the ICUs, the rate may be 3% per day. There is high case fatality rate associated with VAP. Definition of pneumoniae may be based on clinical and radiological criteria: recent and progressive radiological opacities of the pulmonary parenchyma, purulent sputum and recent onset of fever. Diagnosis become more specific after microbiological report obtained. Known risk factors include type and duration of ventilation, the quality of respiratory care, previous use of antibiotics. Hospital acquired pneumoniae also associated with patients having decreased level of consciousness, children's units, elderly and immunocompromised patients[1].

Vascular Catheter Infection

Inflammation, lymphangitis or purulant discharge at the insertion site of the catheter. Organisms colonization the catheter within the vessel may produce bacteremia without visible infection. The main risk factors are length of catheterization, level of asepsis at insertion, continuing catheter care.

Septicemia

Fever or rigors and at least one positive blood culture[1].

Skin and Soft Tissue Infection (SSTI)

Open sores (ulcers, burns and bedsores) encourage bacterial colonization and may lead systemic infection[1].

Gastroenteritis

The most common HAI in children where rotavirus is a child pathogens[1].

1.4.2.6 Pathophysiology of Hospital-Acquired Infections

Within hours of admission, colonies of hospital strains of bacteria develop in the patient's skin, respiratory tract and genitourinary tract. Risk factors of the invasion of colonizing pathogens can be categorized into 3 areas such as iatrogenic, organizational and patient related[36].

Iatrogenic risk factors

It includes invasive procedures (e.g. Intubations, indwelling vascular lines, urinary catheterization) and antibiotic use and prophylaxis.

Organizational risk factors

It includes contaminated air-conditioning systems, contaminated water system, staffing and physical layout facility (e.g. nurse to patient ratio, open beds close together).

Patient related risk factors

It includes the severity of illness, underlying immunocompromised state and length of hospital day.

1.4.2.7 Factors Influencing the Development of Hospital-Acquired Infections

The microbial agents

The patient is exposed to a variety of microorganisms during hospitalization. Contact between the patient and microorganism does not by itself necessarily result in the development of infection but other factors influence the nature and frequency of HAI. The likelihood of exposure leading to infection partly depends on the characteristics of microorganisms, including resistance to antibiotics intrinsic virulence and amount of infective material. Many different bacteria, viruses, fungi and parasites may cause HAI which may be acquired from another person in the hospital (cross-infection) or may be caused by the patient's own flora (endogenous infection). Some organisms may be acquired from an inanimate object or substances recently contaminated from another human source (environmental infection)[1].

Patient Susceptibility

Important patient factors influencing acquisition of infections, which includes age, immune status, underlying illness and diagnostic and therapeutic interventions. The extreme of life infancy and old age are associated with decreased resistance to infection. Patients with malignant tumors, leukemia, diabetic mellitus, renal failure or AIDS have an increased susceptibility to infection with opportunistic pathogens. Immunosuppressive drugs or irradiation may lower resistance to infection. Injuries to skin or mucous membranes bypass

natural defense mechanisms. Malnutrition is also a cause. Modern diagnostic and therapeutic procedures such as biopsies, endoscopic examination, catheterization, intubations ventilation, suction, surgical procedures increase the risk of infections[1].

Environmental Factors

Health care settings are environment where both infected persons and persons at increased risk of infection congregate. Patients with infections or carriers of pathogens admitted to hospital are potential source of infection for patients and staff. The patients who become infected in the hospital are a further source of infection. Crowded conditions within hospital, frequent transfer of patient from one ward to another and concentration of patients highly susceptible to infection in one area (e.g. newborn infants, burn patients and intensive care) all contribute to HAI. Microbial flora may contaminate objects, devices, and materials which subsequently contact susceptible body site of patient[1].

Bacterial Resistance

In the health settings, many patients receive antimicrobial drugs. Through selection and exchange of genetic resistance elements, antibiotic promote the emergence of MDR strains of bacteria; microorganisms in the normal human flora sensitive to the given drug are suppressed, while resistant strains persist and may become endemic in hospital. The widespread use of antimicrobials for therapy prophylaxis is the major determinant of resistance[1].

1.4.2.8 Source of Infection

In health care facility, the sources of infection and of the preceding contamination may be the personnel, the patients or the inanimate environment. The hospital environment can be contaminated with pathogens. The pathogens may be present in food and cause an outbreak of diseases just as they can in a community outside in the hospital. If the water distribution system breaks down, water born infections may develop. In more sophisticated premises the water cooling system of air conditioning equipment may become contaminated with *Legionella pneumophilia* causing Legion-naires disease in susceptible patients. The source of an outbreak of HAI may also be a health worker who is infected or colonized (a carrier). A symptom less carrier however is contaminated or colonized by potentially pathogenic organisms but does not develop any infection. A typical example is *Staphylococcus aureus* which may be carrier in the nasal passages of 30-60% of personnel. Contamination of patients by carriers can give rise to an outbreak of disease. The source of most hospital epidemics is infected patients, i.e. patients contaminated with pathogenic organisms.

These pathogens are often released into the environment in very high numbers, exceeding

the infective dose and contaminate other patients who subsequently develop HAI[34].

The Agent

The agent, the first link in the chain of infection may be classified as under[34]:

a. **Conventional pathogens.** They cause disease in healthy individuals in the absence of specific immunity. Examples: Staph *aureus, Streptococcus pyogenes, Salmonella sp. Shigella spp., Mycobacterium tuberculosis, Bordetella pertusis,* Hepatitis A, and B viruses, rotaviruses, human immuno-deficiency virus (HIV).

b. **Conditional pathogens.** Cause disease other than trivial local infections, only in persons with reduced resistance to infection or when implanted directly into tissue or a normal sterile body area. Examples are *Streptococcus agalactiae, Enterococcus sp., Clostridium tetani, E. coli, Klebsiella sp., Pseudomonas aeruginosa, Candida sp.*

c. **Opportunistic pathogens.** Caused generalized disease but only in patients with profound diminished resistance to infection. Examples: Atypical mycobacteria, *Pneumocystis carini.*

1.4.2.9 The Routes of Transmission (The second link in the chain of infection)

Microorganisms can be transmitted from their source to a new host through direct or indirect contact, by the air or by vectors[34].

Direct Contact

Direct contact between patients does not usually occur in health care facilities, but an infected health care worker can touch a patient and directly transmit a large number of microorganisms to the new host.

Indirect Contact

The most frequent route of transmission, however, is indirect contact. The infected patient touches and contaminates an object, an instrument or a surface. Subsequently contact between that item and another patient is likely to contaminate the second individual who may then develop an infection. During general care, the hands of the health care workers come into close contact with patient. The hands of the clinical personnel are thus the most frequent vehicles for HAI.

Vector-Borne Transmission

This transmission is typical of countries in which insects, arthropods and other parasites are widespread. These become contaminated by contact with excreta or secretions from an infected patient and transmit the infective organisms mechanically to other patients.

Airborne Transmission

It occurs only with microorganisms that are dispersed into the air and are characterized by a low minimal infective dose. These are dispersed in large numbers only because of sneezing or coughing.

Common Vehicle Spread

In common vehicle spread infection, a contaminated inanimate vehicle such as food, water, other liquids and drugs serve as the vehicle for transmission of the agent for multiple persons[32].

1.4.2.10 Host

The 3rd link in the chain of transmission is the host or victims. Host factors that influence that development of infection are the site of deposition of the agent and the host's defense mechanism referred to as immunity both specific as well as non specific[32]. In causation of HAI, decreased resistance of patients due to various factors contribute largely: extreme of age, underlying diseases, invasive measures, immunosuppressive and steroid therapy, poor local resistance due to imperfect blood supply, indiscriminate use of antibiotics help in emergence of drug resistance to pathogens[37].

1.4.2.11 Environment

Everything that surrounds a patient in the hospital is his environment. HAIs can be acquired from other patients, hospital staff, visitors, food, water, dust and other contaminated inanimate articles, drug resistance microorganism. Environment significantly influences the multiple factors the chain of hospital acquired non-pathogenic to pathogenic strains[38].

Spectrum of Occurrence of Cases

To determine whether a problem of HAI exists in a particular hospital, one must relate the currency of cases to the past history of the disease in that institution. HAI may be characterized as sporadic, endemic and epidemic which is to be related with time, place and person. Occurrence and infection is quantified by calculating its incidence and prevalence. Techniques of epidemiological studies: descriptive, analytical experimental all of which may be used to investigate HAI and to evaluate the effectiveness of control and preventive measures. Routine surveillance is also conducted to understand the trend and nature of HAI in this aspect to deal with specific infections[32].

1.4.2.12 Time Trends of Hospital-Acquired Infections

Four time trends to consider for hospital-acquired infections, which are described below[32].

Secular Trends

It is long term trends in the occurrence of a disease that is variations that occur over a period

years. Secular trends generally reflect the immunologic, socioeconomic, educational and nutritional levels of population from which secular data have been reported. For example, the gradual but steady reduction in the incidence of Diphtheria in the United States over the past 50 years. In a hospital, the secular trend of a disease may be difficult to portray due to the lack of adequate data concerning the occurrence of the disease over time.

Periodic Trends

Periodic trends are temporal interruptions of the secular trend and usually reflect that changes in the overall susceptibility to the disease in the population.

Seasonal Trends

It is the annual variations in the disease incidence that are related in part to seasons. In general, the occurrence of particular communicable disease increases when the circumstances that influence its transmission are favorable The seasonal pattern of both community-acquired and hospital-acquired respiratory disease for example involve high incidence in the fall and winter months when transmission through the air is enhanced because people are together in rooms with closed windows and are breathing unfiltered, recirculating air. The seasonal trend of food borne disease involves higher incidence in summer months when ambient temperature are elevated and refrigerated may be inadequate when non-disease producing levels of microorganisms may be allowed to incubate, resulting in the attainment of infectious doses.

Acute or Epidemic Occurrence

Acute or epidemic occurrence of a disease with its characteristic upsurge in incidence. The overall shape of the epidemic curve depends on the specific pathogenicity, concentration and incubation period; the mode and ease of its transmission; the method of transmission; and the environment.

1.4.3 Antimicrobial Resistance

Since their discovery during the 20th century, antimicrobial agents have substantially reduced the threat posed by the infectious diseases. The use of these drugs combined with improvements in sanitation, housing, nutrition and the event of immunization programs has led to a dramatic drop in deaths from diseases that were previously widespread, untreatable and frequently fatal. The gains are now jeopardized by another recent development: the emergence of microbes that are resistant to cheap and effective first choice drugs. The consequences are severe ranging from prolonged illness to greater risk of death. When infections becomes resistant to 1st line antimicrobials, treatment has to be switched to 3rd line drugs, which are nearly always much more expensive and sometimes more toxic.

Treatment failure also increases the numbers of infected people moving in the community and thus general population are at risk of contracting a resistant strain of infection[39].

1.4.3.1 How Antibiotic Resistance Happens

Antibiotic resistance results from gene action. Bacteria acquire genes conferring resistance in any of the three ways[40]:

a) In spontaneous DNA mutation, bacterial DNA (genetic material) may mutate spontaneously. Drug resistant tuberculosis arises this way.

b) In a form of microbial sex called transformation, one bacterium may take up DNA from another bacterium. Penicillin-resistant gonorrhea results from transformation.

c) Most frightening, however, is resistant acquired from small circle of DNA called plasmid that can flit from one type bacterium to another. A single plasmid can provide a slew of different resistance. In 1968, 12500 people in Guatemala died in an epidemic of Shigella diarrhea. The microbe harboured a plasmid carrying resistance to four antibiotics[41].

1.4.3.2 Factors Promoting Antimicrobial Resistance

a) HAI caused by antibiotic resistant pathogens are the selection of resistant mutant strains from patient's own flora during antibiotic treatment or the transfer between bacteria of mobile genetic determinants of resistance. Subsequently resistant strains spread among patients in hospital.

b) Selection of resistance of infecting or colonizing bacteria is enhanced by the factors related to the patient: immunosuppressant, presence of reservoir of resistant mutants.

c) Use of monotherapy rather than combination therapy may favour selection of resistance in certain infections-as will insufficiently high drug doses or inappropriate route of administration which may fail to achieve bactericidal drugs level at the site of infections.

d) Alternation of the endogenous microflora during antibiotic treatment also enhances replacement of susceptible organisms by resistant strains from the hospital microflora.

e) Most commonly transmission occurs as a result of contact between patients via contaminated hands of healthcare staff. Factors predisposing to this transmission include length of stay in hospital, intensity and duration of exposure to broad spectrum antibiotics severity of underlying illness and use of invasive device such as intravascular catheter or surgery[3].

1.5 RESEARCH QUESTIONS:

a) What is the incidence of hospital-acquired infection?

b) What are the potential risk factors for hospital-acquired infection?

c) What are the causative agents and drug susceptibility pattern?

1.6 OBJECTIVES OF THE STUDY:

GENERAL OBJECTIVE:

To determine the incidence of hospital-acquired infection (HAI) and risk factors associated with hospital-acquired infection

SPECIFIC OBJECTIVES:

1. To determine the incidence of hospital acquired infection (HAI)
2. To find out the type of hospital-acquired infection in selected hospital
3. To assess the relationship between the patients related factors and hospital acquired infection
4. To examine the association between hospitals related factors and hospital acquired infection
5. To identify the causative agents responsible for hospital-acquired infection
6. To determine the antimicrobial susceptibility pattern of the nosocomially infected patients

1.7 LIST OF KEY VARIABLES

1.7.1 Hospital acquired infection (HAI)

1.7.2 Patient related factors

- Previous hospitalization
- Prior antibiotic therapy
- Age/Extreme of age
- Functional state
- Invasive device application
- Antibiotic therapy during hospitalization
- Underlying illness
- Visitor/patient/day
- Immunosuppressive therapy
- Immunosuppressive condition
- Current operational treatment

1.7.3 Hospital environment

- Patient's transfer (from one ward to another)
- Food
- Drinking water
- General cleanliness of wards/departments
- Cleaning state-object and material

1.7.4 Common types of hospital-acquired infection

- Surgical site infection (SSI)
- Blood stream infection (BSI)
- Urinary tract infection (UTI)
- Respiratory tract infection (RTI)
- Skin and soft tissue infection (SSTI)

1.7.5 Standard precautions taken by staff

- Hand washing
- Gloving
- Masking
- Gowning
- Device handling

1.7.6 Isolation of microorganism

- Culture

1.7.7 Antibiogram

1.8 OPERATIONAL DEFINITIONS OF SELECTIVE VARIABLES

In this study, following operational definitions have been used for selected variables.

1.8.1 Hospital-acquired infection (HAI)

Hospital acquired-infection was considered as the infection that occurring in a patient while in a hospital in which the infection was not present or incubating at the time of admission. An infection acquired in a hospital by a patient who was admitted for a reason other than that infection. The infection has been considered hospital-acquired when it first appeared more than 48 hours after admission[1].

1.8.2 Principles used in definition of HAI

Principles as used were based on the criteria given by the Centers for Diseases Control and Prevention of US department Health and Human services:

1) Information used to determine the presence and classification of an infection involves various combinations of clinical findings and result of laboratory and other diagnostic tests. Clinical evidence is derived from direct observation of the patient or reviewed of information in the patient's chart or other wards or unit records.

2) Physician's or surgeon's diagnoses of infection derived from direct observation during surgery, endoscopic examination or other diagnostic study or based on clinical judgment.

3) There must be of no evidence that the infection was present or incubating at the time of hospital admission[42].

1.8.3 Surgical site infection (SSI)

Superficial incision SSI: It was considered when the infection occurred within 30 days after the operation and incision involved only skin or subcutaneous tissue of the incision and at least one of the following:

1) Purulent drainage, with or without laboratory confirmation from the superficial incision.
2) Organism isolated from an aseptically culture field or tissue from the superficial incision. At least one of the following signs or symptoms of infection: pain or tenderness, localized swelling, redness or heat and superficial incision were deliberately opened by a surgeon.
3) Diagnosis of superficial incision SSI by the surgeon or attending physician[43].

Deep incision SSI: Infection was considered when it occurred within 30 days after the operation if no implant was left in place or within 1 year if implant was in place and

infection appeared to be related to the operation and infection involved deep tissue (e,g, facial and muscle layers) of the incision and at least one of the following:

1) Purulant drainage from the deep incision but not from the organ/space component of the surgical site.
2) A deep incision spontaneously or was deliberately opened by a surgeon when the patient had at least one of following signs or symptoms: fever (38degree C), localized pain or tenderness unless site is culture negative.
3) An abscess or other evidence of infection involving the deep incision was found on direct examination during reoperation or by histopathologic or radiologic examination.
4) Diagnosis of a deep incisional SSI by a surgeon or attending physician[43].

Organ/ space SSI: Infection occurred within 30 days after the operation if no implant was left in place or within 1 year if implant was in place and the infection appeared to be related to the operation and the infection involved any part of the anatomy (e.g. organs or spaces) other than the incision which was opened or maintained during an operation and at least of the following:

1) Purulent drainage from a drain that is placed through a stab wound into the organ/space.
2) Organism isolated from an aseptically obtained culture of fluid or tissue in the organ/space.
3) Diagnosis of an organ/space SSI by a surgeon or attending physician[43].

Urinary tract infection (UTI)

Symptoms of urinary tract infection were considered when it met one of the following:

a. One of the following: fever (>38^0 C) urgency, frequency dysuria or suprapubic tenderness and aseptically urine culture of >10^5 c.f.u/ml. of urine.
b. Two of the following: fever (>38^0 C), urgency, frequency dysuria or suprapubic tenderness and any of the following:
    1. Pyuria
    2. Physician's diagnosis
    3. Physician institutes appropriate antimicrobial therapy[42].

Bloodstream infections (BSI)

BSI was defined as the isolation of pathogens from one or more blood cultures with clinical symptoms of:

a) Fever (38^0 C), hypotension, chills decreased urine output, lethargy.
b) Pathogen is not related to infection at other sites.
c) Physician institute appropriate antimicrobial therapy[42, 44].

Respiratory infection (less pneumoniae)

Hospital-acquired respiratory infection was defined as the presence of three or more of the following[44]:

a) Cough
b) Purulent sputum
c) Temperature of 101^0 F or more
d) Isolation from sputum of potential pathogenic organisms
e) Radiological findings consistent with a pneumonic process.
f) Microorganisms present in the pleural fluid
g) Microorganisms present in the pulmonary secretions.

Hospital-acquired pneumoniae (HAP)

The definition of hospital-acquired pneumoniae (HAP) was based on clinical and radiological evidences as readily available[1]:

a) Recent and progressive radiological opacities of the pulmonary parenchyma
b) Purulent sputum
c) Recent onset on fever
d) Physician introduced antimicrobial therapy

Skin and soft tissue infection (SSTI)

These were considered when included the following[42]:

a) Skin infection
b) Soft tissue infection
c) Decubitus ulcer infection
d) Burn infection
e) Breast abscess.

1.8.4 Functional state

Related to bathing, toileting, use of bed, eating with the following categories[45]:

Category 1 = Independent in activities, low-level nursing.

Category 2 = Requires some assistance, moderate level nursing

Category 3 = Requires assistance with most of the activities, high level nursing.

1.8.5 Extreme of age

Extreme of age was considered as one year or bellow and sixty years or above[1].

1.8.6 Immunosuppressive therapy

Following therapies were considered as immunosuppressive[1]:

a) Use of cytotoxic drug
b) Steroid therapy
c) Irradiation

1.8.7 Immunosuppressive condition

These are the conditions considered to increase the susceptibility to infection[1]:

a) Malignant disease
b) Diabetes mellitus
c) Renal disease
d) Leukemia
e) Uremia
f) Injuries to skin and mucous membrane
g) Liver failure

1.8.8 Invasive procedure

These included the following therapeutic procedure which increases the susceptibility to develop hospital-acquired infection[1]:

a) Nasogastric tube
b) Urinary catheter
c) Intravascular catheter
d) Mechanical ventilation
e) Endotracheal tube
f) Tracheostomy
g) Orthopedic fixation device
h) Others (specified)

1.8.9 ICU patient

Patients in intensive care units who were at a risk of developing infections because of more sick than other patients[46].

1.8.10 Underlying medical illness/conditions

The following diseases were considered as the underlying medical conditions with which patients were admitted[45]:

a) Cardiovascular disease
b) Coronary heart disease
c) Chronic genitourinary disease

d) Diabetes mellitus
e) Malignant disease
f) Neurological illness
g) Chronic obstructive pulmonary disease (COPD)
h) Any other conditions (specified)

1.8.11 Standard precaution taken by staff

The following precautions are considered standard (regular) as described below. Otherwise were regarded as not regular:

Hand washing

a) Hands to washing after touching blood, secretions excretions and contaminated items whether or not gloves are worn. Hands to be washed immediately after gloves are removed between patient contacts.
b) To use plain soup for routine and washing.
c) To use an antimicrobial for specific circumstances[47].

Gloving

a) Using of gloves (clean nonsterile gloves are adequate) when touching blood, body fluids, secretions, excretions and contaminated items; putting on clean gloves just before touching mucous membrane and non intact skin.
b) Removing of gloves promptly after use, before touching non-contaminated items and environmental surfaces and before going to another patients and wash hands immediately to avoid transfer of microorganisms to patients or environment[47].

Masking

To wear a mask and eye protection or a face shield to mucous membrane of the eyes, nose and mouth during procedures or patients care activities that are likely to generate splashes or sprays of blood, body fluids, secretions and excretions[43].

Gowning

Wearing a gown (a clean nonsterile gown is adequate) to protect skin prevent soiling of clothes procedures or patients care activities that are likely to generate splashes or sprays of blood, body fluids; secretions and excretions or cause soiling of clothing[47].

Appropriate device handling

To handle patient care equipment soiled with blood, body fluids, secretions and excretions in a manner that prevents skin and mucous membrane exposure, contamination of clothing,

transfer of microorganisms to other patients until it has been appropriately cleaned and processed and that single use items are properly discarded[47].

Non-critical patient-care-equipment and items:

These included the following[47]:

a) Stethoscope
b) Sphygmomanometer
c) Bedside commode
d) Electric rectal thermometer

This care was considered to single patient to avoid sharing between patients. Use of common equipment or items when became unavoidable then adequately clean and disinfection was done before use on another patients[47].

1.8.12 General cleanliness of the wards and departments:

Hospital has adequate procedure for routine care, cleaning and disinfections of environmental surface. General cleanliness was defined in the following way:

a) Good

Cleaning of wards/departments, floor and corridors was done three times a day and as and when required as a routine procedure by sweeping or mopping. No accumulation of refuges, gauge, bandage, waste of fruits and were free from foul smell. Toilets were washed three times a day with water and periodically with Lysol/soap/vim/phenol.

b) Satisfactory

Cleaning of wards/departments, floor and corridors was done twice a day and as and when required by sweeping or mopping. No accumulation of refuges, gauge, bandage, waste of fruits and were free from foul smell. Toilets were washed twice a day with water and periodically with Lysol/soap/vim/phenol.

c) Dirty

If not as above, regarded as dirty.

1.8.13 Regular cleaning of object/materials

Regular cleaning of object/materials was considered when patients care items bedside equipment and frequently touched surface received daily cleaning[47]. Otherwise regarded as not regular.

1.8.14 Food hygiene

Food hygiene was said to be maintained when it was prepared and served ensuring the cleanliness of cooking process and environment as under:

a. Maintenance of health and hygiene of the food handlers by routine checkup.
b. Removal of garbage from kitchen at least once after the end of cooking.
c. Serving hot and fresh food to the patients.

1.8.15 Hospital days

Hospital days were considered as the specified quantity of person time in the population at risk from admission to discharge or from admission till development of infection during data collection period.

1.8.16 Routine operation

An operation which was done deliberately with prior planning and after getting clinical and laboratory evidence to justify surgical procedure as a part of treatment or sometimes for diagnostic purpose. The operation was done at least 72 hours after admission.

1.8.17 Urgent operation

An operation which was done within 1 hour after admission of a patient, delay of which would deteriorate his condition or even cause death.

1.8.18 Culture

Growth of microorganisms in an artificial medium within a specified period.

1.8.19 Antibiogram

Antibiogram was defined as a record of the sensitivity of microorganisms to antimicrobial agents.

1.8.20 Family size (Household members)

Family size was considered as the number of family members where husband, wife and their children were included.

1.9 LIMITATIONS OF THE STUDY

1.9.1 Gynae and Obstetric wards were not included. Also significant portion of target population were excluded due to lack of data as they showed disturbances/unwillingness.

1.9.2 The study was conducted only one hospital because it was not possible for the researcher to cover more than one hospital to such a study in which data were collected prospectively.

1.9.3 The researcher had to depend upon physicians, nursing staff/ patients about the clinical history of patients, antibiotic therapy and use of invasive device during hospitalization in some of the occasions as it was continuously taken by the patients whereas discontinued in the case sheet and vice versa.

1.9.4 For socio-demographic study, income level of each respondent could not be incorporated due to highly dignified respondents of target population.

1.9.5 The researcher could not investigate extra cost for prolonged stay of the patients with hospital acquired infection due to no administrative facilities.

1.9.6 Only critical areas were studied regarding staff precautions.

1.9.7 Mortality rate could not disclose due to organizational restrictions.

Chapter-2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

2.1 The Hospital as an Institution

Hospital is a very complex, social and scientific organization that deals with life and health. Its purpose is to receive the sick and wounded and to take care of them in such manner so as to restore them to normal as far as possible. WHO has defined, "hospital as an integral part of a social and medical organization, the function of which is to provide for the population complete health care, both curative and preventive, whose outpatient services reach out to the family in its home environment"[75].

Hospital is a vital part of the health care system. But by the very nature of its work, a hospital constantly exposes patients to microbiological risks. When a person enters hospital, he exchanges his secure home environment for a bed in a small, possibly restricted, hostile area- the ward. From the moment of admission to the hospital the person is potentially put at a disadvantage by his illness, environment, medication, surgery and other treatment. It may seem strange that, in an effort to cure, we take people from the safety of their homes and expect them to make progress in the comparatively unsafe environment of a hospital[76].

An outbreak was defined as the occurrence of hospital acquired infections caused by the same organism in two or more patients who were located on a given ward during a given month. Some outbreaks of infectious disease in hospitals do not differ epidemiologically from outbreaks in other comparable institution such as nurseries, schools or even hotels. The hospital population usually shares a common supply of water, food and members of this population come into close proximity to one another. Thus outbreaks of enteric, diarrhoeal and food born diseases, a variety of respiratory tract infections and the infectious fevers of childhood may occur from time to time. The consequences of these diseases may be more serious for some categories of hospital patients than for healthy persons.[76]

Approximately 40 million people are hospitalized in U.S.A. each year and of those admitted, 5 to 10% acquire nosocomial infection. Of all hospital-acquired infections identified, 30 to 40% are urinary tract infections, 25% are postoperative wound infections and 15% are pneumonia.15% are infections of the blood stream and the remainder are infections at various other sites including the skin, spinal fluid, eye, peritonium etc.[76]

For every 100 admissions to the burn unit there were 34 nosocomial bloodstream infections. Such data show the greatly increased risk of the thermal injury as a result of his primary skin defenses being damaged. There is a similarly great risk of secondary wound infections (63

per 100 admissions) for burned patients also. Another group of patients with unusually high rates of infections are newborns in the special care unit. There overall infection rate is 28.55%. Obviously this is a selected group of newborns, many of who are premature and all of who are of high risk of subsequent infections.[76]

Hospitals may be liable for hospital acquired infections if reasonable procedures and standards have not been met in sterilizing equipment, maintaining proper isolation techniques and maintaining other standards that deal with patients and infections. Most hospital-acquired infections will probably not result in litigation unless there has been some breakdown in isolation or sterilization techniques unless such failure is the direct cause of the hospital acquired infection. The definition of standards of care can be as important as following established policies and procedures[76].

Drug Resistance of Bacteria in Hospitals

Current problems of resistance of bacteria to antimicrobial drugs become more understandable if one recalls some of the history of the development of antibacterial drug resistance. In Paul Ehrlich's laboratory *trypanosomes* became resistant to the drug *p*-rosaniline after repeated exposures. Similarly it was shown that *Pneumococci* could develop resistance to hydrocuprine derivatives following repeated exposure. In the mid 1940s, shortly after the introduction of *penicillin G*, it was recognized that certain strains of *Staphylococci elaborated a potent Beta* lactamase an enzymatic inactivation of penicillin and that penicillin *G* had no therapeutic activity in patients with infections caused by such *Staphylococci*. Major nosocomial pathogens either are naturally resistant to clinically useful antimicrobial drug or possess the ability to acquire resistance. Selective pressures favoring drug resistant bacteria conferred by antibiotic therapy may indeed be principally focused in the institutional setting but they extend widely into the community as well. The increasing prevalence of ampicillin resistant *Haemophilus influenzae*, the increasing frequency of *Beta*-lactamase producing gonococci, the widespread dissemination of MRSA and the emergence of penicillin-insensitive *Pneumococci* are recent examples[77].

2.2 Virulence of Antibiotic Resistant Bacteria

The occurrence of nosocomial infection due to multiply drug resistance organisms is governed by a number of factors including antibiotic selection pressure. The nature of the resistance determinant whether the plasmid is conjugative or nonconjugative or is a transposon and possible linkage with other antibiotic resistance and genetic determinants governing adhesion and pathogenicity.[77]

Evidence from a number of studies suggest that the proportion of bacteria resistant to a given antibiotic may increase as use of the drug increases or conversely may decrease if there is decreased use or cessation of use of the drug.[77]

The problem of resistance occurs in the community and hospital for both Gram positive and Gram-negative bacteria. For example, resistance at the community level has affected *Salmonella, Shigella, E.coli, N. gonorrhoeae, H. influenzae* and most recently *Strep. pneumoniae*. In hospitals resistance has appeared in a variety of Gram negative bacilli as well as in common skin flora such as coagulase negative *Staphylococci* and *Corynaebacteria*. Although the specific "problem bugs" vary from hospital to hospital and depend on the interaction of a number of factors to be described, there are some general correlations.[77]

Resistance Problems In The 1990s

Setting	**Bacteria**	**key resistance**
General hospitals and ICU	Enterobacteriaceae	New Cephalosporin and Aminoglycosides
	Pseudomonas aeruginosa	Aminoglycosides, Antiseudomonads Penicillin, newer Cephalosporin, Carbapenem, Quinolones.
	Acinetobacter	Aminoglycosides, multiple.
	Xanthomonas Multophilia	Multiple
	Staphylococcus aureus	Methicillin, quinolones, Multiple
	Strep. pneumoniae	Penicillin, multiple.
	Enterococci	Gentamicin, ampicillin, Vancomycin.[77]

2.3 Specific Hospital Factors that Influence the Pattern of Infection

The situation in a hospital differs from that in other types of institution in a number of ways. Most infections acquired in hospital are caused by microbes that are commonly present in the general population in whom they cause disease less often and usually in a milder form than in hospital patients. Four main factors influence the frequency and nature of infections.[75]

(A) Low resistance of patients to infection

Many hospital patients have decreased resistance to infection because of the pre-existing disease for which they were hospitalized, the medical or surgical treatment given them in hospital or their age. Natural resistance to infection is lower in infants and in elder people.

(a) General resistance to infection may be lowered by underlying disease (Diabetes) or drug treatment or irradiation.

(b) Natural defense mechanisms of the body surface may be bypassed by injury to skin or mucous membranes (surgery, use of indwelling catheters or tracheostomy tubes).

(B) Contact with infectious persons

Hospitals both accumulate and generate infectious persons. Hospitals are so organized that patients with a uniform type of increased susceptibility to infection tend to be concentrated in the same area. There are numerous opportunities for the spread of microbes from an infected patient to others by direct contact.

(C) Contaminated environmental sites

Certain objects and materials often become contaminated with microbes which may subsequently be transferred to susceptible body sites on patients.

(a) Gram positive cocci are found in air and dust and on surfaces. They may survive for a number of days in dry situations but do not multiply. Infection from them is in reality cross-infection.

(b) Gram positive spore-bearing anaerobes may be introduced into hospital from outside in air or on unsterilized objects; they may be released into the hospital environment from dried faeces or wound exudates.

(c) Gram negative aerobic bacilli are common in moist situations and in fluids, where they often survive for very long periods of time. Many of them have

the additional ability to multiply at these sites in the presence of minimal nutrients.

(D) Drug resistance of endemic microbes

A large proportion of hospital patients receive antimicrobial drugs, microorganisms in the normal body flora that are sensitive to the drug given tend to be suppressed and resistant strains are selected and become endemically established in the hospital population.[75]

(a) Removal of sensitive bacterial flora may reduce the colonization dose of potential pathogens by the oral or cutaneous routes and may prolong faecal excretion.

(b) If a patient becomes a carrier of a resistant pathogen he may become a source of infection for others; if he receives an antibiotic to which the organism is resistant uncontrolled growth of the organism may enhance infectivity for other patients.

(c) Multiplication of the organism at the carrier site may lead to illness either from the effects of locally produced toxin or if resistance to infection is low by favoring invasion of the tissues.[75]

In an excellent review, Mc Gowan has summarized seven types of evidence linking antimicrobial use in the hospital with antimicrobial resistance in hospital bacteria.[77]

(1) Antimicrobial resistance is more prevalent among bacteria causing infection in the nosocomial setting than among bacteria causing community acquired infection. Although exceptions exist they have been relatively few and most of the data support the generalization.

(2) In outbreak situations in the nosocomial setting, patients infected with resistant outbreak strains are more likely to have received previous antibiotic therapy than are patients colonized or infected with susceptible strains of the same species. This has been particularly illustrated in recent outbreaks of MRSA.

(3) Changes in antimicrobial use may lead to parallel changes in the prevalence of resistance to that antibiotic.

(4) Areas of most intense antibiotic use within the hospital generally also have had the highest prevalence of antibiotic resistant bacteria. There are also generally the areas of the

hospital in which the most highly susceptible patients are encountered and include ICU, burn units; oncology units and other special care units.

5) Increased duration of exposure to antibiotic in the hospital generally increases the likelihood of colonization of infection with resistant organisms. This factor may, however, also simply act as a market for more highly susceptible hosts.

(6) The higher the dose of antibiotic given, the greater the likelihood of super infection or colonization with resistant organisms.

(7) Finally, the motion of a cause-effect relation seems to fit the existing data in biologic terms. That is antibiotic therapy produces marked effects on the host's endogenous flora and exerts selective pressure in favor of resistant organisms. As emphasized by Mc. Gowan however, antibiotic therapy appears to act primarily by selecting a drug resistant causative organism rather than by increasing the frequency of nosocomial infection.

Drug resistance organisms- whether mutants, transductants containing plasmids or conjugants Containing R factors- selected by the pressure of antibiotic drugs are probably at a disadvantage however slight. In the absence of the selective pressure R determinants must represent an energy load for the host bacteria. If this were not so, wild bacteria in the community would likely be drug resistant or would at least be a mixture of sensitive and resistant cells. Although R factor containing bacteria acquired in the hospital persist for a time in the community free of selection pressure of antibiotics, they generally decay in the absence of the selective pressure.[77]

(E) Influence of antibiotic therapy on host microflora

Virtually all antibiotics in therapeutic doses produce marked changes in the microflora of the skin, upper respiratory tract, gastrointestinal tract and genital tract. Antibiotic resistant organisms, if present or acquired, are selected out and multiply freely to replace the susceptible organisms inhibited by antibiotic therapy. In the majority of patients, these changes in host microflora are of no demonstrable consequences. As is well recognized, however, the antibiotic resistant micro flora may on occasion result in serious or fatal infection. It is through this mechanism that antibiotic therapy appears to exert its major influence on nosocomial infection that is by determining the character rather than the frequency of nosocomial infection. In recent years, evidence has been presented suggesting that hospital food may frequently be contaminated by multiply drug resistant Gram negative

bacilli and that this may be an important source of nosocomial colonization in patients whose normal GIT flora is suppressed by antibiotic therapy.[77]

2.5 The Intensive Care Unit

An intensive care unit (ICU) is a specially staffed and equipped hospital ward dedicated to the management of patients with life threatening illness, injuries or complications. It is a specialty which evolved from the experience of respiratory and cardiac care, physiological organ support and coronary care units.[78] Critical illness implies failure of one or more vital organ systems.[78]

The care of critically ill patients in special high-technology units is a primary component of modern medicine. Invasive diagnostic and therapeutic procedures are essential for the diagnosis and treatment of critically ill patients. However, life support systems disrupt normal host defense mechanisms. Given the severity of the illness affecting patients in ICU, it is not supporting that mortality might exceed 25 percent. In addition, more than one third of the patients admitted to ICUs experience unexpected complications of medical care. Mortality in the group of patients with complications exceeds 40 percent. Nosocomial infection is one of the most frequent medical complications affecting patients in ICUs. Although ICUs make up only 5 percent of hospital beds and care of less than 10 percent of the hospitalized patients, infections acquired in these units account for more than 20 percent of nosocomial infections.[77]

2.6 Role of the ICU

In general, district and general hospital require ICUs that involve only monitoring and close observation. An ICU that uses complex management and requires investigative back up should be located in a large tertiary referral hospital of the region. Three levels of ICUs can thus classify.

(a) Level-1–district hospital

A level -1- ICU has a role in small district hospitals. It may also be called a high dependency unit, rather than an ICU. Such a unit allows for close nursing observation and electrocardiogram monitoring. Immediate resuscitation is possible but only short term (e.g. less than 24 hours) ventilation should be undertaken.

(b) Level -2- general hospital

A level -2- ICU is located in larger general hospitals. It is capable of undertaking more prolonged ventilation and has a resident doctor and excess to physiotherapy, pathology and radiological facilities at all times.

(c) Level-3-tertiary hospital

A level-3-ICU is located in a major tertiary referral hospital. It should provide all aspect of intensive care required by its referral role. The unit is staffed by specialist, intensivists with trainees, critical care nurses, allied health professionals and critical scientific staff.[78]

2.7 Nosocomial Infections

It is defined as infection which is acquired by patient while they are in hospital or by staffs who are working in the hospital.[79] There are several other important principles upon which nosocomial infection definitions are based. First, the information used to determine the presence and classification of infection should be a combination of clinical findings and results of laboratory and other tests. Second, a physician's or surgeon's diagnosis of infection derived from direct observation during a surgical operation, endoscopic examination or other diagnostic studies or from clinical judgment in an acceptable criterion for an infection unless there is compelling evidence to the contrary.[80]

Nosocomial infections may involve not only patients but also anyone else who has contact with a hospital including members of staff, volunteers, visitors, workers, salespersons and delivery personnel. The majority of nosocomial infections become clinically apparent while the patients are still hospitalized; however, the onset of disease can occur after a patient has been discharged. As many as 25 percent of post operative wound infections for example, become symptomatic after the patient has been discharged. In these cases, the patient become colonized or infected while in the hospital but the incubation was longer than the patient's hospital stay. This sequence is also seen in some infections of newborns and in most breast abscesses of new mothers. Hepatitis B is an example of a nosocomial disease with a long incubation period; its clinical onset usually occurs long after the patient is discharged from the hospital.[77]

Infections incubating at the time of the patient's admission to the hospital are not nosocomial; they are community acquired unless of course they result from a previous hospitalization. However, community acquired infections can serve as a ready source of infection for other patients or personnel. Approximately 30 percent of all reported nosocomial infections are preventable. Epidemics, especially common-vehicle epidemics are potentially preventable,

however, epidemics account for only a small number of the nosocomial infections that occur. Endemic infections account for the majority of nosocomial infections.[77]

The most common sites of endemic nosocomial infections are the urinary tract especially those associated with indwelling bladder catheters, lower respiratory tract and incisional surgical wound infections. The epidemic may be due to a common source, breakdowns in routine techniques, emergence of especially virulent or antibiotic resistant organisms, clustering of very susceptible hosts or to a combination of these factors.[76]

Bacteremia represents the most extreme from of nosocomial infection. The risk of acquiring an endemic nosocomial bacteremia is two to four times higher in elderly patients (>60 years of age).[76]

RISK FACTORS FOR NOSOCOMIAL BACTEREMIA

Host Factors	Therapeutic Factors
(1) New born	(1) Confinement in an ICU or newborn nursery.
(2) Advanced age (>60 years of age)	(2) Systemic antimicrobial therapy
(3) Multiple trauma or burn	(3) Invasive vascular device (especially an arterial pressure monitoring system).
(4) Fatal underlying disease	(4) Receipt of large volumes of parenteral fluid or blood products
(5) Granulocytopenia	(5) Haemodialysis
(6) Corticosteroid or other Immunosuppressive therapy.	(6) Nonvascular invasive device.[76]

Nosocomial infections may significantly increase the duration of hospitalization and costs for many patients and may result in permanent disability or death. The risk of acquiring nosocomial infections can be viewed in terms of a formula which lists the basic factors involved:

$$\text{Risk of infection} = \frac{\text{Dose x Virulence}}{\text{Host resistance}}$$ [76]

Nosocomial infections are not a new or recent entity. They existed as long as hospitals have existed. Florence nightingale's nursing reforms were largely aimed at proper management and prevention of nosocomial infection. Semmelweis introduced the use of antiseptic hand washing techniques and reduced nosocomial puerperal fever deaths of his hospital from over

9 to 3.6 % of maternity patients. Control of nosocomial infections is a very complex issue. There are no available effective established methods of prevention for all types of nosocomial infections.[76]

Nosocomial infection in a population of patients is quantitated by the rate of infection, usually expressed as the number of cases per 100 individuals at risk nosocomial bacteremias because they often occur at a lower frequency are usually expressed as cases per 1000 (or 10 000) hospitalized patients.[76]

2.8 Historical Aspects

Nosocomial infections have been existing as long as there have been hospitals. But attention was not paid until the middle of the nineteenth century. During that time, Florence nightingale improved hospital design and higher standards of nursing care. Almost any microbe can cause a hospital acquired infection (although protozoal infections are rare). The pattern of hospital infection has changed over the years, reflecting advances in medicine and the development of antimicrobial agents. In the pre antibiotic era the majority of infections were caused by Gram positive organisms, particularly S*trepcoccus pyogenes* and S*taphylococcus aureus.* With the advent of penicillin and other antibiotics active against *staphylococci,* Gram negative organisms such as *Escherichia coli* and P*seudomonas aeruginosa* emerged as important pathogens. More recently, the development of more potent and broad spectrum antimicrobial and the increases in invasive medical techniques has been accompanied by an increase in the incidence of antibiotic resistant Gram positive organisms such as *Staph. epidermidis, Enterococci* and Methicillin resistant *staph. aureus* (MRSA) and *Candida.* Currently *Escherichia coli* accounts overall for more hospital infection than any other single species. Viral infections probably account for more hospital acquired infections than previously realized.[81]

2.9 Factors affecting Hospital Acquired Infection

The dynamics of ICU- acquired infections are complex and depend on the contribution of the host‘s underlying conditions, the infectious agents, and the unique environment of the ICU.[82] Although infections could not occur in the absence of the offending microorganisms, host factors exert the major role in determining not only the occurrence of infection and disease but also the outcome of such disease.[76]

Host defenses

Natural host defense mechanisms might be impaired by underlying diseases or as a result of medical and surgical interventions. All patients admitted to hospital will have at least one and often multiple, vascular cannulas that break the normal skin barriers and establish direct access between the external environment and the blood stream. Natural chemical barriers in the stomach are neutralized by administering H_2 blockers or antacids that reduce acidity and allow growth of enteric flora. Physiologic mechanisms for evacuating and cleansing hollow organs are disrupted and circumvented by insertion of endotracheal tubes, nasogastric tubes and urinary catheters. Specific host defense mechanisms also might be impaired by the underlying diseases because of the precarious condition of the patient in the hospital, normal food intake is often suspended. The prevalence of malnutrition / under nutrition is high. Moreover, conditions present in patients might increase the level of malnutrition by increasing metabolic demands. Injured tissue, perfusion deficits and infection cause fever and tachycardia through mechanisms mediated by hormones, cytokines and bacterial products, such as endotoxin. The physiologic response to these mediators is an increase in the O_2 consumption secondary to an increase in metabolic demand. Under nutrition has been associated with increased length of stay, surgical complications and delayed wound healing. Malnutrition suppresses the cellular immune response and impairs delayed hypersensitivity reactions. Several studies suggests that poor nutritional status is a predisposing factor for nosocomial infections such as pneumonia, urinary tract infections, postoperative wound infections and bacteremia. In a study by Schimpff and colleagues, 48 percent of patients with severe trauma developed nosocomial infections in contrast to only 3 percent of those with minor injuries whose length of stay in the hospital was equal to that of the patients with major injuries.[77]

Medical devices

The objectives of intensive care include concurrent monitoring of vital functions and physiologic support of failing organ systems. The technology necessary to achieve these objectives frequently requires introduction of foreign materials into body orifices or insertion of cannulas percutaneously often directly into the circulatory system. In addition to breaking the normal tissue barriers, the invasive devices tend to enhance colonization with nosocomial pathogens.[14]

Intravenous catheters serve a useful purpose for administering fluids and drugs but they are also a frequent source of hospital associated sepsis. After catheters are in longer than 48 hours, they become colonized and ultimately may cause a serious clinical infection.[76]

Medical therapy

Medical therapy while administered for its beneficial effects, it is often accompanied by adverse effects on host defense.[77]

Underlying diseases

Numerous studies observed increasing rates of infections among patients with more severe illnesses. Pre-existing host conditions are important in the development of nosocomial infections.[77]

Infectious agents

Although patients are susceptible to pathogens causing community-acquired infections, nosocomial infections are usually associated with microbes found in the hosts endogenous flora in the hospital. The risk of infection depends on multiple factors involving both intrinsic properties of the nosocomial pathogens and the status of the host immune system. Nosocomial pathogens exhibit various properties that allow them to survive in the hospital environment or within the host.[77]

Adaptability

Pathogens that are common causes of infections such as *Acinetobacter*, *Pseudomonas aeruginosa* and *Legionella pneumophilia* are able to adapt to a variety of environmental extremes. For examples, *L. pneumophilia* can survive in water at temperatures between 5^0 and 45^0c. Pseudomonas has minimal nutritional requirements and can survive in distilled water. This adaptability allows the organism to establish reservoirs in the hospital environment.[77]

Adherence

Adherence to host tissue is the first step in establishing infection. *Escherichia coli*, *Proteus mirabilis* and other Gram-negative bacteria contain fimbriae that enable organisms to attach to selected sites in host tissues. *Staphylococci* adhere to foreign material such as intravascular cannulas, prosthetic valves and joints through a specific receptor mediated process.[77]

Colonial protection

After attachment some bacteria including *Ps. aeruginosa* and *Staphylococcus epidermidis*, produce an amorphous substance or biofilm that protects the bacteria from host defenses. Mucoid appearing colonies of *Ps. aeruginosa* have been isolated from patients with cystic fibrosis.[77]

Toxin production

Exotoxins and endotoxin produced by the organisms might be important in the pathogenesis of nosocomial infections.[77]

Antimicrobial resistance

In ICUs where antibiotics are used more frequently and greater quantity than in almost any other unit in the hospital, antimicrobial resistance ensures survival of some nosocomial pathogens. Moreover the close proximity of patients facilitates transfer of resistant organisms from patient to patient. Antibiotic select resistant organisms and can predispose to the development of hospital acquired infections (HAI). Organisms such as *klebsiella* species are an important source of transferable antibiotic resistance and outbreaks of HAI involving multi drug resistant Enterobacteriaceae have been reported. The resistance was plasmid mediated and emerged in association with an increase in the use of cephalosporins and amikacin. The most significant factors were length of hospitalization, number and duration of antibiotics received and admission to ICUs. Colonization was associated with longer stays in hospital. The number of colonized patients decreased after the antibiotic policy was changed.[77]

Source of colonization

Exogenous infections are those in which the pathogenic microbe is acquired directly from the external environment. Primary endogenous infections are those in which the organism is part of the patient's normal flora. Secondary endogenous infections are those that result from modification of the patient's normal flora or from colonization with hospital flora whereas modern infection control measures have significantly reduced the frequency of exogenous infections. In both types of endogenous infection, host colonization is an important initial step in the subsequent development of HAI. Almost 50 percent of the ICU-acquired infections are preceded by host colonization with the same micro-organism. Kerver and colleagues showed that the oropharyngeal cavity and lower respiratory tract of 60 percent of patients on mechanical ventilation were colonized by ICU-acquired organisms after 5 days in the ICU. After 10 days, 100 percent of the patients were colonized.[5] Nosocomial respiratory

tract infections occurred in 23% of colonized patients but in only 3.3% of non-colonized patients.[76]

2.10 Etiology of Hospital Acquired Infection

A complication of micro-organisms which have produced disease in the hospital setting is extremely long. The organisms are likely to be ubiquitous in distribution either being common within the environment or belonging to the indigenous microflora of the host. The organisms are likely to be resistant to commonly employed antimicrobial agents. Today numbers of four families of aerobic Gram negative bacilli as well as a large miscellaneous group (Enterobacteriaceae, *Aeromonas, Pseudomonas, Comamonas* and the miscellaneous organisms *Acinetobacter*, *Eikenella*, *Achromobacter*, *Flavobacterium* and *Moraxella*) have all been incriminated as potential human pathogens. These bacteria owe much to their antibiotic multi resistance and the selective effect of indiscriminate antibiotic treatment is often to blame for giving them a chance. However the main cause lies with the host.[76] Microbes responsible for nosocomial infection are classified broadly into the following categories:[75]

A. "Conventional" pathogens that cause disease in healthy persons in the absence of specific immunity to them.

B. "Conditional" pathogens that cause disease only in persons with reduced resistance to infection (including newborn infants).

C. "Opportunist" pathogens that cause generalized disease but only in patients with profoundly diminished resistance to infection.

Conventional pathogens are often responsible for institutional outbreaks, conditional pathogens are responsible for the bulk of the infectious and opportunist pathogens cause disease almost exclusively in patients with severe underlying disease.[75]

Class of micro-organisms incriminated in endemic or epidemic nosocomial infections.[76]

Class of agent	**Specific organism**
Viruses	*Herpes virus, Cytomegalo virus,Epstein-Barr virus,*HIV-type-1.
	Myxo virus ---Influenza virus, parainfluenza virus,
	Respiratory syncytial virus, Rubella.
	Varicella-zoster, Hepatitis B, Rubella.
Chlamydia	*Chlamydia trachomatis.*
Bacteria	Gram positive cocci

	Strep. pyogenes, Strep. pneumoniae, Staph. aureus.
	Gram positive bacilli
	Clostridia
	Gram negative bacilli
	Virtually all aerobes and anaerobes, including
	Legionella Pneumophilia
	Mycobacteria
	Mycobacterium tuberculosis, Mycobacterium fortuitum complex.
Fungi	*Nocardia.*
Protozoa	*Toxoplasma gondii, Pneumocystic carini.*[76]

The prevalence of nosocomial infection in the intensive care units in Europe was frequently caused by Enterobacteriaceae (34.4%), *Staph. aureus* (30.1%), *Pseudomonas aeruginosa* (28.7%) and coagulase negative *Staphylococcus* (19.1%).[83]

Percentage of distribution of nosocomial pathogens for surgical site infection (NNIS), 1986-1989 and 1990-1992.

Pathogen	1986-1989	1990-1992
	N=16727	N=11724
Esch. Coli	10	08
Enterococci	13	12
Ps. aeruginosa	08	08
Staph. aureus	17	19
Coagulase negative *Staph.*	12	14
Enterobacter spp.	08	07
Klebsiella pneumoniae	03	03
Proteus mirabilis	04	03
Streptococcal spp.	03	03

The frequency of individual pathogens causing nosocomial UTI has changed markedly in the last 2 decades. The most important factor influencing the distribution of infecting species in the hospital was the use of anti microbial agents. The organisms usually responsible for catheter associated UTI were Gram negative organisms derived from the faecal flora.[84] Although the burn wound may be contaminated at the time of thermal injury, the overwhelming majority of infections in burn patients occur several days after admission and

are therefore hospital acquired by definition. Although organism growing on the burn wound surface may not cause serious infection, they provide a large reservoir for contamination and infection of other body sites or other patients.[76]

Bacteria and fungi isolated from burn wound infections

1. *Staphylococcus aureus*	9. *Enterobacter cloacae*
2. *Pseudomonas aeruginosa*	10. *Proteus mirabilis*
3. *Pseudomonas spp.*	11. *Enterobacter spp.*
4. *Escherichia coli*	12. *klebsiella sp.*
5. *Streptococcus* Group D	13. *Staphylococcus epidermidis*
6. *Streptococcus faecalis*	14. *Streptococcus* Group A
7. *Klebsiella pneumoniae*	15. *E. aerugenes*
8. *Serratia marcescens*	16. *Candida albicans.*[76]

The most frequently encountered pathogen among non-hospitalized diabetic wound was *Staph. aureus* (42%). For the hospitalized diabetic group the frequency of *Staph. aureus* isolation was (13.6%) and ranked 4th position. Other pathogen in order of frequency of isolation were *Pseudomonas* sp. (20.4%), *Esch. coli* (15.9%), *Proteus* sp. (15.7%), *Klebsiella* sp. (7.9%) and *Streptococcus* sp. (7.9%).[85]

Most frequently isolated pathogens in nosocomial lower respiratory tract infections:[77]

1. *Staph. aureus*	6. *Proteus spp.*
2. *P.aeruginosa*	7. *Serratia spp.*
3. *Esch. Coli*	8. *Candida spp.*
4. *Klebsiella spp.*	9. *All others.*
5. *Enterobacter spp.*	

2.11 Sources of Hospital Acquired Infections

The source of infection may be human, i.e. other patients or hospital staff (and occasionally visitors), or environmental from contaminated objects (fomites), food, water or air. The source may become contaminated from an environmental reservoir of organisms e.g. contaminated antiseptic solution distributed for use into sterile containers. Human sources may be people who are incubating an infection, or they may be healthy carriers.[81]

Organisms that cause nosocomial infections come from either endogenous (autogenous) or exogenous sources. Endogenous infections are caused by the patient's own flora; exogenous

infections result from transmission of organisms from a source other than the patient. Either endogenous organism are brought into the hospital by a patient (this represents colonization outside the hospital) or the patient becomes colonized after being admitted to the hospital. In either instance, the organisms colonized the patient may subsequently cause a hospital acquired infection.[82]

Kinds of lab accidents resulting in infection [81]

1. Spill or spatter
2. Needle stick
3. Broken glass injury
4. Bite or scratch
5. Mouth pipetting

Many of the causative organisms not only are ubiquitous but are psychrophilic or cryophilic. Refrigerators, ice machines, faucets aerators and sink drains in intensive care units may be the source of pseudomonas. Hospital associated infections do not necessarily represent breaks in technique on the part of hospital personnel.[76]

2.12 Mode of Transmission of Hospital Acquired Infection

The hospital offers many opportunities for the exchange of microbes.[82] The important routes of spread of infection in hospitals are those common to all infections: air born, contact and common vehicle. The same organism may be spread by more than one route.[81]

Common routes of transmission for different micro-organisms are the followings:

Airborne transmission

Infection may be spread by air-borne transmission from the respiratory tract (talking, coughing, sneezing) from the skin by natural shedding of skin scales, during wound dressing or bed making and by aerosols from equipment such as respiratory apparatus and air conditioning plants. Infectious agents may be dispersed as small particles or droplets over long distances.[82] Letts et al. (1983) state that micro-organisms become airborne as a result of shedding from hair or exposed skin.[86] Douglas et al. stated that airborne bacteria were potential source of contamination and infection of surgical wounds in operation theatre.[87]

Contact spread

The most common routs of transmission for hospital infection are by direct contact spread from person to person or by indirect contact spread via contaminated hands or equipment. Faeces, urine or pus as well as contaminated dust particles or fluids may be carried on

thermometers, bed pans, bed-linen, cutlery or other shared items. Hands and to a lesser extent, clothing of hospital staff serve as vectors of Gram-negative and Gram positive infection around a busy theatre or ward. Procedures involving contact with mucosal surfaces, e.g. insertion of a urinary catheter may introduce micro-organisms from the contaminated hands of the operator or from the patient's own urethral flora into the normally sterile bladder. Similarly, intravenous fluids and topical medicaments have direct contact with vulnerable sites for infection. Food-borne infection may occur from any food source available in the hospital. Accidental transmission of predominantly blood-borne infections such as hepatitis B by needle stick or contaminated sharp injury.[82]

Common vehicle spread

In common vehicle spread infection, a contaminated inanimate vehicle serves as the vector for transmission of the agent to multiple persons. The victims become infected after contact with the common vehicle. Common vehicles include food (salmonellosis, Hepatitis A) blood and blood products (Hepatitis B and HIV), intravenous fluids (Gram negative septicaemia) and drugs (Salmonellosis) in which units or batches of a product become contaminated from a common source and serve as a common vehicle for multiple infections.[81] Contaminated solutions had been the source for surgical site infections caused by *Pseudomonas aeruginosa*, *Pseudomonas multivorans* and S*erratia marcescens.*[88]

Self-infection and cross infection

Self infection may occur due to transfer into the wound of *Staphylococci* carried by the patient in his nose and distributed over his skin or of coliform bacilli and anaerobes released from his bowel during surgery.[82] Ahmed (1982) stated that almost all the infections of UTI were auto infection from the gut. It was stated that *Esch.coli* of the gut might colonize at the pre urethral area from where ascending infection started. Due to indiscriminate use of ampicillin the gut *Esch. coli* might be a resistant type of beta lactamase producers or R-plasmid type which gave a high percentage of resistance.[89] Alternatively, cross-infection may result from *Staphylococci* or coliform bacilli derived from other patients or healthy staff carriers: the organisms may be transferred into the wound during operation through the surgeon punctured gloves or moistened gown on imperfectly sterilized surgical instruments and materials or by air-borne theatre dust; or postoperativly in the ward from contaminated bed-linen by air-borne ward dust or in consequence of a faulty wound dressing technique.[82] Bacteriophage typing of the isolates showed that auto infection was responsible for 81% while cross infection from patient to patient was found in 19%.

Transfer from staff to patient was not demonstrated.[76]

2.13 Relative Frequencies of Major Hospital Acquired Infections

The infections most commonly acquired in hospital are surgical wound infections, infections of the urinary and respiratory tracts and bacteremia. The relative frequencies of different kinds of hospital infection vary for different patient groups but overall urinary tract infections (UTI) are the most common hospital-acquired infections.

The relative frequencies of different kinds of nosocomial infection vary for different patient groups but overall UTI are the most common nosocomial infections.

Other infection which may cause outbreaks in the hospital setting include gastroenteritis and hepatitis.[81] Certain hospital areas appear to experience an increased incidence of hospital acquired pneumonia over 7% in a newborn ICU, over 10% in a general medical ICU and more than 20% in a respiratory ICU. Hemming et al. reported an increased duration of hospitalization of more than 5 weeks in infants in a newborn ICU who developed a nosocomial infection at any site. Since hospital acquired pneumonia occurs more than three times as frequently as bacteremia. Pneumonia is the leading cause of death among hospital acquired infections[76].

2.14 Socioeconomic Impact

The hospital in reality plays a vital role in maintaining and restoring the health of all members of the community. Hospital is a place to reduce the suffering of the patients to make the patients healthy and comfortable. Patients are supposed to consider it as a place where once they can land are sure of getting relieved of all of their health related sufferings. But at times hospital itself increases the sufferings of some of the patients by superimpose infection, patients get this infection while in hospital with some other health related states or events. This infection increases the morbidity and mortality in hospitalized patients causing increases in the cost of hospital care. This nosocomial infection is a health problem for the community resulting a public health problem in the developed and developing countries as well. The impact of nosocomial infection at personal and economical level needs evaluation. Personal incapacitation, prolonged illness causing increased length of emotional stress and agony, even death may be the consequences of nosocomial infection. Prolonged hospitalization of infected patients results in decrease availability of hospital facilities for other patients and has a significant impact upon hospital practices. This prolonged hospitalization sometimes develops negative attitude to others in taking of hospital service. Financial cost to the patient

as a result of nosocomial infection is considerable. It also increases pressure on hospital activities in respect of man, material and resource point of view and deprives other sick persons to avail the hospital facilities. Because of morbidity it hampers personal income causing increase of sufferings to the family and ultimately at national level.[90] The mean post operative hospital stay in case of patients (of Dhaka city) with hospital acquired infection was 25 days which was 3 times than that of the causes without infection (8.6days). This result in unnecessary monetary loss and bed occupancy.[91] Nosocomial cost was about 40 million US dollars in a year in Thailand. In comparison to this a full preventive program required one million US dollars in Thailand.[92] Patients with nosocomial infection spent on an average 22 extra days in the hospital. The cost of these days would present the huge amount of 2.5 million. US dollars in a year for Ottawa general hospital alone whose entire annual budget was only about 14 million US dollar.[10] Postoperative wound infection delayed patients discharge by an average of 7.7 days and it would represent 800000 US dollars per annum for a 600 beds hospital.[93] The mean extra cost per infected case was 10,440 US dollars and extra days of hospital staying was 5.2 days in case of neonates acquiring nosocomial infection.[94] Approximately 2 million nosocomial infections annually in the United states. These infections resulted in substantial morbidity, mortality and cost. This excess duration of hospitalization secondary to nosocomial infections was 7 to 8.2 days for surgical site infections 7 to 21 days for blood stream infections, 6.8 to 30 days for pneumonia. The estimated mortality associated with nosocomial blood stream infection and pneumonia were 23.8% to 50% and 4.8% to 71% respectively. The estimated average cost of these infections was $ 2734 for each surgical site infection. US $ 3061 to 4000 for each blood stream infection and US $ 4947 for each Pneumoniae. In countries with prospective payment system based on diagnosis related groups hospitals loss from US $ 4886 for each nosocomial infection.[95] “Hospital costs and mortality attributed to nosocomial bacteremia” this study was carried out from January 1st 1972 to December 31st 1974 on 435 admitted patients at the John Hopkins Hospital was case control study on mortality and hospital costs contributed to HAI. This study gave an opportunity to know the awesome effect of nosocomial infection that this mortality was 14 times greater in patients with such infection had an average hospitalization period that was 14 days longer than the average stay for member of control group.[96]

Cost of extra days can be calculated by using formula:

$$\text{The cost of extra days} = \frac{\text{Total patients}}{100} \times \%\text{ of nosocomial infection} \times \text{extra days} \times \text{cost/bed/day}$$

About hospital direct cost, the study showed an average excess of approximately $ 3,600 for patients who had nosocomial infection.[96]

2.17 Mechanisms of Antimicrobial Resistance in Microorganisms

Inactivation of antimicrobial agents

B-lactamases

Chloramphenicol acetyltransferases

Aminoglycoside modifying enzymes

Decreased drug accumulation (membrane impermeability antimicrobial efflux)

Intrinsic resistance

Acquired resistance: - chromosomally mediated

- Plasmid mediated

Alteration in target site

Penicillin binding proteins

DNA gyrase

RNA polymerase

Ribosome

Metabolic bypass

Altered dihydrofolate reductases

Altered dihydropteroate synthetases

Overproduction of target enzyme inhibited by antimicrobial agents

Gene amplification

Mutation in regulatory gene

Auxotrophic change

Thymine auxotrophy

Genetic basis of resistance of microorganisms to antimicrobial agents

Microbial resistance to antimicrobial agents is a matter of great importance if sensitive strains are supplanted by resistance ones, then the valuable drugs become useless. Resistance to antimicrobials may be an acquired property or an intrinsic naturally occurring trail that is a characteristic of a species.

Acquired resistance may developed either from changes or mutation to genomic DNA or by acquisition of antimicrobial resistance genes through mobile genetic elements (plasmids, bacteriophages, intregrons and transposons) by gene transfer mechanisms such as conjugation transformation, transduction, site specific integration or conjugative transposition. After each

new antimicrobial agent becomes widely used, antimicrobial resistance gene eventually emerge and spread throughout the world's bacterial population. Antimicrobial agent emerge either mobilized through obscure strains or by evolving from obscure ancestral gene.[97] About one hundred resistance genes have been recognized to date. Each encodes a protein that either inactivate antimicrobial agents or prevents them from blocking their target function or provides a new function to substitute for the function blocked by the agents. Resistance genes may be situated on chromosomes, plasmids, integrons or on transposons. A resistant gene may emerge and spread through a sequence of events: mutation to enhance, transposition to a plasmid, recombination with other plasmids, linkage with other resistance genes, transfer of plasmid to new strains and migration of resistant strains from one host to colonized or infect others. Continuous use of the antimicrobial agents amplifies the resistant bacterial population and tends to distribute the resistant agent in progressively larger population of bacteria. DNA hybridization and polymerase chain reaction are two major techniques, which can be used to detect antimicrobial resistant genes.

Plasmid and antimicrobial resistance

A plasmid is a naturally occurring autonomous, extra chromosomal, circular duplex and self –replicating DNA molecule. It ranges in size from 1kb. to greater than 400 kb. and is extremely common in bacteria and even present in eukaryotes. The number of plasmids per chromosome is 1 to 20. Single copy plasmids maintain parity with chromosome but multi copy plasmids exist in a characteristic number of 10-20 per bacteria cell. Copy number is the result of an existing replication control mechanism in the bacteria. Plasmids that share the same replication control system tend to as incompatible. Thus, incompatibility groups of plasmids have been defined which can be used for epidemiological investigations. Recently plasmid replication typing has been developed to classify plasmid.[98] Plasmids can exists either in an autonomous, extra chromosomal state or they can be inserted into bacterial chromosome and can be carried as a part of it and called an episome. A plasmid is a major class of mobile genetic elements. The mobile conjugation plasmid has the necessary genes known as tra genes, required for the conjugation process, which is a natural and probably most important genes transfer mechanism. The plasmid may transfer themselves into different species and even into different genera. A conjugative plasmid can mobilize a non-conjugative plasmid which they are present in the same host. Plasmid may have a co-valantly closed circular (CCC), open circular or linear from of DNA. Plasmid DNA usually encodes no essential but rather acts as a dispensible accessory source of DNA that provides many unique functions to bacteria without overloading the main genome. They carry genes for the

inactivation of antibiotics, the production of toxin, the break down of natural products and invasion genes. Some plasmids have no known phenotyping function and are known as cryptic plasmids. Plasmids mediated resistance occurs much more frequently than chromosomal resistance in clinically important bacteria. It is responsible for most of the resistance phenomena and in association with transposon greatly increases the rapid spread of resistance factors or genes. The first R-factor or R-plasmid was detected in Japan in *S. dysentery* type-1 in mid 1950s. Plasmid and chromosomes can themselves exchange genes by general recombination or by transposition thus increasing the spread of resistant genes even in the single bacterial cell. Plasmids are involved in the dissemination of antibiotic resistance in many ways. A single clone of a specific bacterium may spread antibiotic resistance by clonal spread or by plasmid transfer or by plasmid and transposon spread or by mobilization of resistance genes from plasmid to chromosome or vice versa. Resistant plasmids may contain any number of individual resistant genes and in recent years "Super" plasmid encoding resistance to 8 or more antimicrobials have been reported.

Chromosome and antimicrobial resistance

Chromosomal resistance is the result of mutation in the genome. It may occur spontaneously or by selective pressure of antibiotics on the organisms resulting in clonal spread of resistance with suppression of susceptible organism. A chromosomal resistant gene may transfer to a plasmid by transposition. It is a less frequent cause of emergence of clinical significant drug resistance in a given patient because of low frequency of mutation (10^{-7} to 10^{-12}). Chromosomal mutants are resistant in most of the cases by virtue of changes in the drug receptors or target.

Transposon and antimicrobial resistance

A transposon is a small mobile genetic element of specific DNA sequence which is able to transpose itself between unrelated DNA sequences. It is not self-replicating and therefore, must exists on a chromosome, plasmid or bacteriophage. Transposon often known as jumping genes can move between plasmids. Between chromosome and plasmid as well as to and from a phage. The simplest transposon is an insertion sequence (IS) typically about 1kb long and consists of a gene for a transposase bounded by inverted terminal repeats. Many antimicrobial resistant genes reside within transposons and it is probably this fact that explains the evolution of R plasmids from ones with few resistance genes to ones with many. Some transposons contain many antibiotic resistant genes i.e. Tn 2571. Transposition is a continuous an ongoing process in bacterial populations. Recently, a new class of transposons

has been described that has the capability to move from the chromosome of one bacterium to another without being part of a plasmid or bacteriophage. These are known as "conjugative" transposons and have been detected in aerobic and anaerobic Gram-positive bacteria.[99]

Integrons and antimicrobial resistance

Recently, a family of potentially mobile DNA elements called integrons has been described within some bacterial chromosomes. Integrons consists of two conserved DNA segments separated by various acquired antibiotic resistant gene cassettes. The whole integron is flanked by a short (25 base pairs) imperfect inverted repeat base pair. [100]

The integrons does not encode the proteins necessary for transposition. The site specific integration function (the insertion site and integrase production) is performed by the conserved DNA segment. A majority of the integrons appear to depend on host genome for their movement. Independent transposition of integron Tn 402 has been observed. The integron probably acts as an expression cassette by supplying the promoter for the inserted genes. The presence of a specific site for integration on the integron will favour tandem integration of antimicrobial resistant genes resulting in a multiple resistant integron. Integrons have been shown to encode trimethoprim resistant dihydrofolate reductase and sulfonamide resistant dihydrofolate synthetases.[101]

2.18 Infection Control Program

The primary role of an infection control program is to reduce the risk of hospital-acquired infection thereby serving to protect patients, employees and visitors. In the current era of health care reform and associated focus on cost control, the value of effective infection control is obvious.[15]

Although effective infection control programs reduce the incidence of nosocomial infections, these infections continue to be a problem even in hospital with very effective program. Some HAIs are unavoidable using techniques now available but many can be prevented and a hospital infection control program should be designed to identify preventable infection, determine why they occur and reduce the probability of their occurrence.[77]

2.19 Situation in Europe

Spencer RC (1994)

This study reported the result of European prevalence of infection in ICU in Western Europe which was conducted on a cohort of 10,038 patients admitted to 1417 adults ICUs from 17

countries. The study revealed overall 21% of ICU patients developed a minimum of one HAI. Pneumoniae was the most frequent infection (47%) followed by LRTI (18%), UTI (18%) and BSI (12%)[102].

Plowman et al (2000)

Conducted in district general hospital of UK where 4000 patients with hospital stay of over 30 hours from medical, surgical, orthopedic, urology, gynecology, ENT, elderly care and obstetric were recruited. The study result revealed that 7.8% of patients had one or more HAIs of whom 13% of patients developed infections died compared with 2% who died not acquire infection in hospital. The overall death rate was 7.1 times higher for infected than uninfected patient. The mean length of study was eight days for uninfected compare to infected patients having longer hospital stay (Figure 2.1)[103].

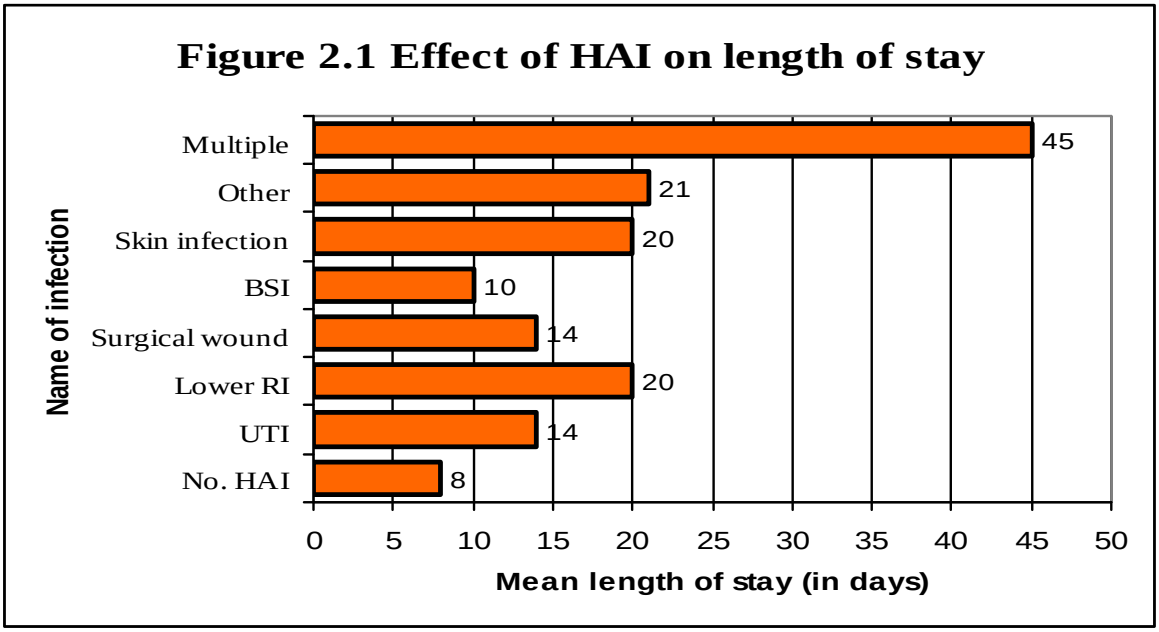


Figure 2.1 Effect of hospital-acquired infection on length of stay (in days)

The mean cost of treatment was 1628 pound for uninfected patients which were considerably greater for those with infections of any type (Figure 2.2)[103].

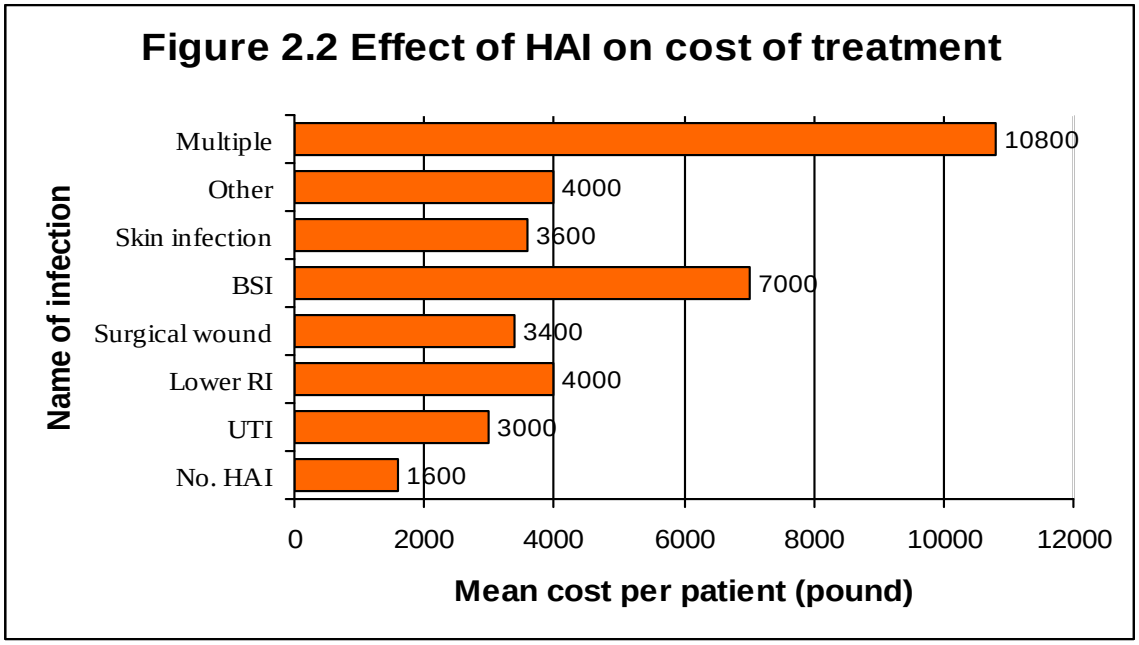


Figure 2.2 Effect of hospital-acquired infection on cost of treatment

The study concluded that the yearly economic burden of HAIs was one billion pound for the NHS and affect one in ten patients. The total number of bed days consumed by the HAI was estimated at about 3.6 million a year or equivalent to about 27400 bed hospitals working at 90% capacity. The study was enumerated the costs and consequences of HAI as shown by a table bellow. (Table 2.1)[103].

Table 2.1 Costs and consequences of hospital-acquired infection (HAI)

Variables	No HAI	HAI	HAI effect
Mean costs (pound)	1628	4782	3154
Mean stay (in days)	8	22	14
Deaths (%)	2	13	11
Mean admission work (in days)	23	29	6

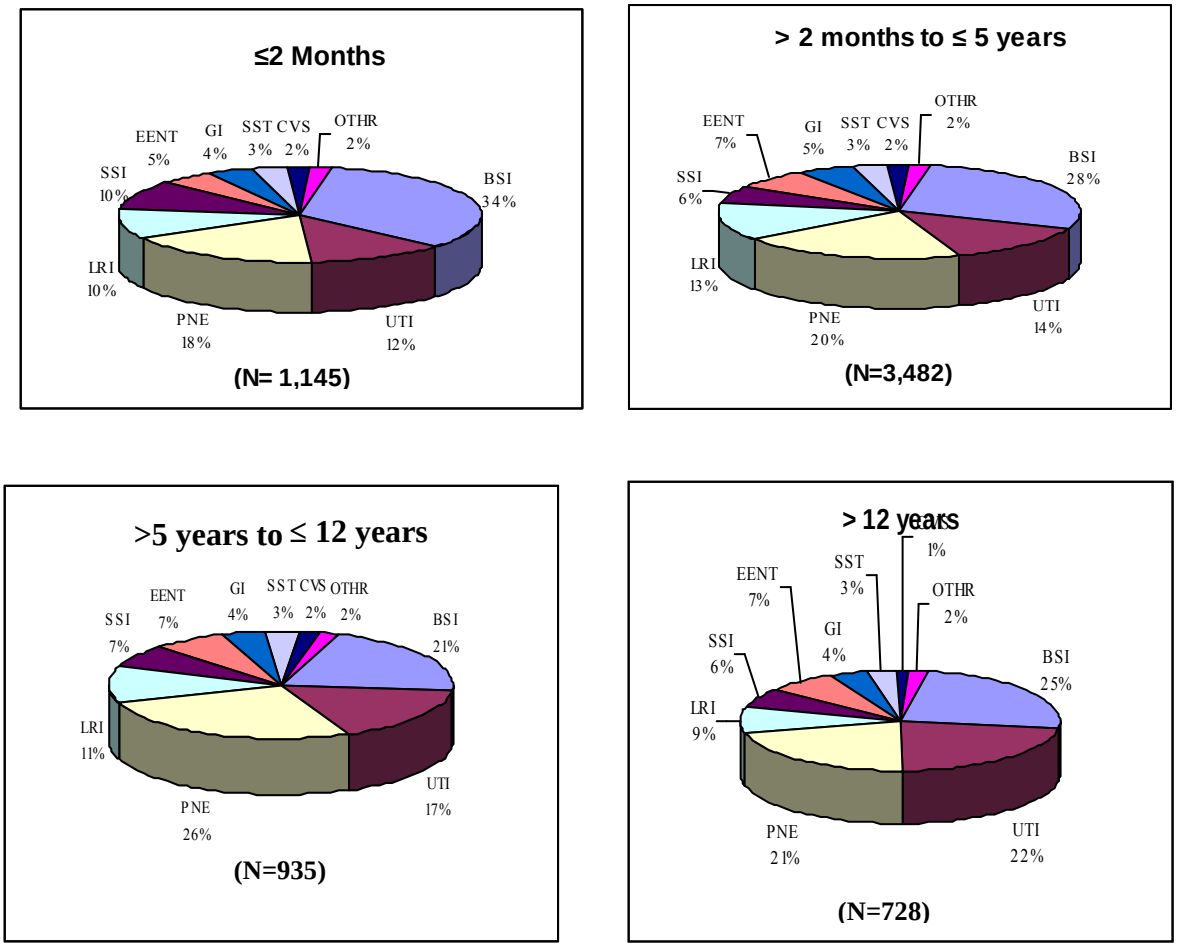
The study estimated that 5000 patients die each year in the United Kingdom. The study result suggested that hand washing could reduce the infection by about half[103].

Richards J. Michael et al (1999)

This study conducted on NIs in Pediatric Intensive care units (PICU) in the USA with the aim of the epidemiology of NIs in PICU. The PICU was defined as a unit in which > 80% of patients were the age of 18 but was no dedicated to the care of neonatal infants. Data were collected prospectively between January1992 and December from 61 pediatric ICUs in the

US using the standard surveillance protocols and nosocomial site definitions of the National Nosocomial Infections Surveillance System's ICU surveillance component. All patients in the ICU were monitored for nosocomial infection at all body sites for a period of at least one calendar month. The study showed that data on 110709 patients with 6290 NIs were analyzed. Among the 6290 infections, primary BSIs (28%), pneumoniae (21%) and UTI (15%) were most frequent and were almost associated with the use of invasive device. In comparison to older children, primary BSI and surgical site infections were reported more frequently in infants having the age 2 months or less. The distribution of NIs by age showed 1145 (18%) infections in children aged 2 months or less, 2433 (39%) in children> 2 months but <1 year, 1049 (17%) in children of 1 year up to 5 years, 935 (15%) in children > 5 years to 12 years and 728 (11%) in children 13 years and older[104] (Figure 2.3).

Figure 2.3 Distribution of major infection sites by age group



Note: BSI indicates bloodstream infection; UTI, Urinary tract infection; PNE, pneumoniae; LRI, lower respiratory infection other than pneumoniae; SSI, surgical site infection; EENT,

eye, ear, nose, or throat infection; GI, gastrointestinal infection; SST, Skin and soft tissue infection, CVS, cardiovascular infection; other, other infection.

The study concluded with the fact that the most common NIs in pediatric ICUs was BSIs and the distribution of infection sites and pathogens differed with age to that of adult ICUs.

Antibiotic-resistant bacteria are an emerging problem in intensive care units (ICUs). Infections caused by multidrug-resistant organisms may result in prolonged hospitalization, increased mortality rates and costs. Pseudomonas aeruginosa is a certain nosocomial pathogen with notable virulence factors and the ability to exhibit antibiotic resistance. Acinetobacter species have been associated with numerous outbreaks of infection especially in ICUs [66]. Multidrug resistant *Ps. aeruginosa* and *Acinetobacter* species shows an increased risk of infection in patients in ICUs and clonal dissemination of multidrug-resistant strains occurs commonly [66]. In addition, Fagon et al[67] reported that pneumonia with Acinetobacter spp. or P. aeruginosa was related with increased mortality rates (40%). Similarly, Blot et al[68] reported a crude hospital mortality rate of 42% for patients with A. baumannii bacteraemia. The use of broad spectrum antibiotics may lead the colonization with these pathogens and consequently to serious infections. The most important determinants for reduction of incidence of infections caused by Pseudomonas and Acinetobacter species in ICUs are rational antibiotic management, investigation of environmental sources of infection and strict contact isolation procedures. Optimizing empirical therapy requires knowledge of antimicrobial resistance patterns.

Hospital-acquired pneumonia is the most common life-threatening hospital-acquired infection and the majority of cases are associated with mechanical ventilation. Ventilator-associated pneumonia occurs in approximately 10 to 20% of patients who are on ventilators for longer than 48 hours and is associated with significant increases in length of hospital stay, mortality, and costs[71]. Gram-negative organisms predominate in hospital acquired pneumonia, particularly *Ps. aeruginosa*, *A. baumannii*, and the Enterobacteriaceae[70]. Between 1986 and 2003, *Acinetobacter* species were the only gram-negative organisms that increased significantly as a cause of pneumonia in ICUs in the United States[70]. Unfortunately, the resistance of these organisms to antibiotics particularly to carbapenems has posed important therapeutic challenges.

In a recent survey, 26.4% of 679 *Ps. aeruginosa* isolates and 36.8% of 427 *A. baumannii* isolates that caused ventilator-associated pneumonia were resistant to carbapenems

(imipenem or meropenem)[69.] Similar data have been reported from other parts of the world with countries such as Greece reporting rates of carbapenem resistance of up to 85% among ICU isolates[72]. Of greatest concern are reports of infections caused by organisms that are resistant to all currently available antibiotics including the polymyxins[73, 74] .

Recent data from the U.S. National Healthcare Safety Network indicate that gram- negative bacteria are responsible for more than 30% of hospital-acquired infections and these bacteria predominate in cases of ventilator-associated pneumonia (47%) and urinary tract infections (45%)[69]. In intensive care units (ICUs) in the United States, gram-negative bacteria account for about 70% of these types of infections and similar data are reported from other parts of the world[70]. A range of gram- negative organisms are responsible for hospital-acquired infections. Unfortunately, multidrug-resistant organisms including *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, and extended-spectrum β-lactamase (ESBL)–producing or carba-penemase-producing Enterobacteriaceae are increasingly being reported worldwide.

The health professional's role in preventing hospital acquired infections

Despite their best intentions, health professionals sometimes act as vectors of disease, disseminating new infections among their unsuspecting clients. Attention to simple preventive strategies may significantly reduce disease transmission rates. Frequent hand washing remains the single most important intervention in infection control. However, identifying mechanisms to ensure compliance by health professionals remains a perplexing problem. Gloves, gowns and masks have a role in preventing infections but are often used inappropriately, increasing service costs unnecessarily. While virulent microorganisms can be cultured from stethoscopes and white coats, their role in disease transmission remains undefined. There is greater consensus about sterile insertion techniques for intravascular catheters—a common source of infections—and their care. By following a few simple rules identified in this review, health professionals may prevent much unnecessary medical and financial distress to their patients.

Infection control programmes are cost-effective[105, 106] but their implementation is often hindered by a lack of support from administrators and poor compliance by doctors, nurses, and other health workers. Some health professionals suffer from the “Omo syndrome”—a belief that they are always super clean and sterile. Many are visibly upset when their poor hygiene practices are exposed and are offended when it is suggested that they may be potential vectors of disease and are spreading virulent microorganisms among their patients.

Hand washing

Most nosocomial infections are thought to be transmitted by the hands of health care workers. It has long been known that hand hygiene among health care workers plays a central role in preventing the transmission of infectious agents. Hand-washing is the most effective way of preventing the spread of infectious diseases[131].

But despite a Joint Commission requirement that Centers for Disease Control and Prevention hand hygiene guidelines be implemented in hospitals, compliance among health care workers remains low.[132] The reasons of lack of compliance to hand washing include: lack of appropriate equipment, low staff to patient ratios, allergies to hand washing products, insufficient knowledge among staff about risks and procedures, the time required and casual attitudes among staff towards biosafety[133].

The hands of staff are the commonest vehicles by which microorganisms are transmitted between patients.[107] Hand washing is accepted as the single most important measure in infection control.[107-108] Not surprisingly, hospital staff believe that they wash their hands more often than they actually do and they also overestimate the duration of hand washing[109]. In a study of nurses' practices, hands were only cleaned after 30% of patient contacts and after 50% of activities likely to result in heavy contamination. Poorer hand washing performance was related to increasing nursing workload and the reduced availability of hand decontaminating agents.[110] At many hospitals and clinics, particularly in developing countries, hand wash basins are poorly accessible and the unavailability of soap, sprays, and hand towels is a regular, annoying occurrence.

Alcoholic hand disinfection is generally used in Europe, while hand washing with medicated soap is more commonly practiced in the United States[111]. The superiority of one method over the other is a moot point. Voss and Widmer argue that alcoholic hand disinfection with its rapid activity, superior efficacy and minimal time commitment, allows easy and complete compliance without interfering with the quality of patient care[111]. They estimated that given 100% compliance, soap hand washing would consume 16 hours of nursing time for a 24 hour shift whereas alcoholic hand disinfection from a bedside dispenser requires only three hours. Hand washing using a spray can be accomplished in 20 seconds, compared with 40–80 seconds for soap.

Theatre staffs are sometimes reluctant to remove their wedding rings when scrubbing up. Higher microbial counts after washing are found in health workers who prefer not to remove rings[112] and may put the patient at risk for a nosocomial infection[113]. The value of surgical scrubbing using a brush is questioned. In one study, subjects who washed with an antiseptic soap alone had a twofold greater reduction in bacterial counts than when they scrubbed with a brush[114].

Continued monitoring and educational efforts can improve hand washing habits.[115-116]. Larson *et al* reported that by providing feedback to staff regarding the frequency of hand washing, compliance improved by 92% [115]. When feedback was stopped compliance quickly returned to baseline levels. The importance of constantly reminding staff of the need for hand washing and of senior staff setting a good example by their own hygienic practices cannot be over emphasized.

It is difficult to provide clear guidelines on how often hands should be washed. The Hand washing Liaison Group is emphatic: "an explicit standard [should] be set that hands should be decontaminated before each patient contact[117]." We recommend the use of chlorhexidine solution before the performance of invasive procedures. The thoroughness of application is more important than the time spent on washing or the agent used.

Gloves

Gloves are a useful additional means of reducing nosocomial infection but they supplement rather than replace hand washing. Possible microbial contamination of hands and transmission of infection has been reported despite gloves being worn[118]. Not surprisingly, health care workers who wash their hands more often are also more likely to wear gloves[107]. Single use gloves should never be washed, desterilized or disinfected and gloves must be changed after each patient encounter.

Sterile gloves are much more expensive than clean gloves and need only be used for certain procedures such as when hands are going to make contact with normally sterile body areas or when inserting a central venous or urinary catheter. Clean gloves can be used at all other times including during wound dressings. For gloves to be used appropriately they must be readily available. Again, this is not always the case at many clinics and hospitals in poorer settings.

Gowning

Gowns help keep infectious materials off clothing, although in some centres they are used more as reminders that the patient is isolated. Two recent studies confirm that staff gowning in the neonatal intensive care unit is an unnecessary custom[119-120]. Wearing gowns did not reduce neonatal colonization, infection or mortality rates. There was no change in traffic patterns in the unit or in hand washing behavior[119] and it was not cost-effective[120]. The universal use of gloves and gowns was found to be no better than the use of gloves alone in preventing rectal colonization by vancomycin resistant enterococci in a medical intensive care unit[121].

Masks

It has never been shown that wearing surgical facemasks decreases postoperative wound infections. When originally introduced, the primary function of the surgical mask was to prevent the migration of microorganisms residing in the nose and mouth of members of the operating team to the open wound of the patient. However, it is now recognized that most bacteria dispersed by talking and sneezing are harmless to wounds[122]. The prevailing opinion that masks are useful in preventing surgical site infection has been challenged[123-125]. Orr reported a 50% decrease in wound infections when masks were not worn but the study was criticized for lack of proper controls[124]. Tunevall, using better controls, confirmed the earlier findings of lack of clear benefit from wearing masks[125]; after 1537 operations performed with face masks, 73 wound infections were recorded (4.7%), while following 1551 operations performed without face masks, 55 infections occurred (3.5%). The difference was not significant. Thus while masks may be used to protect the operating team from drops of infected blood and from airborne infections, they have not been proven to protect the patient.

Stethoscopes

Some health personnel have difficulty in accepting that the stethoscope, the symbol of their professional status may actually be a vector of disease. In a study of 150 health care workers (50 paramedics, 50 nurses, and 50 doctors), staphylococcus species (mostly coagulase negative) were cultured from 89% of the participants' stethoscopes, the mean number of colony forming units increasing the longer stethoscopes were not cleaned[126]. Overall, 48% of health care providers cleaned their stethoscopes daily or weekly, 37% monthly, 7% yearly, and 7% had never cleaned them. Cleaning the stethoscope's diaphragm resulted in an

immediate reduction in the bacterial count by 94% with alcohol swabs, 90% with a non-ionic detergent, and 75% with antiseptic soap[126].

There are no studies on the beneficial effect of regularly cleaning stethoscopes on nosocomial infection rates. Nevertheless, we suggest that regular disinfection should be carried out (at least once daily) as the level of contamination rises from 0% to 69% after more than one day without cleaning of the stethoscope [127]. Isopropyl alcohol is an effective cleaning agent [128] but may dry out the stethoscope's rubber seals and damage the tubing if used routinely.

White coats

Like the stethoscope, the white coat has long been a symbol of the medical professional. Many institutions insist that junior doctors, in particular, wear a white coat as part of a mandatory dress code. About half of all patients still prefer their doctor to wear one[129]. However, they may be less enthusiastic about this if they realized that white coats harbour potential pathogens and are thereby a source of cross infection particularly in surgical areas [130]. The cuffs and pockets of the coats are the most highly contaminated areas. The recommendation that the coat is removed and a plastic apron is donned before wound examination is rarely followed in practice. While few would challenge the sartorial elegance of the white coat, clearly its value needs to be critically assessed. There is little microbiological evidence for recommending changing white coats more often than once a week or for excluding the wearing of white coats in non-clinical areas[130].

ROLE OF THE LABORATORY IN INFECTION CONTROL

The success of the hospital's infection control efforts hinges to a large extent on the active involvement of the laboratory in all aspects of the infection control program. Laboratory personnel should understand why infection control is necessary, the approaches being taken by the hospital's infection control program to meet its objective to reduce nosocomial infections, and how the laboratory can support and cooperate with the program.

Development of Infection Control Programs

In the 1940s and '50s, severe *S. aureus* pandemics caused substantial morbidity and mortality in U.S. hospitals. In part because of these pandemics, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) in 1958 first recommended that hospitals appoint infection control committees[134]. However, faced with growing numbers of drug-resistant

pathogens, increasing use of high-risk medical interventions and the introduction of more immunosuppressive agents and therapies, hospitals, along with regulatory and accrediting organizations began to realize that a committee alone cannot adequately deal with the problem of nosocomial infections. In most hospitals, the committee directs the infection control activities but its members, already responsible for other hospital functions usually do not have the time or the skill to perform the day-to-day duties of infection control. In the 1960s, infection control programs were begun in U.S. hospitals and a new health care professional, the infection control practitioner (ICP) was introduced. In the United States, there is now an ICP in almost every hospital[135]. According to a recent study, most ICPs are registered nurses, although some have other professional backgrounds; 9% are either medical technologists or respiratory therapists[136]. The Association for Practitioners in Infection Control, a professional organization for infection control was organized in 1972 and changed its name to the Association for Professionals in Infection Control and Epidemiology in 1993. Physician hospital epidemiologists who serve as medical directors of the infection control program, particularly in larger hospitals are growing in number and have their own professional organization, the Society for Hospital Epidemiology of America [137, 138, 139]. The JCAHO has had considerable influence on the adoption of formal infection control programs in hospitals. As part of its accreditation standards, JCAHO prescribes the broad elements of infection control programs but gives hospitals wide leeway in designing their own infection control programs[140]. JCAHO standards stipulate key organizational structures and functions which determine the ability of health care institutions to provide quality health care[141]. In 1986, the JCAHO unveiled its Agenda for Change, which is a major research and development project that is expected to culminate in 1996 with the introduction of indicators to assess the actual performance of hospitals[142]. Clinical indicators including eight in infection control that are currently undergoing phase II pilot testing, are expected to radically change the JCAHO survey process for accreditation[143, 144]. None of the clinical indicators for infection control specifically assess the quality of the microbiology laboratory. The CDC, through its guidelines development, nosocomial infection surveillance methodology, outbreak investigations, and laboratory studies has provided much of the scientific and epidemiologic basis for infection control in the United States. It also organized some of the early training for ICPs and hospital epidemiologists. Its landmark study on the efficacy of nosocomial infection control (SENIC Project) demonstrated that to be effective, nosocomial infection programs must include the following components: (i) organized surveillance and control activities, (ii) adequate number of trained infection control staff, and (iii) a system for reporting SSI rates to

surgeons[145]. Other organizations have made important contributions to infection control, particularly the American Hospital Association[146], the American Society for Microbiology, and specialty groups, such as the American College of Surgeons and the Association of Operating Room Nurses. Individual states also promote infection control through regulations in their health codes and hospital licensure standards.

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Surveillance of Nosocomial Infections

Surveillance is defined as "the ongoing, systematic collection, analysis and interpretation of health data essential to the planning, implementation and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know"[148]. Surveillance, which is an essential element of an infection control program, provides the data to identify infected patients and determine the site of infection and the factors that contributed to the infection. When infection problems are recognized, the hospital is able to institute appropriate intervention measures and evaluate their efficacy. Surveillance data are also used to assess the quality of care in the hospital. If the data collected are to be most useful for decision making, the hospital should focus on their most important and predominant problems and use surveillance methods that adhere to sound epidemiologic principles.

The nosocomial infection surveillance system may be sentinel event based or population based or both. A sentinel infection (or sentinel group of infections) is one that clearly indicates a failure in the hospital's efforts to prevent infections and in theory, requires individual investigation[149]. Denominator data are usually not collected in sentinel event-based surveillance. Sentinel event-based surveillance will identify only the most serious problems and should not be the only surveillance system in the hospital. Population- based surveillance, that is, surveillance that is done on patients with similar risks, requires both a numerator (the infection) and denominator (number of patients or days of exposure to the risk). If the infection rates are to be used for inter-hospital comparisons, the rates must be adjusted for patients' intrinsic and extrinsic risks of infection[150]. To calculate risk-adjusted rates from population-based surveillance data, corresponding risk factors in both the

numerator and denominator must be collected. The risk factors may be patient characteristics such as underlying disease conditions or they may be procedures or devices used to diagnose or treat the patient.

The NNIS system employs a population-based surveillance system that provides risk-adjusted rates that can be used for inter-hospital comparisons[151]. Data are collected for four surveillance components that target different populations of inpatients: (i) all patients in the hospital (called hospital-wide), (ii) patients in the ICU, (iii) patients in the high-risk nursery, and (iv) patients who undergo an operative procedure. Except for the hospital-wide component, important and specific risk factors are collected for the population of patients monitored. For example, in the ICU surveillance component, data are collected on the type of ICU and the total number of days that patients are exposed to a urinary catheter, central vascular line, or ventilator; these are called device-days. Risk-adjusted infection rates from aggregated data reported by hospitals participating in the NNIS system have been published[152, 153,154].

Requirements for a surveillance system.

A hospital should have clear goals for doing surveillance. Furthermore, these goals must be reviewed and updated frequently to meet new infection risks in changing patient populations, the introduction of new high-risk medical interventions, and changing pathogens and their resistance to antibiotics. A surveillance system should include the following elements.

- **Trained personnel.**

A typical ICP will spend about half of her or his time performing surveillance[155, 156]. The ICP should have, at minimum, knowledge about clinical patient care, epidemiology, and microbiology. Unfortunately, some hospitals appoint individuals to the infection control position but do not provide them with training to adequately perform infection control functions. Courses in infection control are available through the Association for Practitioners in Infection Control and Epidemiology and its local chapters. Individuals who meet certain time and practice qualifications and successfully pass a written examination can be certified in infection control[157].

- Accepted definitions and criteria for nosocomial infections, risk factors, and other outcomes.

- Readily available sources of data for identifying infections.
- Accurate and complete denominator data.
- Analysis and dissemination of data to those who need the information.
- Confidentiality of the data.
- Selection of patients for monitoring.
- Strategies for identifying infected patients.
- Use of surveillance data for continuous quality improvement.

Specific Laboratory Support Functions

The microbiology laboratory should be actively involved in the infection control program. As the source of microbiologic culture information, the laboratory must provide easy access to high-quality and timely data and give guidance and support on how to use its resources for epidemiologic purposes. The services that the infection control program can offer to the laboratory include functioning as a liaison to the clinical services to improve the quality of specimens sent to the laboratory and promoting appropriate use of cultures and other laboratory tests. It can also assist the laboratory with its system for monitoring antimicrobial agent susceptibilities by identifying the pathogens that are of nosocomial origin.

Interaction of the laboratory with the infection control program.

A current and thorough discussion of the role of the laboratory in infection control can be found in the text Hospital Infection[158]. Other publications on this subject are also informative[159, 160]. In brief, the microbiology laboratory can support the infection control program in the following ways.

Ensure high-quality performance in the laboratory. Because the surveillance system ordinarily uses the results of cultures and other tests ordered by physicians for the diagnosis and treatment of patients, the surveillance program benefits when the laboratory performs high quality work on clinical specimens. Additional laboratory tests may be necessary for epidemiologic purposes, but this is rare and should be discussed thoroughly with the infection control program first. The cost of cultures and other tests performed for epidemiologic purposes is usually not charged to the patient.

Designate at least one person from the microbiology laboratory to be the consultant to the infection control program and to serve as a member of the infection control committee. Any

activity of the infection control program that involves the laboratory should be coordinated through a designated person. Conversely, this representative should keep the infection control program informed about changes in the laboratory that may affect surveillance and other aspects of the program. This person should be selected for his or her knowledge of and interest in infection control.

Make laboratory test results available in an organized, easily accessible, and timely manner. The infection control program depends on the cooperation of the laboratory in making laboratory data accessible. The design of the laboratory's record keeping system should accommodate the needs of the infection control program and should be developed in collaboration.

Provide training on basic microbiology for the infection control program staff. Most beginning ICPs do not have a working knowledge of microbiology and will require training before they are able to effectively use the laboratory services for the infection control program. The ICP will need to be taught how to interpret the results of cultures and other tests in order to conduct surveillance.

Monitor laboratory results for unusual findings. The laboratory should watch for clusters of pathogens that may indicate an outbreak, the emergence of multidrug-resistant organisms, and the isolation of highly infectious, unusual, or virulent pathogens. The laboratory staff is usually the first to recognize these unusual events or trends, and reporting them early to the infection control program may avert a more serious problem.

Use environmental cultures judiciously. Microbiology laboratories are often asked to perform environmental cultures to assess microbial contamination of inanimate objects or the level of contamination in certain areas of the hospital. Such culturing must be coordinated with the infection control program to ensure that it is performed only when indicated and that the specimens are processed appropriately. In the past, environmental cultures were performed extensively in most hospitals[161].

Epidemiologic typing of microorganisms

To investigate whether microorganisms are clonal or not, the laboratory usually examines the results of species identification and biochemical tests and patterns of susceptibility to

antimicrobial agents. However, more specialized techniques are occasionally required to type certain organisms[162].

Chapter-3

MATERIALS & METHODS

MATERIALS AND METHODS

3.1 Study Design

It was a descriptive type of cross sectional analytical study. Observations were repeated in the same population over a specified period by means of follow up examinations. The researcher planned the study and possibly recorded the exposures before the outcome was apparent. Conceptual framework of study is shown as under:

Conceptual framework of study

Time →

Direction of Inquiry →

Admitted patients	→	**Screening to note having any infection during admission**	→	**Exposed to hospital environment**	→	**Follow-up starts more than 48 hours after admission**	→	**Outcome (Hospital Acquired Infection)**	→	**Identification of microbial by culture**	→	**Antimicrobial resistivity pattern**

3.2 Study Period

The duration of the study was a period of January 2015 to July 2015.

3.3 Place of Study

The present study was carried out at United Hospital Ltd. (UHL), a tertiary care hospital, Dhaka, Bangladesh. This hospital having specialized type of medical facility situated at Gulshan, Dhaka. It is noted that most of the dignified personnel of the country and patients of critical conditions are treated here. This hospital is well communicated from all sites with rest of the city as well as with all parts of the country. The reasons for choosing United Hospital Ltd. Dhaka as study place are mentioned bellow:

a) UHL, Dhaka is one of the best hospital in respect to its size, facility, quality service and high standard management. The rate of the hospital-acquired infection (HAI) of this hospital could reflect the situation of other hospitals in the country.

b) Since the researcher himself is involved with research work, so it was easily assessable to every site of this hospital. As a result, no extra time was required to collect data which helps researcher to conserve time and conveyances.

c) As this entire hospital is highly equipped and connected with internal server through computer networking, therefore, almost all types of clinical investigations

like laboratory investigations, others infection related information (Chest x-ray), patients clinical history, patients personal information, date of admission, date of discharge, length of hospital stay, transfer of patients among different places etc. were possible to collect almost all types of data just sitting before one computer.

3.4 Study Population

The study population comprised of all admitted patients of almost all the departments/wards such as Cardiology, Neurology, Urology, Orthopedics, Oncology, Critical Care Unit and surgical wards. The researcher selected the admitted patients as samples who were available after 48 hours or more and at the time of data collection period.

3.5 Selection Criteria of the study Population

Following criteria were used to select the respondents in this study:

3.5.1 Inclusion Criteria

All admitted patients of almost all wards (Critical Care Unit, General surgery, cardiology, neurology, urology, Oncology, orthopedic) during a period of 7 months from January 2015 to July 2015.

a) Patients those were available 48 hours or more after admission.
b) Those who were willing to participate in the study.

3.5.2 Exclusion Criteria

a) Patients who died or discharged from the hospital within 48 hours of admission.
b) Patients who were admitted 48 hours before the end of data collection period.
c) Gynecological ward and some other wards like ENT, Dental, and General wards.
d) Patients who were not willing to provide data or lack of information.

3.6 Sample size and its distribution

3.6.1 Almost all the admitted patients who were available during the data collection period fulfilling the selecting criteria were included in the sample. The total number of respondents in the sample was 1108 (One thousand one hundred and eight).

3.6.2 The HAI was determined by reviewing the concurrent medical records and laboratory evidence (culture report), concern physicians and with the help of

infection control and prevention department. The total number of hospital acquired infection (HAI) had been developed 104 (One hundred and four) respondents out of 1108 study population.

3.6.3 From the culture report, the number of respondent developed HAIs by pathogenic organisms was determined.

3.6.4 The sensitivity pattern was confirmed among the respondents developed HAI by antibiogram.

3.7 Sampling Technique

All the study subjects happened to be available during the data collection and gave date were included in sample, so no sampling technique was required to get the desired sample size.

3.8 Research Approach

After getting approval of the research proposal from the Rajshahi University, data were start to collect. Microbiological tests (culture and antibiogram) were carried out in the Department of Microbiology of UHL. Verbal consent from the patient was taken during interview. Before data collection, the respondents were made clear that they were at liberty to withdraw from the study at any time. They also had the freedom not to answer any question. The respondents were given full assurance that under no circumstances findings of the interview and other investigations/examination will be disclosed to any unauthorized person or the authority.

3.9 Research Instruments

A questionnaire and checklist was prepared and used for data collection. The instruments were prepared keeping in view the research questions, objectives and variables of the study. The instruments were pre-tested among 15 admitted patients of different wards for clarity, accuracy, unambiguity and to find out face validity of the questions. Minor modifications out of pre-testing were incorporated in the questionnaire and checklist. Having this modification, final versions were used for data collection. The research instruments contained mainly structured questions.

3.10 Data Collection Procedure

On the day of admission, screening was carried out by physical examination and reviewing of medical chart to make a note whether the respondents had any infection before admission. If anybody was found already infected, he/she was considered community acquired infection (if any) other than those noted on admission. After the study population was screened on the day of admission to confirm whether any infection

acquired before admission, they were followed up till either development of first event of infection or discharge without infection. After explaining the purpose of the study to the respondents, data were collected by the researcher through face to face interview. In addition, discussion with relevant physicians, nurses others staff, patient's medical charts were reviewed and necessary information was documented on checklist.

Patients who were readmitted 72 h after discharge from hospital were regarded as new case. Patients with infection at the time of admission were included in the non-infected group for the purpose of analysis. However, such patients were included in the group with hospital acquired infection when they developed a new infection at a different anatomical site during hospital stay.

All 1108 patients in the study group were also followed-up till hospital discharge to acquire data on length of hospital stay and outcome. Information on each patient was recorded on a structured case report form.

3.10.1 The basis of diagnosing the hospital-acquired infection

a. Presence of clinical symptoms and signs of infection.
b. Examination of wounds and catheter entry sites.
c. Reviewing of procedures that might lead to infection.
d. Reviewing of laboratory test results including cultures for blood, urine, sputum, Tracheal aspirate, Endotracheal tube, suction materials, infected wound, pus, urinary catheter and others catheter etc.
e. X-ray chest (for pneumoniae)

3.10.2 Physical examination

a. To locate the symptoms and signs of infection
b. Wounds and skin where catheter had been placed were examined for redness, swelling and presence of pus or an abscess.

3.10.3 Method of Prospective Observation

The study population was followed-up first more 48 hours after admission to see any evidence of infection. The study populations were kept under observation till a first event of infection or discharge without infection.

3.10.4 Method of Case Findings

Hospitalized patients were observed and their medical charts were reviewed by the researcher during ward round. Medical charts included results of Microbiology tests, clinical data and physician's diagnosis. Reports on newly infected patients were collected

by personal contact with ward nurses and infection control department. Patient's fever charts were examined regularly to find out any sign of infection. The principles in defining the HAI were done by CDC criteria. The results of microbiological tests and antibiogram were collected in regular basis from Microbiology Department and specifically incorporated into the checklist on regular basis.

Antimicrobial therapy was administered to the patients as necessary and cultures were requisitioned when infection was suspected. Patients were always sampled for microbial culture before starting a new antimicrobial. Appropriate essential investigations were regularly performed as needed.

3.10.5 Measurement of Incidence

The incidence was measured as incidence rate which is the number of new event (disease onsets) in a specified quantity of person-time (hospital days) in a population at risk. It was restricted to first events of hospital-acquired infection (HAI) developed by the respondents. The population at risk was composed of all those who had not yet suffered a first event. After a respondent acquired an event of HAI, that respondent was withdrawn from the population still at risk for a first event of infection. Each respondent who never acquired an event of HAI would contribute all hospital-days to the pool of days at risk, but a respondent who became infected would contribute only those hospital-days before the onset of the HAI.

$$\textbf{Incidence Rate} = \frac{\textbf{Number of first events of infection}}{\textbf{Observed time at risk for a first event (Total person-time at risk)}} \textbf{ X 1000}$$

HAI has been expressed as the number of first events of infection in 1000 hospital-days.

3.10.6 Culture and Antibiogram

After the events of hospital-acquired infections were determined on the basis of clinical evidences, the specimen of infected personnel (blood, tracheal aspirate, Endotracheal tube, urinary catheter, pus, infected wound, suction materials, body fluids and others catheter, sputum, urine etc.) were sent to Microbiology department to confirm the laboratory diagnosis. If culture yielded growth of organism, antibiogram was done. The results were documented in the questionnaire.

3.10.7 Identification of the organism

The organisms were identified by their colony morphology, staining characters, pigment production, motility and other relevant biochemical tests as per standard methods[163].

Microbiological methods

The organisms were isolated from the specimen by inoculation and subculture on blood agar and MacConkey agar media. All the isolates were tested for sensitivity against antimicrobial agents like Amikacin (AK), Amoxyclavonic acid, Penicillin-G (P), Co-trimoxazole (SXT), Ceftriaxone (CRO), Cefepime (CFM), Cefixime (CXM), Ceftazidime (CAZ), Ciprofloxacin (CIP), Gentamicin (CN), Imipenem (IPM) Meropenem (MEM), Netilmicin(NET), Colistin sulphate (CT), Piperacillin-Tazobactam (TZP), Doxycycline (DO), Linezolid (LZD), Vancomycin (VA), Erythromycin (E), Oxacillin (OX), Nalidixic Acid (NA), Nitrofurantoin (F), Aztreonam (ATM) by disc diffusing method of Kirby Bauer et al[164]. The potency of each batch of disc was standardized by the reference strain of ATCC Esch. coli, No 25922 and Pseudomonas aeruginosa No 27853. Zone of inhibition were compared with the standard value and was considered as sensitive (S), moderately sensitive (M) and resistant (R) according to the NCCLS (1998)[165].

3.10.8 Antibiotic disc

All the discs used in this study were Oxoid Ltd, UK which is commercially available.

Preservation of the discs

All the discs were kept at 2-8^{o}C. Prior to use, the containers were left at room temperature for about half an hour to minimize condensation resulting from the warm air reaching the cold container.

3.10.9 Culture media used in the study

1. Blood agar medium (BA)
2. MacConKey agar medium (MA)
3. Muellar Hinton agar medium (MHA)
4. Chocolate agar medium (CA)
5. Saboroid Dextrose agar medium (SDA)

3.10.11 Media for antibiotic susceptibility test

Muellar-Hinton agar media were used for antimicrobial susceptibility testing for all the isolated bacteria[163].

Drug Sensitivity test

A loopful of confluent growth of the test organisms was taken with a sterile wire loop from a pure culture in a tube containing a sterile normal saline[51]. Within 15 minutes after standardization of inoculums, a sterile cotton swab was immersed into the bacterial suspension. The excess suspension was removed by rotating the swab with firm pressure against the inner side of the tube above the fluid level. The plates were dried in an incubator at 37^{o}C for 30 minutes before use. The swab was then streaked evenly on the surface of freshly prepared media in three different planes (by rotating the plate 60^{o}each time) to get a uniform distribution of inoculums. The plates were left at room temperature for 10-15 minutes with lid closed to allow the inoculums to dry. The antimicrobial sensitivity discs were then placed on the inoculated surface by sterile fine forceps 15 mm away from the edge of the petridish and having 20-25 mm gap between the discs. The plates were then inverted and incubated at 37^{o}C for 18-24 hours.

Reading of the sensitivity test

Each plate was examined after overnight incubation (18-24 hours) and diameter of the complete zone of inhibition were measured in mm with the help of scale placed on the under surface of the petridish without opening the lid. Zone of inhibition was measured in two directions at right angles to each other through the center of the disc and average of the two reading was taken[53].

3.10.12 Biochemical Test

Principle of the test

Microgen^{TM} GnA + B-ID system was used to identification Enterobacteriaceae and an extensive range of oxidase-positive Gram negative Bacilli. This system employs 24 standardized biochemical substrates in microwells to identify the Enterobacteriaceae which had been selected on the basis of computer analysis. The dehydrated substrates in each well are reconstituted with a saline suspension of the organism to be identified. When individual substrate is metabolized, a color change occurs during incubation or after addition reagents. The permutation of metabolized substrates can be interpreted using the Microgen identification system software to identify the test organism.

Inoculation and Incubation

A single colony was emulsified from an 18-24 hour culture in 3 ml sterile 0.85% normal saline for the GN A micro well test strip. Carefully peel back the adhesive tape sealing the microwell test strip. Using a sterile Pasteur pipette, 3-4 drops of the bacterial suspension were added to each well of the strip. After inoculation, 3-4 drops of mineral oil was added

into well 1, 2, 3 and 9 (GN A strip). Then it was sealed the top of the microwell test strip with adhesive tape and incubated 35-37oC. Test strip were read after 18-24 hours incubation for organism.

Procedure

Next day results were recorded of all positive reactants with the aid of the color chart provided. Then 2 drops of Kovac's reagent added to well 8. Red color indicated positive result and recorded it after 60 seconds. 1 drop of VP 1 reagent and 1 drop of VP 2 reagent was added to well 10. Pink/red color indicated positive result and recorded it after 15-30 minutes. One drop of TDA reagent was added to well 12. Cherry red color indicated positive result and recorded it after 60 seconds. The sum of the positive reactions for each triplet forms a single digit of the octal code that is used to identify the isolate through Microgen Identification system software.

3.11 Data Processing and Analysis

At the end of the day, individual questionnaire and checklist were checked to see whether it was filled completely and consistently. Then the data were entered into the SPSS (Statistical Package for Social Science) Programme version IBM SPSS Statistics 21 by the researcher himself. An analysis plan was developed keeping objective of the study in mind. Nominal data were described and expressed in percentage. Parametric data were expressed as mean ± SD (Standard Deviation). Univariate analysis was used to compare the variables affecting the development of HAI. To test the statistical significance, the t-test was used for continuous variables while the Chi Square (X^2) test was used for categorical variables. Epi info-7 version were used to analyze Odds ratio (OR), relative risk. In addition, results were considered statistically significant if the p value was <0.05. Odds ratio (OR) with 95% confidence interval was employed to measure the magnitude of association between the studied variables and HAI. Logistic regression analysis was used to determine independent contribution of variable to the development of HAIs.

Chapter-4

STUDY FINDINGS

STUDY FINDINGS

A total of 1108 respondents were studied who were happened to be available for admission in United Hospital Limited, Dhaka during January 2015 to July 2015. They were followed up till the development of hospital-acquired infection (HAI) or their discharge which ever comes early. The total follow up period where all respondents were at risk for 11886 hospital days (person-time). The result of this study has been discussed under socio-demographic characteristic of the respondents, incidence, pattern of hospital acquired infection, patient related and hospital-related risk factors associated with hospital-acquired infection; hospital-acquired infection caused by potential pathogens and the antimicrobial susceptibility patterns of infective agents.

4.1 Socio-demographic characteristics of the respondents

This subsection describes the socio-demographic characteristics of the respondents and would help in contextualizing the study findings. It gives an idea about age, gender, religion, education, occupation, marital status and family size (household size) of the study participants.

4.1.1 Age structure

Out of 1108 respondents, majority of study respondents were in the productive years of life. The mean age was 43.778 years with standard deviation (SD) 18.174 years and range 0.8-92 years. As illustrated below in the table 4.1.1, more than two-thirds were aged between 20-59 years. However, almost nearly equal proportion were either minor (<12years) or (>60 years) consisting of around 9.7% and 14.4% respondents respectively. Only 4.3% respondents were adolescents aged 13-19 years.

4.1.2 Sex

The study respondents were dominated by males. As illustrated in table 4.1.1 around 704 (63.5%) respondents were males while the remaining 404 (36.5%) were females. This was probably due to the fact that the study was not conducted to Gynae and Obstetric wards.

Table 4.1.1 Distribution of respondents by socio-demographic characteristics (n=1108)

Socio-demographics characteristics		No. of respondents	Percentage
Age in years	Up to 12	108	9.7
	13-19	48	4.3
	20-59	792	71.5
	60 and above	160	14.4
	Total	**1108**	**100.0**
Mean ± SD= 43.778 ± 18.174 years; minimum age 0.8 and maximum 92 years			
Sex	Male	704	63.5
	Female	404	36.5
	Total	**1108**	**100**
Religion	Islam	1092	98.6
	Hindu	10	0.9
	Buddhist	6	0.5
	Total	**1108**	**100**
state of education	Primary (i-v)	32	2.9
	Class vi- class x	138	12.5
	SSC	162	14.6
	HSC	160	14.4
	Graduation	296	26.7
	Post graduation	260	23.5
	Not yet schooling	60	5.4
Occupation	Service holder	396	35.7
	Businessman	362	32.7
	Housewife	118	10.6
	Student	70	6.3
	Retired	102	9.2
	Not yet applicable	60	5.4
	Total	**1108**	**100**
Marital status	Married	880	79.4
	Unmarried	228	20.6
	Total	**1108**	**100**
Family size (number of house hold members)	2 members	116	10.5
	3-4 members	496	44.8
	5 and above	422	38.1
	Not applicable	74	6.7
	Total	**1108**	**100**
Mean ± SD = 4.11 ± 1.118 members			

4.1.3 Religion

As expected, majority of the study respondents were Muslims (99.0%) where around 1.0% were Hindu and Buddhist (Table 4.1.1).

4.1.4 Educational qualification

Majority of the participants were graduate 26.7% and post graduate 23.5% almost similar proportion as the study location was aristocratic zone in Dhaka. SSC and HSC qualified were same proportion of 14%. However 12.5% and 2.9% were with high school and 2.9% primary education. On the other hand 5.4% had no schooling at all (Table 4.1.1).

4.1.5 Occupation

As in (Table 4.1.1), the study respondents were mainly 35.7% service holder, 32.7% were business man. 10.5% were house wife, around 9.2% retired followed by 6.3% respondents were students. Among other respondents, nearly 5.4% were yet to have any occupation because of tender age and doing no work.

4.1.6 Marital status

As shown in table 4.1.1, 880 (79.4%) respondents were married and 228 (20.6%) respondents were not married.

4.1.6 Family size (household members)

It was evident from the study that around 44.8% respondents used to live with family having 3-4 members followed by 38.1% respondents who had family members 5 or above. Around 6.7% respondents were single living whereas 10.5% respondents were living as two member's family. The range of family members was 2-6 and mean of family size was 4.11 with standard deviation (SD) 1.118 (Table 4.1.1).

4.2 Hospital acquired infection (HAI): Incidence and types

This subsection will focus on magnitude of hospital-acquired infection (HAI) and pattern of different type of HAI.

4.2.1 Incidence and rate of hospital-acquired infection (HAI)

Distribution of respondents at risk of hospital-acquired infection (first event) by hospital days shows that out of 1108 respondents, 1004 (90.6%) respondents were observed until there discharge for 9810 hospital days (person time) during the data collection period who did not developed any HAI. 104 (9.4%) respondents were at risk for 2076 hospital days (person time) who developed HAI. As illustrated in the table 4.2.1, 1108 respondents have been followed for

11886 hospital days (person time) and among them 104 respondents developed HAI that yielded **incidence rate 8.75/1000 hospital days.**

Table 4.2.1 Distribution of respondents at risk for HAI by hospital days

Hospital days	No. of respondents	%	Total hospital days
Hospital days on discharge (without infection)	1004	90.6	9810
Hospital days on development infection	104	9.4	2076
Total	**1108**	**100**	**11886**

- As illustrated in Table 4.2.1, 1108 respondents were followed for 11886 hospital days (person time). Among them, 104 respondents developed hospital acquired infection which yielded an **incident rate 8.75/1000 hospital day.**
- **9.4% admitted patients developed HAI**

4.2.2 Type of hospital-acquired infection (HAI)

The distribution of respondents by type of infection as illustrated in figure 4.1, where out of 1108 respondents (admitted patients), 104 (9.4%) respondents developed hospital-acquired infection. Six type of HAI were found among the respondents such as 56.7% Respiratory Tract Infection (RTI) which was the highest followed by 15.4% Urinary Tract Infection (UTI), 10.6% Blood Stream Infection (BSI), 9.6% Ventilator Associated Pneumoniae (VAP), 4.8% Surgical Site Infection (SSI) and 2.9% Skin and Soft Tissue Infection (SSTI).

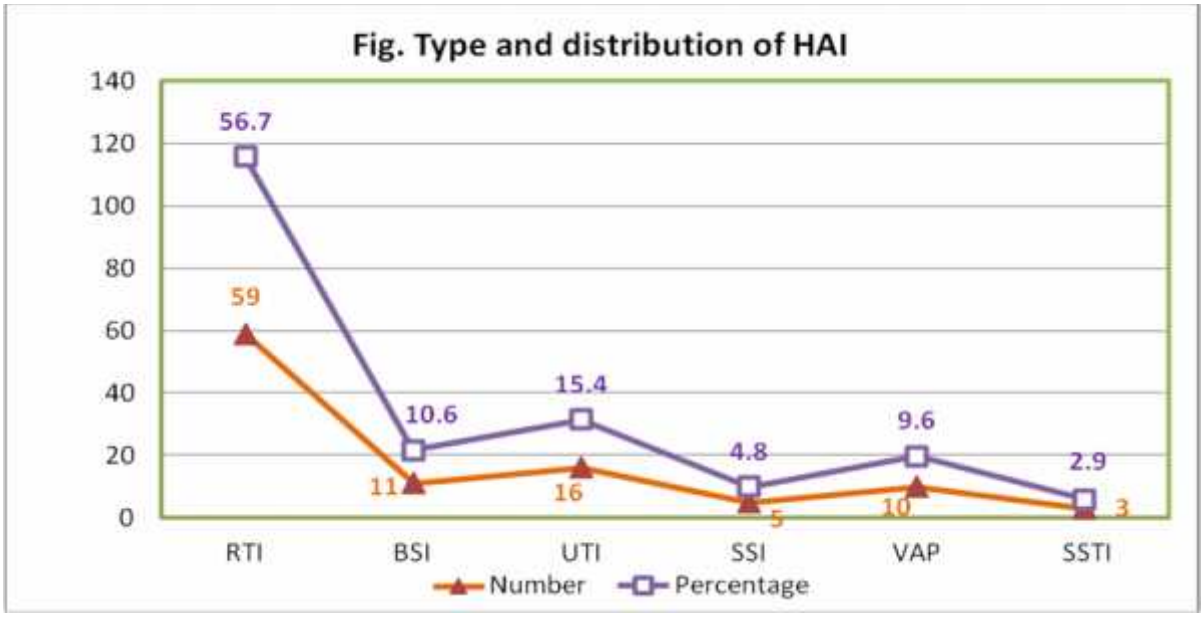


Figure 4.1 Distribution of HAI by type of infection

4.3 Patient related factors and hospital-acquired infection (HAI)

This subsection examines association between (HAI) and different patient related factors such as, age, gender, education, occupation, marital status, family size, functional state of respondents, history of antimicrobial intake during 3 month prior to admission, previous hospitalization, visitors, nature of underlying illness application of invasive procedures, immunosuppressive therapy and immunosuppressive conditions, antimicrobial therapy during hospitalization, duration of antimicrobial therapy, duration of hospital stay (hospital days).

4.3.1 Association of age and HAI

Table 4.3.1 depicts that age group 60 and above the most susceptible group were 17.5% of them developed HAI followed by 9.3% of age group 20-59, 7.4% of up to 12 years developed infection. The minor age group adolescents (between13-19) was less susceptible to HAI were around 4.2% of the respondents developed HAI. However, among the age groups, differences were found statistically significant (x^2=15.50, df=3, p=0.001).

Table 4.3.1 Distribution of respondents developed HAI by age (n=1108)

Age in years	HAI				Total	(%)
	Infection		No infection			
	No.	%	No.	%		
Up to 12	8	7.4	100	92.6	108	100
13-19	2	4.2	46	95.8	48	100
20-59	66	8.3	726	91.7	792	100
60 and above	28	17.5	132	82.5	160	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: X^2 = 15.50, df=3, p=0.001						

Extreme of age and HAI is concerned, where 16.7% of respondents of extreme of age group developed infection out of 168 respondents comparison to around 8.1% of not of extreme of age out of 940 respondents (Table 4.3.2). Extreme of age group is found more susceptible to HAI. However, in the present study the association was found statistically significant (x^2=12.341, df=1, p=0.001).

Table 4.3.2 Distribution of respondents developed HAI by extreme of age

Extreme of age	HAI				Total	(%)
	Infection		No infection			
	No.	%	No.	%		
Yes	28	16.7	140	83.3	168	100
No	76	8.1	864	91.9	940	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: X2 = 12.341, df=1, p=0.001						

4.3.2 Sex and HAI

The gender distribution of respondents developing HAI shows that 74(10.5%) male respondents developed infection out of 704 respondents while 30(7.4%) female respondents developed infection out of 404 respondents. Males were found to be more susceptible to hospital-acquire infection compared to females as depicted in the table 4.3.3. However the association between sex and development of HAI was not found statistically significant (x^2=2.87, df=1, p=0.09).

Table 4.3.3 Distribution of respondents developed HAI by sex

Sex	**HAI**				**Total**	**(%)**
	Infection		**No infection**			
	No.	**%**	**No.**	**%**		
Male	74	10.5	630	89.5	704	100
Female	30	7.4	374	92.6	404	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: X^2 = 2.87, df=1, p=0.09						

4.3.3 Educational status and HAI

The distribution of educational status of the respondents and development of HAI, around 11.8% of respondents out of 170 developed infection of having ten years schooling as depicted in table 4.3.4. However, almost an equal proportion of respondents, around 9% either from SSC and HSC or from graduate and postgraduate group developed infection. The not applicable group showed little bit lower rate of 6.7% of them developed infection. The difference was found statistically not significant (x^2=1.76, df=3, p=0.625).

Table 4.3.4 Distribution of respondents developed HAI by education qualification

Educational qualification	HAI				Total	(%)
	Infection		No infection			
	No.	%	No.	%		
Primary and others	20	11.8	150	88.2	170	100
SSC & HSC	30	9.3	292	90.7	322	100
Graduate and post graduate	50	9.0	506	91.0	556	100
Not applicable	4	6.7	56	93.3	60	100
Total	**104**	**9.4**	**1004**	90.6	**1108**	100
Test statistics: $X^2 = 1.76$, df=3, p=0.625						

4.3.4 Occupation and HAI

Majority of retired person, around 16% out of 102 participants developed infection followed by house wife where around 12% out of 118 respondents developed infection as illustrated in table 4.3.5. There is almost same among the respondents of service holder, businessman, students where around 8.6% out of 396, 8.3% out of 362, 8.6% out of 70 respondents developed infection respectively. Not applicable group were found to be less susceptible to develop HAI 6.7% out of 60. However, the association between occupation and development of HAI was found statistically not significant (x^2=7.00, df=5, p=0.221).

Table 4.3.5 Distribution of respondents developed HAI by Occupation

Occupation	HAI				Total	(%)
	Infection		No infection			
	No.	%	No.	%		
Service holder	34	8.6	362	91.4	396	100
Businessman	30	8.3	332	91.7	362	100
Housewife	14	11.9	104	88.1	118	100
Student	6	8.6	64	91.4	70	100
Retired	16	15.7	86	84.3	102	100
Not yet applicable	4	6.7	56	93.3	60	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: $X^2 = 7.00$, df=5, p=0.221						

4.3.5 Marital status and development of HAI

As depicted in table 4.3.6, where the distribution of respondents developing HAI by marital status shows that around 10.0% married respondents out of 880 developed infection in comparison to 7.0% unmarried respondents out of 228. Out of study finding, married respondents were found to be more liable in developing HAI but the association of marital

status and development of HAI was found statistically not significant (x^2=1.894, df=1, p=0.169).

Table 4.3.6 Distribution of respondents developed HAI by marital status

Marital status	HAI				Total	(%)
	Infection		No infection			
	No.	%	No.	%		
Married	88	10.0	792	90.0	880	100
Unmarried	16	7.0	212	93.0	228	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: X^2 = 1.894, df=1, p=0.169						

4.3.7 Family size (household members) and HAI

The not applicable groups were found to be more susceptible to develop HAI as around 16.0% developed infection out of 74 respondents followed by group 5 members and above where around 11.0% developed infection out of 422 respondents as depicted in table 4.3.7. The highest proportion of not applicable group may be due crowded condition because of space problem as the unmarried, unrestricted life style, unhygienic conditions etc. Respondents of family size having 2 member and 3-4 members were found to be less susceptible to HAI as 5.2% and 8.0% developed infection out of 116 and 496 respondents respectively. Through more infections were prevailing among not applicable and 5 members and above group but the association was found statistically not significant (X^2=4.318, df=3, p>0.05).

Table 4.3.7 Distribution of respondents developed HAI by family size

Family size	HAI				Total	(%)
	Infection		No infection			
	No.	%	No.	%		
2	6	5.2	110	94.8	116	100
3 to 4	40	8.1	456	91.9	496	100
5 and over	46	10.9	376	89.1	422	100
Not applicable	12	16.2	62	83.8	74	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: X^2 = 4.318, df=3, p>0.05						

4.3.8 Functional state of respondents and developed of HAI

4.3.8.1 Different functional states and HAI

Majority of respondents were active before developing HAI. As demonstrated in figure 4.2 around 57.8% patients were independent meaning performing activities at their own while

28.5% required some assistance and 13.7% respondents required assistance most of the time. Functional states of the respondents were found to be associated with HAI. Around a third (29.0%) developed HAI who required assistance most of the time in comparison to only 5% of those who could perform activities at their own. Around 8.9% who required some assistance developed HAI (table 4.3.8). However, the study result revealed that different functional state of the patients had strong association in developing HAI which was found statistically highly significant (x^2=82.962, df=2, p<0.001).

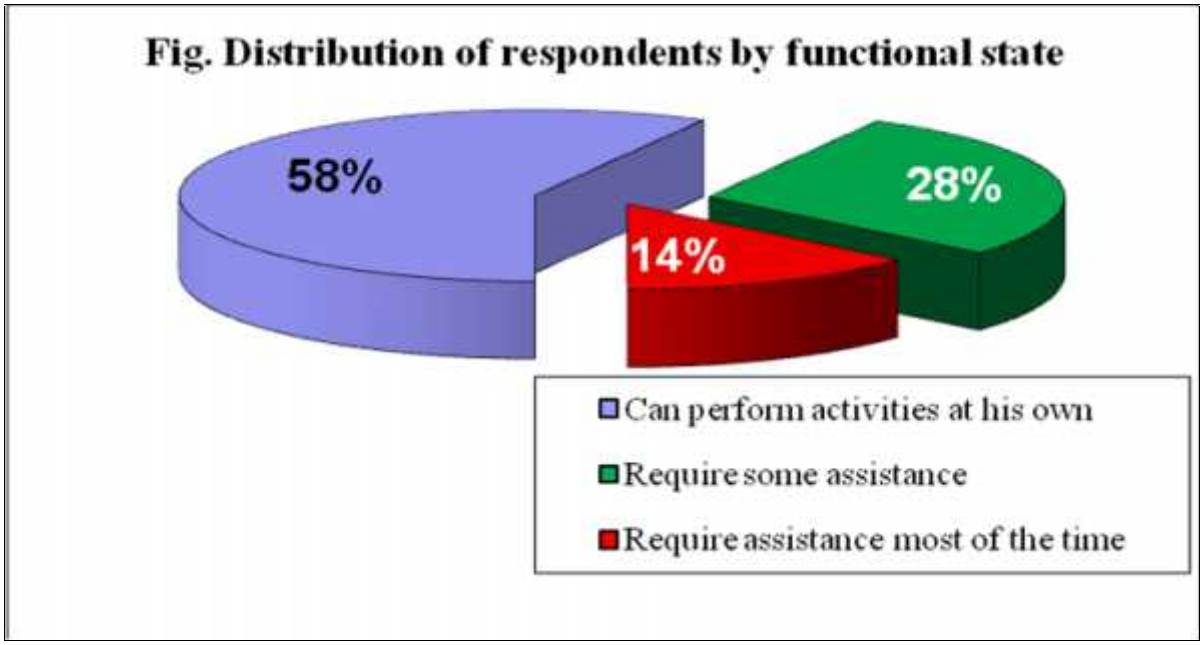


Figure 4.2 Distribution of respondents by different functional states

Table 4.3.8 Distribution of respondents developed HAI by functional state

Functional state of respondents	HAI				Total	(%)
	Infection		No infection			
	No.	%	No.	%		
Can perform activities of its own	32	5.0	608	95.0	**640**	100
Require some assistance	28	8.9	288	91.1	**316**	100
Require assistance in most activities	44	28.9	108	71.1	**152**	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: X^2 = 82.962, df=2, p<0.001						

4.3.8.2 Comparison of risk among functional states and development of HAI

The incidence of HAI was significantly higher among the respondents who required nursing assistance most of the time than those with some or no assistance. An individual who required nursing assistance most of the time had 20 times more risk of developing HAI and those who required some assistance had 6.78 times more risk than those who required no assistance. The odds ratio (OR) for three functional categories was: 0.3, 0.9 and 6.1.

Table 4.3.8. (a) Comparison of risk among functional status for HAI

Factors	Odds Ratio (OR)	95% CI	Relative Risk (RR)	P value
Can perform activities of its own	0.3	0.19-0.45	3.85	0.705
Require some assistance	0.9	0.58-1.44	5.40	<0.05
Require assistance in most activities	6.1	3.93-9.42	12.98	0.000

4.3.9 Antimicrobial therapy within 3 months prior admission and hospital-acquired infection.

Majority of the respondents did not have the history of having antimicrobial therapy within 3 months before admission as demonstrated in the table 4.3.9 whereas 376 (33.9%) respondents took antimicrobials within 3 months prior admission. 11.7% respondents out of 376 having the history of antimicrobial therapy developed hospital-acquired infection while 8.2% respondents out of 732 who did not have any history of antimicrobial therapy developed infection. However, the difference was found statistically not significant (X^2 =3.589, df=1, p>0.05).

Table 4.3.9 Distribution of respondents developed HAI by antimicrobial therapy within 3 months prior admission

Antimicrobial therapy within 3 months prior admission	HAI				Total	(%)
	Infection		No infection			
	No.	%	No.	%		
Yes	44	11.7	332	88.3	376	100
No	60	8.2	672	91.8	732	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: X^2 = 3.589, df=1, p>0.05						

4.3.10 Previous hospitalization and HAI

History of previous hospitalization was higher among those who were hospitalized within 6 month prior to study compared to those who were not. Out of 1108 respondents, 378 (34.7%) had history of previous hospitalization and 730 respondents (65.3%) did not have. As depicted in the table 4.3.10 that 13.2% respondents out of 378 who had the history of previous hospitalization developed infections, whereas 7.4% respondents out of 730 developed infection who did not have the history of previous hospitalization previous history of hospitalization have been found significantly associated with development of HAI (x^2=9.953, df=1, p<0.01).

Table 4.3.10 Distribution of respondents developed HAI by previous hospitalization

Previous hospitalization	HAI				Total	(%)
	Infection		No infection			
	No.	%	No.	%		
Yes	50	13.2	328	86.8	378	100
No	54	7.4	676	92.6	730	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: X^2 = 9.953, df=1, p<0.01						

4.3.11 Association of visitors and development of Hospital-acquired infection

4.3.11.1 Visitors and hospital-acquired infection

The study found that visitor had played a significant role in the developed of HAI. Majority respondents were visited by at least two visitors. As depicted in the table 4.3.11 that 70 respondents (6.3%) were visited by more than three visitors, 96 (9.0%) respondents were 3 visitors, respondents 540 (48.7%) by two visitors, 290 respondents (26.2%) by one visitor. Only 112 (10.0%) respondents did not have any visitors.

It is evident from the study that 60% respondents developed hospital- acquired infection who were visited by more than three visitors while 2.1%, 2.9% and 39.6% respondents developed HAI who were visited by one, two or three visitors respectively. On the other hand, respondents who did not have any visitor, had the lowest HAI (figure 4.3).The association between visitor and development of hospital-acquired infection was found statistically highly significant (x^2=182.91, df=4, p<0.001).

Table 4.3.11 Distribution of respondents by number of visitor/patient/day

Number of visitor/patient/day	No. of respondents	Percentage
1	290	26.2
2	540	48.7
3	96	8.7
>3	70	6.3
No visitor	112	10.1
Total	**1108**	**100.0**

Test statistics: X^2 =182.91, df=4, p<0.001.

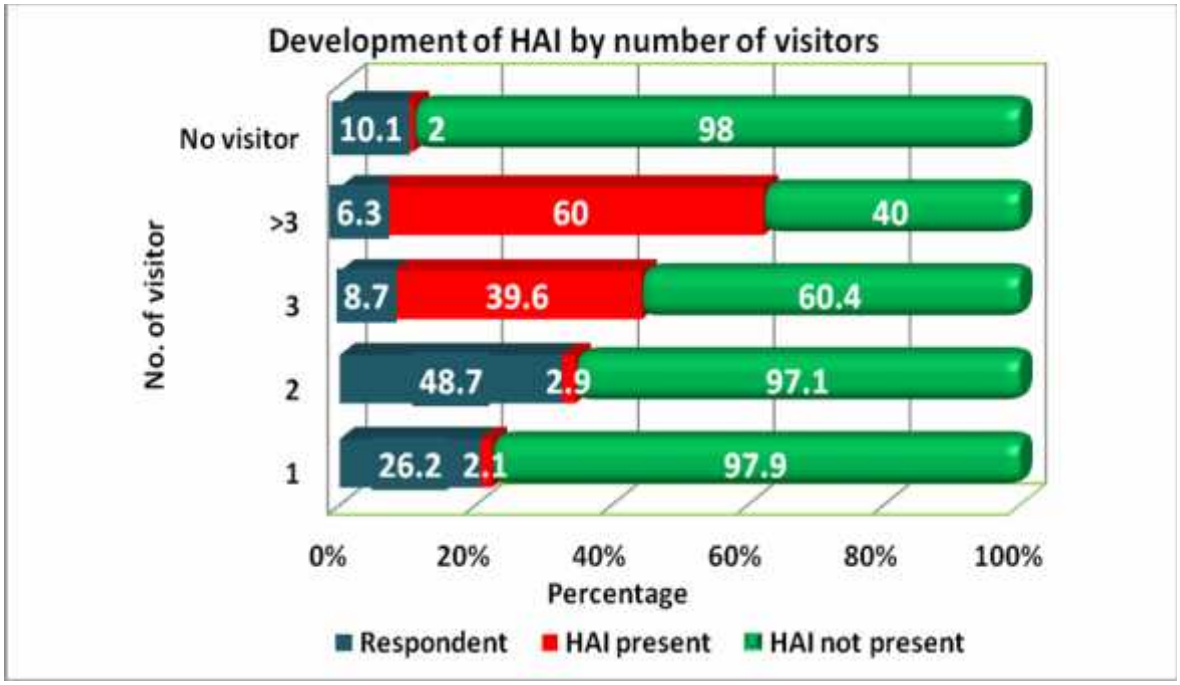


Figure 4.3 Development of HAI by number of visitors

4.3.11.2 Comparison of risk among number of visitor and HAI

The incidence of HAI was significantly higher among the respondents who had more visitors than those with fewer no visitors. An individual who was visited by more than three visitors had 118 times more risk of developing HAI and 47 times more risk who are visited by 3 visitors than the respondents who had 1visitor (Table 4.3.11.(a)). The odds ratio (OR) for the four categories were: 0.2, 0.2, 9.4 and 23.6.

Table 4.3.11. (a) Comparison of risk among number of visitors for HAI

Factors	Odds Ratio	95% CI	Relative risk	P value
1 visitor/patient/day	0.2	0.07 - 0.36	0.93	<0.05
2 visitors/patient/day	0.2	0.1 – 0.29	1.91	<0.05
3 visitors/patient/day	9.4	5.82 – 15.16	10.79	0.000
>3 visitors/patient/day	23.6	13.72 – 40.63	13.02	0.000

4.3.12 Food and drinking water and hospital acquired infection

Every respondent were in the opinion that they were provided fresh and hot food as well as supplied with bottle water. The study result revealed that no respondents were found to suffer from food and food born disease during the time of hospitalization which might be due to strict compliance of consuming food and drink provided by hospital itself.

4.3.13 Distribution of respondents by underlying illness

Table 4.3.12 shows that out of 1108 respondents, 50(4.5%) had coronary heart disease, 26(2.3%) had chronic genitourinary problems, 46(4.2%) had diabetes mellitus and 38(3.4%) had malignant disease and 22 (2.0%) had Ventilator Associated Pneumoniae (VAP). On the contrary, 926(83.6%) had none.

Table 4.3.12 Distribution of respondents by underlying illness

Underlying illness	No. of respondents	Percentage
Coronary heart disease	50	4.5
Chronic genitourinary disease	26	2.3
Diabetic mellitus	46	4.2
Malignancy	38	3.4
VAP	22	2.0
Total underlying illness	**182**	**16.4**
No underlying illness	926	83.6
Total	**1108**	**100**

4.3.14 Underlying illness and hospital-acquired infection

Table 4.3.13 depict the distribution of respondents who developed hospital-acquired infection by underlying illness where out of 182 respondents, hospital-acquired infection was developed by 44 (24.2%) of them. On the other hand, out of 926 who did not have any under lying illness, 60 (6.5%) had contracted infection. The association of having more hospital-acquired infection among the respondents with underlying illness was found statistically highly significant (x^2=56.004, df=1, p<0.001).

Table 4.3.13 Distribution of respondents developed HAI by underlying illness

Presence of underlying illness	**HAI**				**Total**	**(%)**
	Infection		**No infection**			
	No.	**%**	**No.**	**%**		
Yes	44	24.2	138	75.8	**182**	100
No	60	6.5	866	93.5	926	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: X^2 = 56.004, df=1, p<0.001						

4.3.15 Invasive device application and HAI

The table 4.3.14 shows the respondents who were observed for invasive device application and its association with subsequent development of HAI, if any. It was found that out of 404 (36.5%) respondents having the application of invasive device, 60(5.4%) were given nasogastric tube, 220(19.9%) were undergone intravascular device, 84 (7.6%) had urinary catheter, 36 (3.2%) mechanical ventilation and 4(0.4%) had orthopedic device, rest 704(63.5%) did not have any invasive device. Out of 404 who did have invasive device application, 84 (20.8%) of them developed infection where as out of 704 respondents of not having invasive device, only 20 (2.8%) of them had infection (table 4.3.15). Hospital-acquired infection was found significantly associated with application of invasive device statistically (x^2=69.666, df=1, p=0.00).

Table 4.3.14 Distribution of respondents by application of invasive device

Name of invasive device	No. of respondents	Percentage
Nasogastric tube	60	5.4
Intravascular device	220	19.9
Mechanical Ventilator	36	3.2
Urinary catheter	84	7.6
Orthopedic device	4	0.4
Total	**404**	**36.5**
No device	704	63.5
Total	**1108**	**100.0**

Table 4.3.15 Distribution of respondents developed HAI by presence of invasive device

Presence of application of invasive device	HAI				Total	(%)
	Infection		No infection			
	No.	%	No.	%		
Yes	84	20.8	320	79.2	404	100
No	20	2.8	684	97.2	704	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: X^2 = 69.666, df=1, p=0.000						

As illustrated in figure 4.4, the development of HAI was more with increased duration of use of invasive device. In that context it shows that only 3.3% of respondents developed HAI who had the application of invasive device up to 5 days, while 21.8% by 6-10 days, 38.9% by 11-15 days, 21.4% by 16-20 days and 50.0% by more than 20 days. The association of developing HAI with duration of use of invasive device was statistically significant (t=12.063, p=0.000).

The incidence of HAI was significantly higher among the respondents who had been applied invasive device for long duration than those with short duration. An individual who was applied device for more than 20 days were 32 times at risk of developing HAI than those who had 5 days or less of device use. (Table 4.3.15.(a)). The odds ratios for the four categories were: 0.1, 1.8, 1.61, 1.6 and 3.2.

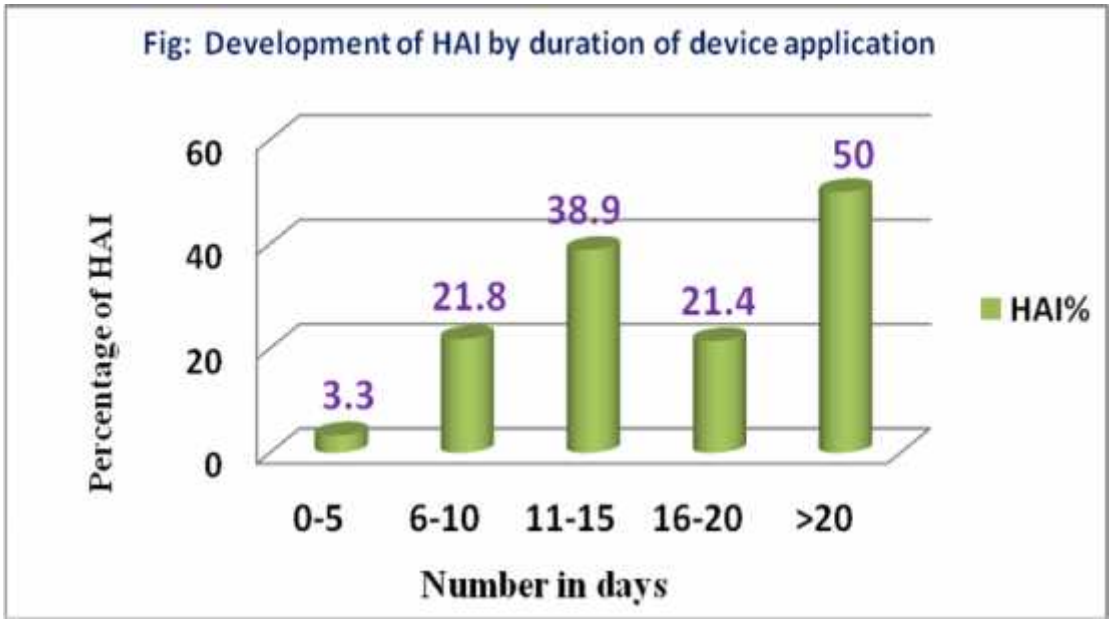


Figure 4.4 Development of HAI by duration of invasive device use

Table 4.3.15. (a) Comparison of risk among duration of invasive device use for HAI

Factors (Duration of invasive device use)	Odds Ratio	95% CI	P value
1-5 days	0.1	0.03-0.60	0.000
6-10 days	1.8	1.14-2.96	0.000
11-15 days	2.6	1.31-5.20	0.000
16-20 days	1.6	0.89-2.78	0.000
>20 days	3.2	0.52-19.28	0.000

4.3.16 Immunosuppressive therapy and development of hospital acquired infection

The distribution of respondents developing hospital-acquired infection by immunosuppressive therapy shows that 88(7.9%) respondents were undergone immunosuppressive therapy (twenty four cytotoxic drugs and sixty four steroids therapies) and 1020 respondents (92.1%) did not have any such therapy (table 4.3.16). Out of 88 respondents who were given immunosuppressive therapy, 28 (31.8%) developed infection in comparison to 76 (7.5%) of 1020 of not treating with immunosuppressive therapy (table 4.3.17). The study result found the association of developing HAI because of treating with immunosuppressive therapy as the difference was found statistically highly significant (x^2=56.554, df=1, p<0.001).

Table 4.3.16 Distribution of respondents by immunosuppressive therapy

Name of immunosuppressive therapy	No. of respondents	Percentage
Cytotoxic drug	24	2.2
Steroid therapy	64	5.8
Total	**88**	**7.9**
No therapy	1020	92.1
Total	**1108**	**100.0**

Table 4.3.17 Distribution of respondents developed HAI by immunosuppressive therapy

Presence of immunosuppressive therapy	HAI				Total	(%)
	Infection		No infection			
	No.	%	No.	%		
Yes	28	31.8	60	68.2	88	100
No	76	7.5	944	92.5	1020	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: $X^2 = 56.554$, df=1, p<0.001						

4.3.17 Immunosuppressive condition and development of hospital-acquired infection

Presence of immunosuppressive condition among the respondents developing hospital-acquired infection illustrates that out of 1108 respondents, 326 (29.4%) were undergone treatment among with immunosuppressive condition and 782 (70.6%) did not have such condition. Among the respondents with immunosuppressive condition, 36 (3.2%) had malignancy, 72 (6.5%) had diabetes mellitus, Renal failure 50 (4.5%), Chronic Genitourinary disease 12 (1.1%), COPD 14(1.3%), Nervous system disorder 64 (5.8%), Chronic cardiac disease 46 (4.2%) and 32 (2.9%) had injury to skin and mucous membrane (table 4.3.18).

Distribution of respondent developed HAI by immunosuppressive condition, 80 (24.5%) developed infection while 24 respondents (3.1%) out of 782 developed infection who did not have the condition (table 4.3.19). The study result revealed the association between development of HAI and presence of immunosuppressive condition as the difference was found statistically highly significant (x^2=124.708, df=1, p=0.000).

Distribution of respondent developing hospital-acquired infection by the presence of specific immunosuppressive condition shows (Figure 4.5) that 14 (17.5%) malignant respondents, 16 (20.0%) diabetics, 12 (15.0%) renal failure, 2 (2.5%) Chronic Genitourinary disease, 4 (5.0%) COPD, 18 (22.5%) nervous system disorder, 12 (15.0%) chronic cardiac disease, 2 (2.5%) skin and mucous membrane developed HAI where as 24 respondents (3.1%) developed HAI presenting no immunosuppressive condition.

Table 4.3.18 Distribution of respondents by presence of immunosuppressive condition

Immunosuppressive condition	No. of respondents	Percentage
Malignancy	36	3.2
Diabetic Mellitus	72	6.5
Renal failure	50	4.5
Chronic Genitourinary disease	12	1.1
COPD	14	1.3
Nervous system disorder	64	5.8
Chronic cardiac disease	46	4.2
Injury skin and mucous membrane	32	2.9
Sub Total	326	29.4
No condition	782	70.6
G. Total	1108	**100**

Table 4.3.19 Distribution of respondents developed HAI by immunosuppressive condition

Presence of immunosuppressive condition	**HAI**				**Total**	**(%)**
	Infection		**No Infection**			
	No.	**%**	**No.**	**%**		
Yes	80	24.5	246	75.5	**326**	100
No	24	3.1	758	96.9	782	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: X^2 = 124.708, df=1, p=0.000						

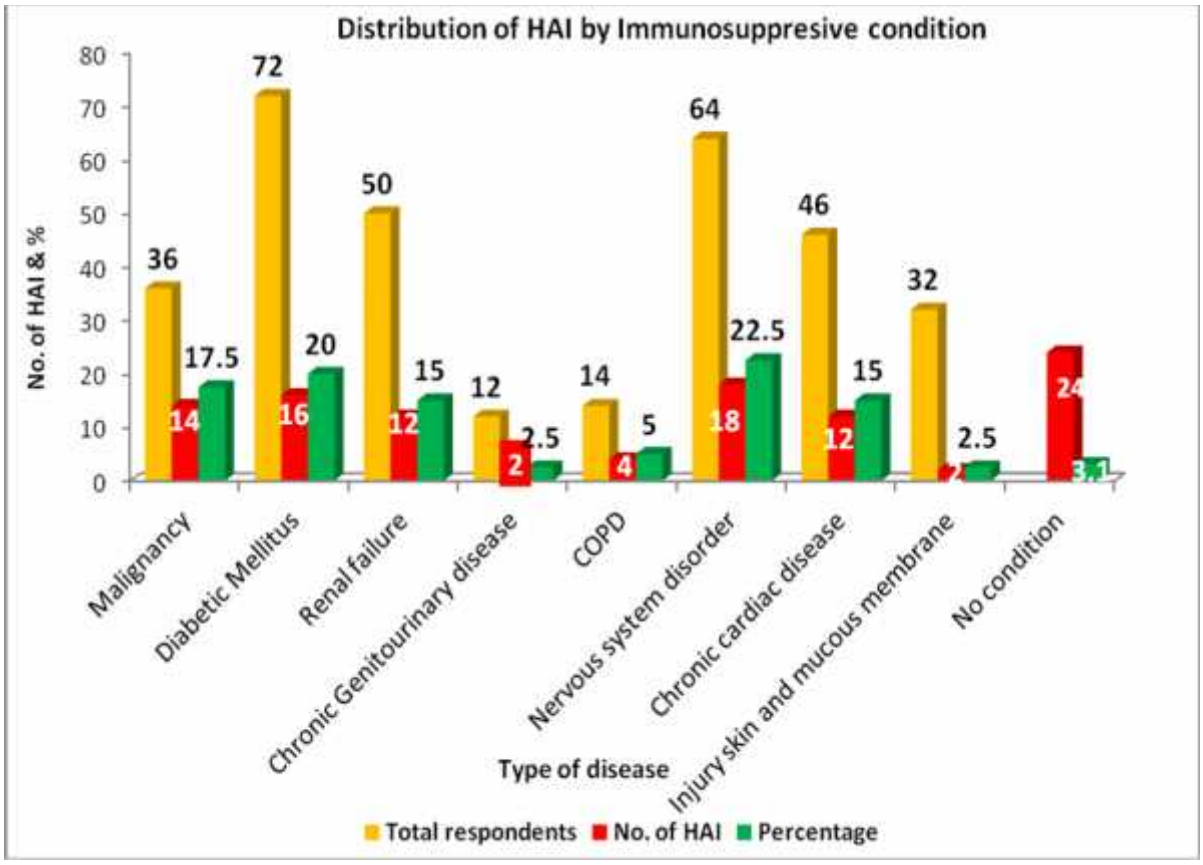


Figure 4.5 Immunosuppressive condition and development of HAI

4.3.18 Antimicrobial therapy during hospitalization and development of hospital-acquired infection

The increasing incidence of hospital-acquired infections caused by antibiotic resistant pathogens are the selection of resistant mutant strain from patients own flora during antibiotic treatment as a result of excessive antibiotic prescribed by hospital doctors subsequently, resistant strains spread among patients in the hospital. Increasing antibiotic resistant is also caused by transmission of resistant bacteria within hospital by cross colonization of patients. Table 4.3.20 shows that out of 1108 respondents, 804 respondents were given antimicrobial therapy during hospitalization and 304 were not given. Those who were given antimicrobials, 96 respondents (11.9%) developed hospital-acquired infection on the contrary those who were not given antimicrobials, 8 of (2.6%) developed infection. The result showed the association between antimicrobials therapy during hospitalization and development of hospital-acquired infection as the difference was found statistically highly significant (x^2=22.474, df=1, p<0.001).

Table 4.3.20 Distribution of respondents developed HAI by antimicrobial therapy during hospitalization

Antimicrobial therapy during hospitalization	HAI				Total	(%)
	Infection		No infection			
	No.	%	No.	%		
Yes	96	11.9	708	88.1	804	100
No	8	2.6	296	97.4	304	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: $X^2 = 22.474$, df=1, p<0.001						

4.3.19 Development of HAI by duration of antimicrobial therapy

4.3.19.1 Association of duration of antimicrobial therapy and development of HAI

The larger the antibiotic use, the higher the incidence of HAI is. Duration of antimicrobial use after admission and development of hospital-acquired infection shows that out of 280 who had antimicrobial use up to 5 days, 16 (5.7%) developed hospital-acquired infection. Like wise 28 respondents (7.6%) of duration 6-10 days, 30 (26.3%) of duration 11-15 days, 8 (36.4%) of duration 16-20 days and 14 (70.0%) of duration more than 20 days developed infection (figure 4.6). The association of duration of antimicrobial use during hospitalization and development of hospital-acquired infection was found statistically highly significant (t=9.675, p=0.000).

The incidence of HAI was significantly higher among the respondents who had been taken antimicrobials for long duration than those with short duration. An individual who was applied device for more than 20 days were 50.5 times more at risk of developing HAI than those who had 5 days or less such type of therapy. (Table 4.3.20.(a)). The odds ratios for the four categories were: 0.4, 0.5, 3.2, 3.9 and 20.2.

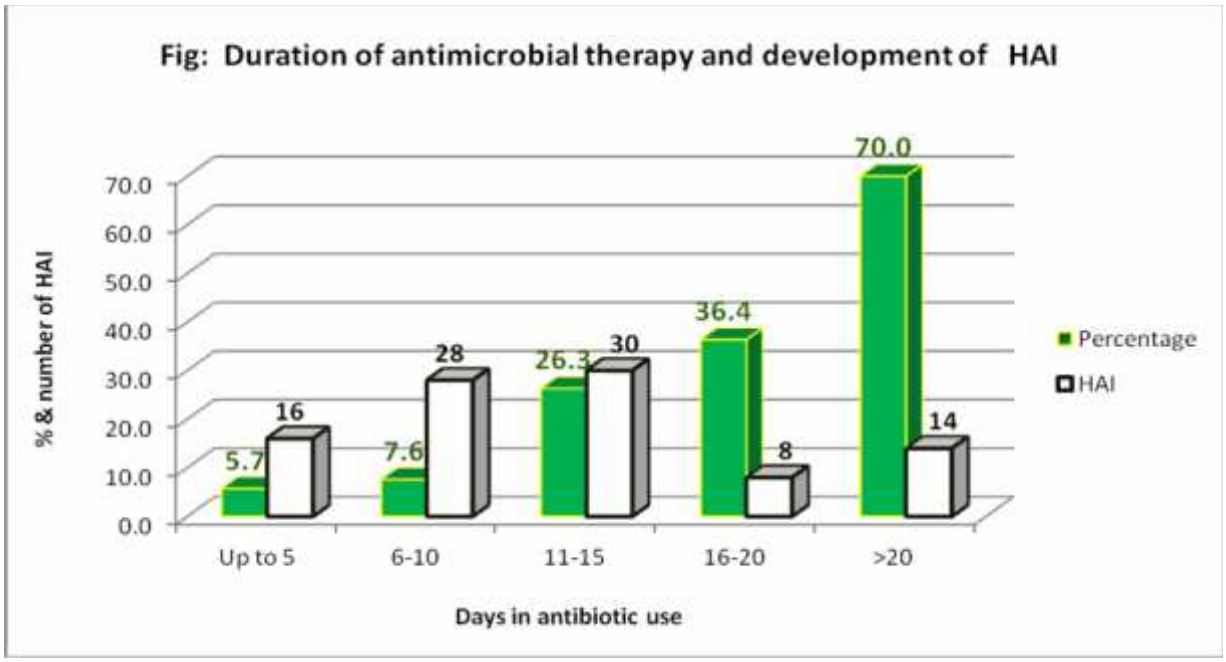


Figure 4.6 Development of HAI by duration of antimicrobial therapy use

Table 4.3.20. (a) Comparison of risk among duration of antibiotic use for HAI

Factors (Duration of antibiotic use)	Odds Ratio	95% CI	P value
1-5 days	0.4	0.21-0.63	0.000
6-10 days	0.5	0.30-0.75	0.001
11-15 days	3.2	1.97-5.32	0.000
16-20 days	3.9	1.55-10.03	0.000
>20 days	20.2	7.56-54.08	0.000

4.3.20 Development of hospital-acquired infection and type of operation

The presence of HAI was more in emergency operations than in routine operations. Out of 304 respondents, 233 of them underwent routine operation and 71 of the respondent's undergone emergency operation. Among the respondents undergone routine operation, 47 (20.2%) developed infection in comparison to the respondents undergone emergency operation of whom 19 (26.8%) developed infection (table 4.3.21). The association between development of hospital acquired infection and type of operation was found statistically not significant (x^2=1.390, df=1, p=0.238).

Table 4.3.21 Distribution of respondents developed HAI by type of operation

Type of operation	HAI				Total	(%)
	Infection		No infection			
	No.	%	No.	%		
Routine	47	20.2	186	79.8	**233**	100
Emergency	19	26.8	52	73.2	**71**	100
Total	**66**	**21.7**	**238**	**78.3**	**304**	**100**
Test statistics: X^2 = 1.390, df=1, p=0.238						

4.3.21 Development of hospital-acquired infection and surgery performed at present

Distribution of respondents developing hospital-acquired infection by surgery at present showed that out of 1108 respondents, 304 respondents undergone surgery at present, 55 respondents (18.1%) developed infection (postoperative) while 49 respondents (6.1%) out of 804 developed infections who did not undergo any surgery at that period (table 4.3.22). The association between surgery and non surgery and development of hospital-acquired infection was found statistically significant (x^2= 41.251, df=1, p=0.000).

Table 4.3.22 Distribution of respondents developed HAI by stage of operation

Stage of operation	HAI				Total
	Infection		No infection		
	No.	%	No.	%	
Post operative	55	18.1	249	81.9	**304**
Non operative	49	6.1	755	93.9	804
Total	**104**	**9.4**	**1004**	**90.6**	**1108**

Test statistics: X^2 = 41.251, df=1, p=0.000

4.3.22 Site of operation and hospital-acquired infection

As illustrated in table 4.3.23, where out of 304 respondents, 43.1% were undergone operation involving cardiac surgery, 5.9% gastrointestinal tract, 11.5% involved nervous system, 14.8% were operated involving KUB, and 24.7% were operated involving Musculo-skeletal tissue, wound debribement, surgical toileting, incision and drainage.

Distribution of respondents developed hospital-acquired infection by site of operation shows that 21.7% respondents out of 131 undergone operation of cardiac surgery, 33.6% out of 35 respondent's nervous system developed infection. 25.8% out of 45 respondent's undergone operation of kidney, ureter, bladder and 31.5% out of 75 respondents, who were undergone operation involving bone and skeletal tissue, wound debribement, surgical toileting, incision and drainage developed HAI respectively (figure 4.7). The study result revealed that there was no association between development of hospital-acquired infection and site of operation as the association was found statistically not significant (x^2=3.78, df=1, p>0.05).

Table 4.3.23 Distribution of respondents by site of operation performed

Site of operation	No. of respondents	Percentage
Operation involving Cardiac surgery	131	43.1
Operation involving GI tract	18	5.9
Operation involving nervous system	35	11.5
Operation involving kidney, ureter, bladder (KUB), Urethra, testis	45	14.8
Musculo-skeletal tissue, wound debriement, surgical toileting, incision and drainage	75	24.7
Total	**304**	**100.0**
Respondents without operation	804	
Total	**1108**	

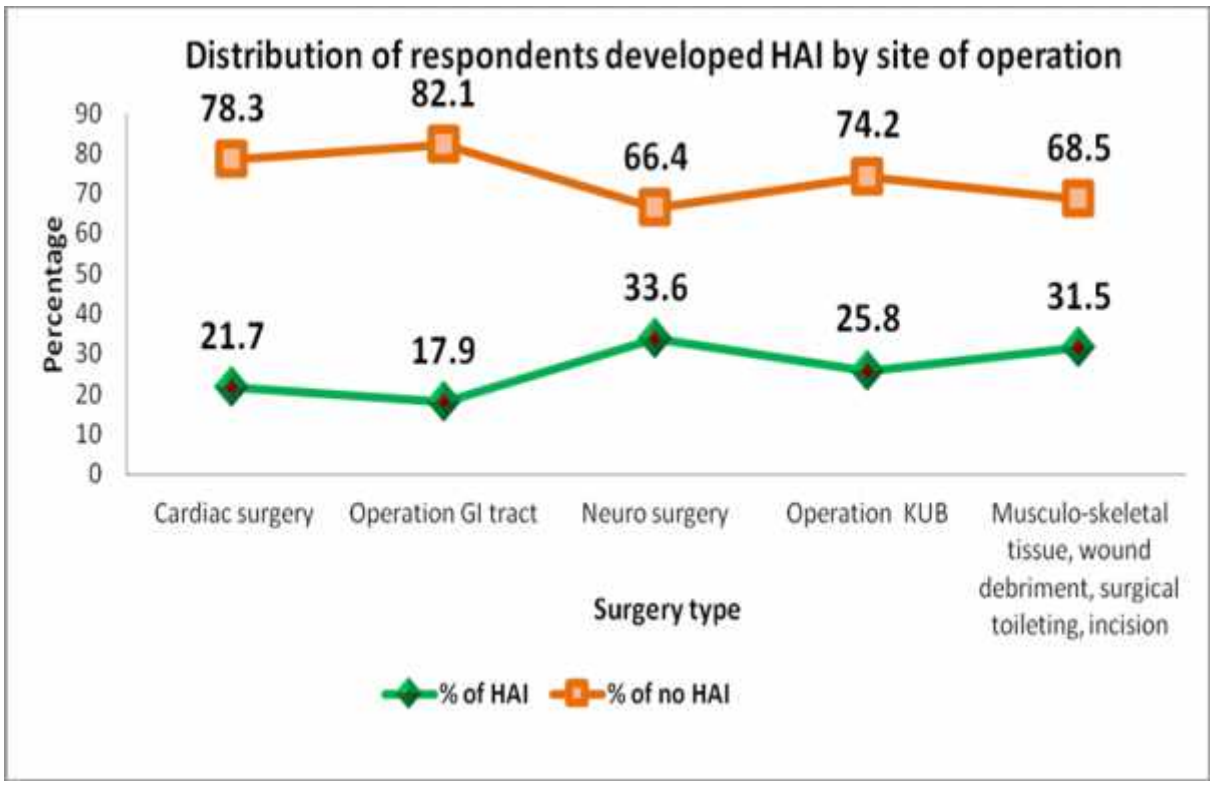


Figure 4.7 Distribution of Respondents developed HAI by site of operation

4.3.23 Hospital days (hospital stays) and development of hospital-acquired infection

As mentioned earlier out of 1108 respondents, 104 (9.4%) developed hospital-acquired infection and 1004 respondents (90.6%) did not develop infections. Hospital days on development of infection is concerned where out of 104 respondents, 36 of the respondents,(3.2%) developed infection by 3-10days, similarly 36 respondents (3.2%) by 11-20days, 14 respondents (1.3%) by 21-30days, 8 respondents (0.7%) by 31-40 days and 6 respondent (0.5%) by 41-50 days and lastly 2 respondents (0.4%) by 51- 60 days. The mean hospital days for development of hospital-acquired infection was 19.96 with standard deviation ±13.11 (table 4.3.24).

On the other hand (table 4.3.25 shows that distribution of respondents by hospital days on discharge out of 1004 respondents, 584 respondents (52.7%) were discharged by 10 days, 298 (26.9%) by 11-20 days, 98 (8.8%) by 21-30 days and 24 (2.2%) by 31-40 days. The mean hospital days on discharge was found as 9.77 and standard deviation ±7.13). The association between hospital days and development of infection was found statistically significant (t=9.77, p=0.000)

Table 4.3.24 Distribution of respondents developed HAI by hospital days

Hospital days on development of infection	No. of respondents	Percentage	Minimum days	Maximum days
3-10	36	3.2	8	60
11-20	36	3.2		
21-30	14	1.3		
31-40	8	0.7		
41-50	6	0.5		
51-60	4	0.4		
Total	**104**	**9.4**		
No infection	1004	90.6		
Total	**1108**	**100**		

Mean ± SD = 19.96 ± 13.11

Table 4.3.25 Distribution of respondents did not develop HAI by hospital days

Hospital days on discharge without infection	No. of respondents	Percentage	Minimum days	Maximum days
Upto 10 days	584	52.7	3	40
11-20	298	26.9		
21-30	98	8.8		
31-40	24	2.2		
Total	**1004**	90.6		
Events of infection	104	9.4		
Total	**1108**	100		
Mean ± SD = 9.77±7.13				
Test statistics: t=7.845, p=0.000				

4.3 Hospital related factors and HAI

HAI is an outcome of interplay of multiple factors related to patients and the environment in which they stay. We have so far focused on patient related factors. This section will examine environment related issues such as, type of wards, frequent patients transfer, cleanliness and precautions taken by staff.

4.41 Different wards and hospital-acquired infection

HAI were found to be different across different wards of admission. As depicted in table 4.4.1, among 1108 respondents 376 (33.9%) were treated in Cardiology ward, 164 (14.8%) were treated in general surgical ward, 122 (11.0%) in neurology, 98 (8.8%) in Urology, 44 (3.9%) in Orthopedic ward, 104 (9.4%) in ICU, 56 (5.0%) oncology and others 144 (13%).

The proportion of HAI was found highest at Intensive Care Unit (ICU). 30.8% respondents at ICU develop hospital-acquired infection while 12.5% for oncology, 10.7% for neurology, 3.7% for general surgery, 5.1% for urology and 4.5% for orthopedic ward (figure 4.8).

Table 4.4.1 Distribution of respondents by different ward

Name of different wards	No. of respondents	Percentage
Cardiology	376	33.94
General Surgery	164	14.80
Neurology	122	11.01
Urology	98	8.84
Othopedic	44	3.97
ICU	104	9.39
Oncology	56	5.05
Others	144	13.00
Total	**1108**	**100**

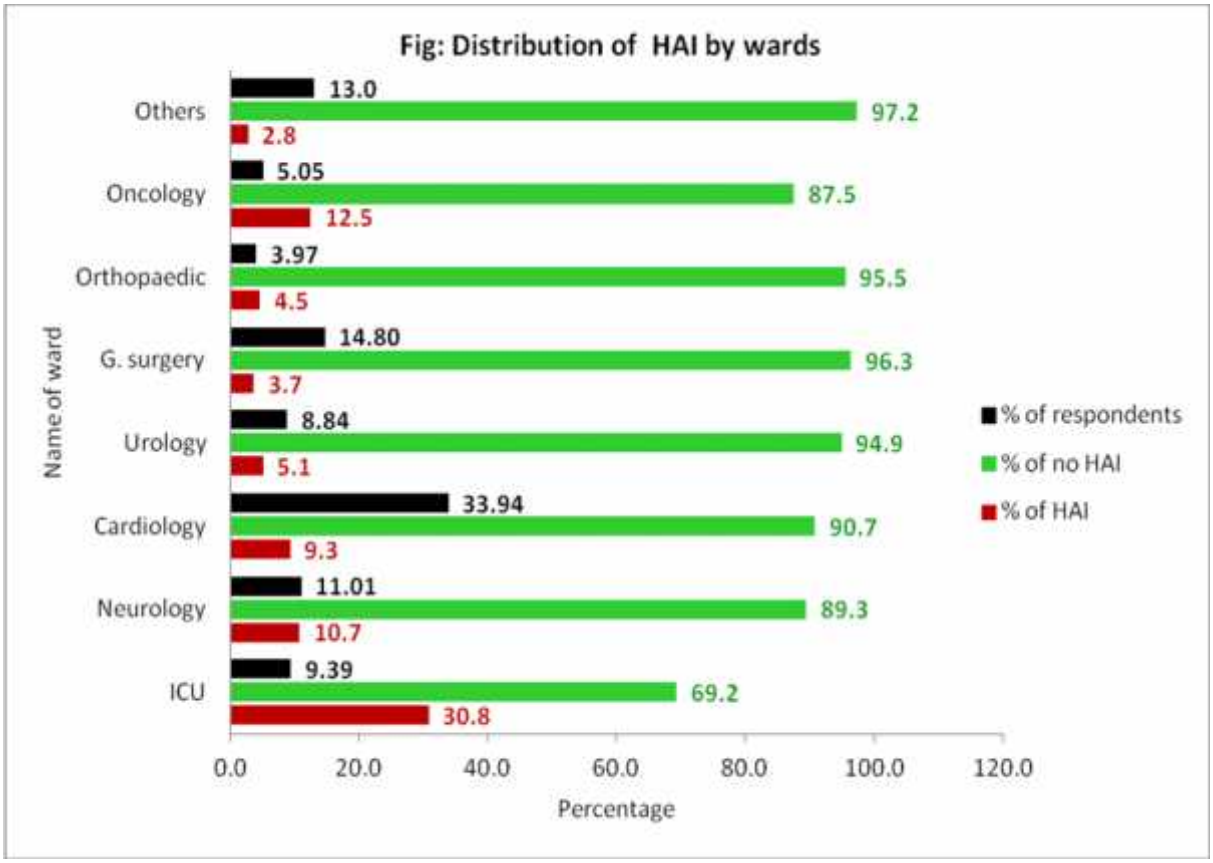


Figure 4.8 Distribution of HAI by wards

4.4.2 Hospital environment and HAI

This section will focus some environmental factors associated with hospital acquired infections which includes frequent transfer of patients, general cleanliness, cleaning object/materials, standard precautions taken by hospital staff.

Table 4.4.2 shows 110 respondents (9.9%) were transferred frequently from one ward to other and 998 (90.1%) were not transferred.

Table 4.4.2 Distribution of respondents by frequent transfer

Hospital environment	Yes		No		Total
	No.	%	No.	%	
Frequent patient transfer from one ward to another	110	9.9	998	90.1	1108

4.4.3 Frequent transfer of patients and HAI

Frequent transfer played an important role in hospital-acquired infection. Table 4.4.3 shows that respondents (14.5%) developed infection out of 110 respondents who were transferred from one ward to other, where as 88 respondents (8.8%) developed infection out of 998 who were not transferred from any ward. The association of contracting hospital-acquired infection and patients, transfer between wards was found statistically not significant (X^2=3.822, df=1, p>0.05).

Table 4.4.3 Distribution of respondents developed HAI by frequent transfer

Frequent transfer	**HAI**				**Total**	**(%)**
	Infection		**No infection**			
	No.	**%**	**No.**	**%**		
Yes	16	14.5	94	85.5	110	100
No	88	8.8	910	91.2	998	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: X^2=3.822, df=1, p>0.05						

4.4.4 General cleanliness and HAI

Distribution of respondents by general cleanliness of wards /department shows that out of 1108 respondents, 780 respondents (70.4%) lodged in wards whose general cleanliness was satisfactory objective and 328 respondents (29.6%) were lodging in wards having dirty environment (table 4.4.4). Table 4.4.5 shows around 9.0% respondents developed infection lodging in wards /departments with satisfactory general cleanliness, while around 10.4% developed infection who lodged in wards which was dirty. The association of general cleanliness and development HAI was found statistically not significant (X^2=0.263, df=1, p>0.05).

Table 4.4.4 Distribution of respondents by state of hospital environment

Inanimate environment	**No. of respondents**	**Percentage**
General cleanliness		
Satisfactory	780	70.4
Dirty	328	29.6
Total	**1108**	**100.0**
Cleaning object/material		

Regularly done	804	72.6
Not regularly done	304	27.4
Total	**1108**	**100.0**

Table 4.4.5 Distribution of respondents developed HAI by general cleanliness of the wards/departments

State of general cleanliness	HAI				Total	(%)
	Infection		No infection			
	No.	%	No.	%		
Satisfactory	70	9.0	710	91.0	780	100
Dirty	34	10.4	294	89.6	328	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: X^2=0.263, df=1, p>0.05						

4.4.5 Cleaning objective/material used by patients and HAI

As depicted in table 4.4.4 that cleaning of object / material used by patients were done regularly for around 73.0% respondents in comparison to around 27.0% respondents, which were not done regularly. Cleaning objective /material used by patients and development of HAI as shown in table 4.4.6 that 76 respondents (9.5%) developed infection out of 804 respondents where cleaning of object /material were regularly done, while 28 (9.2%) out of 304 respondents developed HAI where cleaning of objective /material were not done regularly. The association of state of cleaning object /material of patients and development of hospital-acquired infection was not found statistically significant (x^2=0.008, df=1, p>0.05).

Table 4.4.6 Distribution of respondents developed HAI by cleaning object material

Cleaning object/material	HAI				Total	(%)
	Infection		No infection			
	No.	%	No.	%		
Yes	76	9.5	728	90.5	804	100
No	28	9.2	276	90.8	304	100
Total	**104**	**9.4**	**1004**	**90.6**	**1108**	**100**
Test statistics: X^2=0.008, df=1, p>0.05						

4.4.6 State of standard precautions taken by hospital staff

In our study, Standard precautions, such as hand washing, putting on gloves and masks, putting on gowns, appropriate device handling were assessed based on observation one time /day among doctors and nurses in critical care unit. As illustrated in the figure 4.9, hand washing was found regular for 43% among doctors while regular for 41% among nurses, masking was found regular for 47% among doctors and regular for nurses 74% occasions, gowning found regular by doctors 47% and regular for nurses 73% occasions, appropriate device handling by doctors 45% and for nurses 39% occasions.

Figure 4.9 Standard precautions taken by staff

4.4.8 Logistic regression predicting independent risk for developing hospital-acquired infection

As illustrated in the table 4.4.7 where risk factors are shown to predict the independent risk for developing HAI. The study result from logistic regression shows that respondents with factors like functional state (OR=22.067, p=0.001), number of visitor/patients/day (OR=71.000, p=0.000), underlying illness (OR=4.602, p=0.000), duration of device use (OR=19.000, p= 0.011 and duration of antimicrobial use (OR=1.079, p=0.001) were found as independent risk for developing HAI. However with functional state 1 (can perform activities at his/her own), fewer or no visitor, short duration of antimicrobial therapy, immunosuppressive therapy had preventive preventive/protective effect.

Table 4.4.7 Logistic regression predicting risk for developing HAI

Independent risk factors	Significance	Odds ratio (OR)	95% CI	
			Lower Bound	Upper Bound
Immunosuppressive condition	.001	49.054	5.074	474.222
Duration of antibiotic use	.001	1.079	1.030	1.131
Functional status 1(need no assistance)	.000	.289	.187	.447
Functional status 3(need most assistance	.001	22.067	3.839	126.836
Underlying illness	.000	4.602	2.998	7.064
Duration of device use	.011	19.000	1.947	185.388
Immunosuppressive therapy	.224	.393	.087	1.771
1 visitors/patient/day	.001	.228	.097	.536
>3 visitors/patient/day	.000	71.000	27.752	181.645

4.5 Hospital-acquired infection (HAI) caused by microorganisms

4.5.1 Microorganisms causing HAI

As illustrated in Figure 4.10 that 9 (nine) different types of microorganisms caused HAI among 104 (9.4%) out of 1108 respondents. The present study discloses Gram negative bacilli were predominant infective agents. As infecting species were concerned the most common one was *K. pneumoniae* 34 (32.7%) followed by *Acinetobacter baumannii* 18 (17.3%), *Esch. coli* 18 (17.3%), *Ps. aeruginosa* 14(13.5%), *Staphylococcus aureus* 6 (5.8%), *Streptococcus pneumoniae* 4(3.8%), *Streptococcus pyogenes* 4(3.8%), *Enterococcus faecalis* 4(3.8%) and *Enterobacter sp.* 2(2.0%).

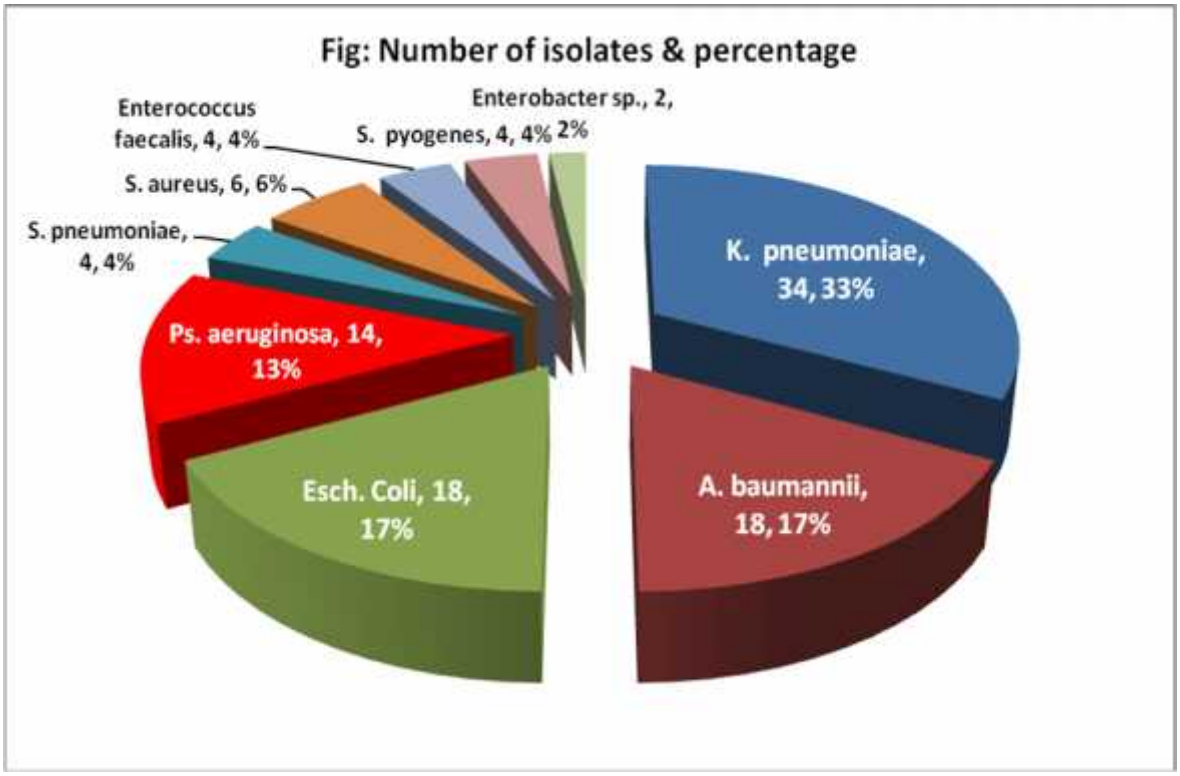
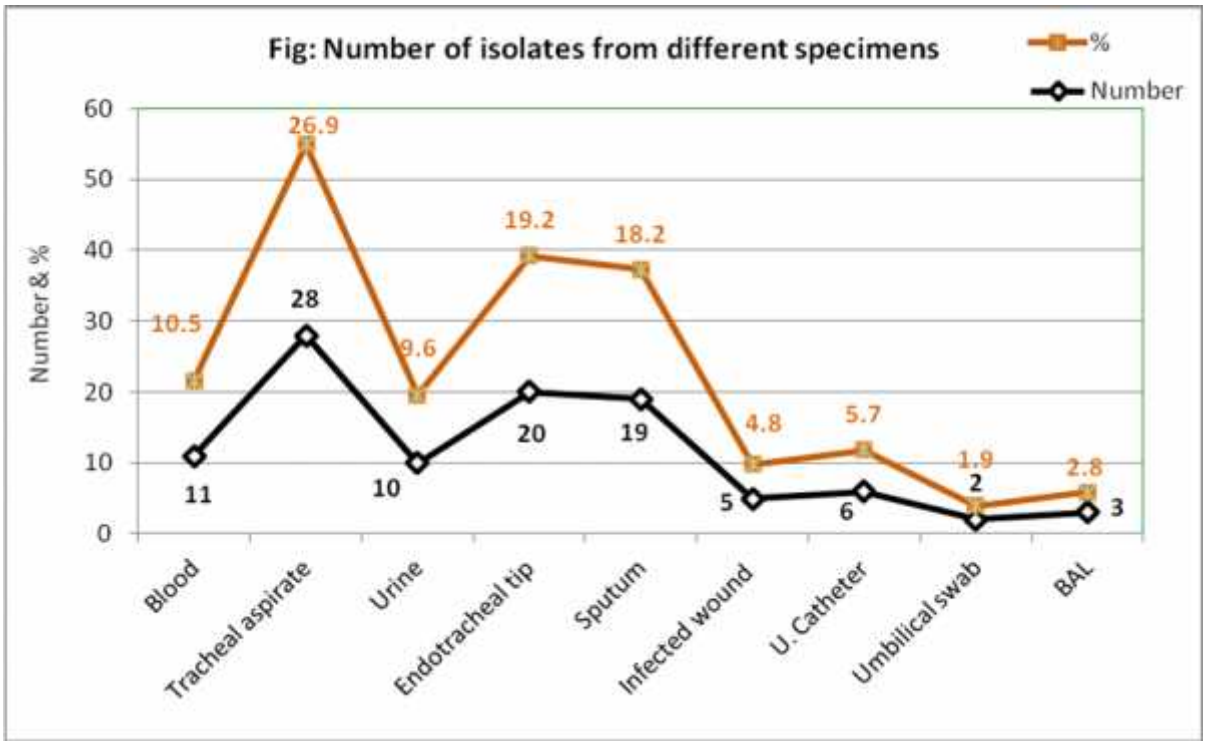


Figure 4.10 Distribution of respondents by different bacterial pathogens

From the figure 4.11 shows among the specimens, tracheal aspirate were highest 26.9% followed by endotracheal tip 19.2%, sputum 18.2% and blood 10.5%.



U. Catheter- Urinary Catheter, BAL- Bronco Alveolar Lavage

Figure 4.11 Number of isolates from different specimens

4.5.2 Antibiogram of different bacterial isolates

Table 4.5.1 shows the antibiogram of different bacterial isolates of Enterobacteriaceae from different culture. *K. pneumoniae* were 76% sensitive to colistin followed by imipenem 65%. On the other hand, the high resistance rates to ceftriaxone and cefixime were found equal proportion
of 94%. Resistances were observed to amoxyclavonic acid, cefepime, ceftazidime, ciprofloxacin and amikacin to 82%, 71%, 76%, 71% and 65% respectively. *A. baumannii* were 78% sensitive only to colistin followed by cefepime and ceftazidime 44% each. High resistances were found 89% against amoxyclavonic acid, Cefixime and aztreonam. Amikacin, imipenem and piperacillin-tazobactam were noted resistance to 78% each and 67% gentamicin.

Esch. coli were sensitive (89%) to Colistin followed by amikacin and imipenem 67% but 100% resistance were found from amoxyclavonic acid, Cefixime and ceftriaxone. 78% resistance were observed from cefepime and ciprofloxacin.

Pseudomonas aeruginosa were 86% sensitive ceftazidime and piperacillin-tazobactam but 100% resistant to ceftriaxone. Sensitivity of colistin showed 71%. However, 86%, 71% resistant were detected against cotrimoxazole and netilmycin respectively.

Enterobacter sp. showed 100% sensitive against amikacin, cefepime, ciprofloxacin, imipenem and colistin but 100% resistant to amoxyclavonic acid, ceftriaxone and gentamicin.

Table 4.5.2 shows for antimicrobial sensitivity pattern of gram positive infective organisms responsible for HAI. *Staphylococcus aureus* showed 100% sensitive to amoxyclavonic acid, vancomycin each but 100% resistant against Cefixime and oxacillin. Penicillin and Erythromycin were found 67% resistance each.

S. pneumoniae were observed 50% sensitive against amoxyclavonic acid and ciprofloxacin. 100% sensitive to doxycycline, penicillin and erythromycin.

S. pyogenes showed 100% sensitive to doxycycline, erythromycin and vancomycin but 50% resistant to amoxyclavonic acid, cefepime and ciprofloxacin.

Enterococcus sp. were found 100% sensitive against amoxyclavonic acid, doxycycline, linezolid and vancomycin but 100% resistant from cefepime and penicillin.

Table 4.5.1 Antimicrobial sensitivity pattern of Gram negative bacteria

Organism		AK	%	AMC	%	FEP	%	CFM	%	CRO	%	CAZ	%	SXT	%	CIP	%	GN	%	IPM	%	MEM	%	NET	%	F	%	NA	%	CT	%	TZP	%	ATM	%
A. baumannii	S	4	22	2	11	8	44	2	11	4	22	8	44	4	22	4	22	6	33	4	22	4	22	3	33	0	0	0	0	14	78	4	22	2	11
	R	14	78	16	89	10	56	16	89	14	78	10	56	14	78	14	78	12	67	14	78	14	78	6	67	4	100	4	100	4	22	14	78	16	89
Esch. coli	S	12	67	0	0	4	22	0	0	0	0	0	0	4	22	4	22	8	44	12	67	12	67	10	56	-	-	-	-	16	89	8	44	0	0
	R	6	33	18	100	14	78	9	100	18	100	18	100	14	78	14	78	10	56	6	33	6	33	8	44	-	-	-	-	2	11	10	56	18	100
Enterobacter sp.	S	2	100	0	0	2	100	0	0	0	0	2	100	0	0	2	100	0	0	2	100	2	100	2	100	-	-	-	-	2	100	2	100	2	100
	R	0	0	2	100	0	0	2	100	2	100	0	0	2	100	0	0	2	100	0	0	0	0	0	0	-	-	-	-	0	0	0	0	0	0
K. pneumoniae	S	12	35	6	18	10	29	2	6	2	6	8	24	10	29	10	29	14	41	22	65	20	59	12	35	2	17	0	0	26	76	10	29	8	24
	R	22	65	28	82	24	71	32	94	32	94	26	76	24	71	24	71	20	59	12	35	14	41	22	65	10	83	12	100	8	24	24	71	26	76
Ps. aeruginosa	S	6	43	0	0	8	57	2	14	0	0	12	86	2	14	8	57	8	57	10	71	10	71	4	29	-	-	-	-	10	71	12	86	4	29
	R	8	57	7	100	6	43	12	86	14	100	2	14	12	86	6	43	6	43	4	29	4	29	10	71		-	-	-	4	29	2	14	10	71

Amikacin (AK), Amoxyclavonic acid, Co-trimoxazole (SXT), Ceftriaxone (CRO), Cefepime (CFM), Cefixime (CXM), Ceftazidime (CAZ), Ciprofloxacin (CIP), Gentamicin (CN), Imipenem (IPM) Meropenem (MEM), Netilmicin(NET), Colistin sulphate (CT), Piperacillin-Tazobactam (TZP), Nalidixic Acid (NA), Nitrofurantoin (F), Aztreonam (ATM)

Table 4.5.2 Antimicrobial sensitivity pattern of Gram positive bacteria

Organism		AMC	%	FEP	%	CFM	%	SXT	%	CIP	%	F	%	NA	%	DO	%	LZD	%	OX	%	VA	%	E	%	P	%
S. aureus	S	6	100	4	67	0	0	4	67	2	33	-	-	-	-	4	67	6	100	0	0	6	100	2	33	2	33
	R	0	0	2	33	6	100	2	33	4	67	-	-	-	-	2	33	0	0	6	100	0	0	4	67	4	67
S. pneumoniae	S	2	50	2	50	2	50	0	0	2	50	-	-	-	-	4	100	4	100	4	100	4	100	4	100	4	100
	R	2	50	2	50	2	50	4	100	4	50	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0
S. pyogenes	S	2	50	2	50	0	0	2	50	2	50	-	-	-	-	4	100	4	100	-	-	4	100	4	100	2	50
	R	2	50	2	50	2	100	2	50	2	50	-	-	-	-	0	0	0	0	-	-	0	0	0	0	2	50
E. faecalis	S	4	100	0	0	2	50	2	50	2	50	4	100	4	100	4	100	4	100	-	-	4	100	2	50	0	0
	R	0	0	4	100	2	50	2	50	2	50	0	0	0	0	0	0	0	0	-	-	0	0	2	50	4	100

Amoxyclavonic acid, Penicillin-G (P), Co-trimoxazole (SXT), Ceftriaxone (CRO), Cefepime (CFM), Ciprofloxacin (CIP), Doxycycline (DO), Linezolid (LZD), Vancomycin (VA), Erythromycin (E), Oxacillin (OX), Nalidixic Acid (NA), Nitrofurantoin (F)

Chapter-5

DISCUSSION

DISCUSSION

Hospital acquired infection is a problem affecting the hospitalized patients both in developed and developing countries. In developed countries many interventions were made to control Hospital acquired infection. But in developing countries like Bangladesh no emphasis has yet been given in this field. In different situations and perspective the pattern of nosocomial infections is different. Many studies have been documented hospital-acquired infections (HAI) as a global threat for a major cause of morbidity and mortality. A high frequency of HAI means a poor quality of health care services which may lead to avoidable cost. Despite rapid advances of medical science in both therapeutic and diagnostic arena HAI persist as a bane in hospital through out the world.[1] Although the situation in Bangladesh is largely unknown, a tertiary level hospital data showed a clear increases in 2003 in hospital-acquired infection in Bangladesh[22]. It is believed around 80% of HAI are caused by microbial flora that patients bring upon admission. This “stay at home” flora appears to be opportunistic to new environment and is able to take advantage of new routes that medical procedures offer. A number of risk factors have been linked with the development of HAI specially the organisms with antibiotic resistance properties. Perhaps, the most important is prior antimicrobial therapy, especially broad-spectrum agent which has been shown to suppress normal microbial flora which protect body from pathogenic ones. This may result in growth of microorganisms resistant to antibiotic used[166]. The extent and pattern of its resistance to different antimicrobials are largely unknown in Bangladesh because of lack of studies on this field. The present study aimed at describing the state of hospital-acquired infection in United Hospital Limited, Dhaka, Bangladesh. In doing so, it tends to fill a major gap in current knowledge of extent of HAI. It would contribute to the knowledge on socio demographic and economic correlates as well as patient and hospital related information associated with development of HAI. Overall, the study found that HAI constituted a major avoidable health problem in the hospital with significant economic sequelae, patients, suffering and administrative inconveniences.

The significance of these findings will now be discussed in relation to the objectives of study and in the light of findings from other related research. The research may provide information of value to health planners in taking timely measures and future investigators for further research. The following subsections will now delineate the discussion on the study findings in details:

5.1 Socio-demographic characteristic and HAI

5.1.1 Age

This study was carried out on a special group of population, which are largely dominated by young males. From the present study it is evident that maximum respondents (71.5%) were in the age group of (20-59) followed by group 60 years and above (14.4%). The range of age was from 0.8-92 years. The mean age was around 43.78±18.18 years. Regarding development of HAI by age group, 60 years and above were 17.5%. No gross difference was found among the age group up to 12 years and 20-59 years in developing HAI. According to Health and Population Statistical Report 1999-2000, the proportion of population in age group15-59 years was 54.0% and extreme of age group, group was 8.90% which do not accord with the present study[26]. However the present study finding regarding mean age is almost similar to study finding found by Hussain et al[21] where the mean age of the respondents was 39±22 years. The present study does not accord with Sopena Neives, et al[167] where the mean age of the respondents were found as 63.2±16.9 years. The present study result revealed that there was statistical association between age group and development of HAI. Also for extreme of age the difference was found statistically significant.

The study result is not consistent with the study finding of Hussain et al[21] where no association was found statistically in developing HAI with different age group. A clear picture of distribution of HAI by age has been shown in a study conducted by Richards j. Michael et al[168] where HAI was happened to occur with different proportion among different age groups. The present study concludes that the difference was there because of might be not equal hospital facilities for all departments and to some extent due to short duration of study period.

5.1.2 Sex

The present study shows that majority of respondents 704 (63.5%) were male and 404 (36.5%) were female. The male and female ratio was 1.74:1. The present study finding does not show any similarity to BBS Report 2002 were proportion of male and female were shown (50.94%) and (49.06%) respectively[169] but shows the similarity with the finding evident in there study done in 1990 on Nosocomial Infection at Dhaka Medical College Hospital by Hussain et al[21] were the majority of respondents (70.0%) were male. The present study is also consistent with the study done by Sopena Neives, et al [167] where the male respondents were found higher (70.3%). The study respondents consist of less number of females because of not

including the Gynae and Obstetric ward as significant number of patients is there. Moreover, this difference may be due to more exposure of male to environment than female.

As far as association of sex and development of HAI is concerned, the present study finding shows that 10.5% and 7.4% of HAI was happened to occur among male and female respondents respectively and association of sex and HAI was not found statistically significant. The similar result of no association between sex and development of HAI (male: 27.9%, female: 34.7%) was found by Hussain et al[21]. The present study reveals that sex difference was not found in developing HAI may be of not including Gynae and Obstetric ward in the study, equal health consciousness among both the sexes and some extent, short duration of study period also.

5.1.3 Religion

The present study revealed that majority (98.6%) of respondents participated were Muslims and only (1.0%) were Hindu and Buddhist. It does not correspond with BBS findings (2002)[169] where it was shown that the religion of people in our country was 88.3% Muslims, 10.5% Hindus and rest 1.2% Buddhist and Christian because of obvious reasons of greater proportion of Muslims. The study results find that religion could not show any difference in developing HAI which may be due to very few numbers of respondents from Hindu and Buddhist.

5.1.4 Educational qualification

It was found in the study that majority of respondents (94.6%) were educated. Among the respondents, maximum (26.7%) were having graduate followed by the respondents (23.5%) post graduate degree, then 14.6% SSC qualified, 14.4% were HSC qualified, 12.5% high schooling and lastly 2.9% primary education. At the stage of not yet schooling were 5.4%. According to BBS 2002 literacy rate of population 5+, 7+ and adult literacy rate were 48.1%, 47.3% and 51.0% respectively[169]. The study result revealed that the adult literacy rate is much higher, might be because of majority portion respondents were adult and they were educated to greater extend because of service requirement, educational facilities, family motivation as well as understanding the importance of education for every aspect of life. In the present study the association of educational qualification and development of HAI where HAI was developed by 11.8% respondents who had education from class i – class x, 9.3% who were SSC and HSC qualified, 9.0% who had graduate and post graduate degree. The study shows

that educational qualification did not show any association in developing HAI as it was found statistically not significant. Furthermore, no difference may be because of short duration of study period and absence of large sample.

5.1.5 Occupation

The present study shows that majority of respondents (35.7%) having service holder at present followed by businessman (32.7%), housewife (10.6%), retired (9.2%), students (6.3%) and 5.4% in not applicable group. So as to occupation and development of HAI is concerned, majority of infection occurred among retired person (15.7%), followed by housewife (12%). Service holder, businessman and students were found to contribute almost equally in developing infection (8%). The present study result revealed that there was no association with occupation and development of HAI as the difference was not noticed statistically significant. This study does not accord with the study conducted by Hussain et al[21] where by occupation, maximum number was businessman (18.3%) followed by student (17.65%) and house wife (16.6%). Regarding HAI development in that study, highest infection was happened to occur within housewife (45.0%) but in the present study highest numbers of respondents were among the service holder (35.7%) while infection was highest among retired person (15.7%). This difference may be due to age factors and less immunity than adult.

5.1.6 Marital status

In the present study 880 (79.4%) respondents were married and 228 (20.6%) were unmarried. 10.0% married and 7.0% unmarried respondents developed HAI which shows no association of developing HAI by marital status as it was found statistically not significant. This may be due to smaller sample size, socioeconomic improvement as a whole and ensured medical facility irrespective of marital status.

5.1.7 Family size (Household members)

Majority of respondents (44.8%) in the present study had 3-4 members in their family followed by 38.1% respondents having family members 5 and above, 10.5% having 2 members. On the contrary, minor portion (6.7%) respondents used to live without family. The study result revealed that mean number of a family members of study population was 4.11± 1.118 which is lower than the national figure of 5.5 as average households member[26]. This may be due to marital restriction up to certain age, better family planning, socioeconomic

improvement and awareness of populations. Regarding association of developing HAI by number of family members, this study shows that 16.2% of respondents developed infection having single life followed by 10.9% family members having 5 and above and 8.1% by family of 3-4 members. 5.2% infection shows 2 family members. The highest rate of infection 16.2% among single life is not clear. They are mostly live in dormitory where environment might be unhygienic condition, crowded condition because of scarcity of space helped in colonization of bacteria that become resistant in hospital environment after admission resulting development of higher percentage of HAI.

A few research works on socio-demographic status and development of HAI in Bangladesh has been done, even globally the research work may be done but could not be reviewed extensively by the researcher. Therefore, researcher has to face lot of limitation to compare and determine his position in this regard. However, a study was conducted by Islam Saiful et al[170], on skin infection among hospitalized children to compare the pattern of socio-demographic features and nutritional profile of skin infected and non-infected children with malnutrition. The above mentioned study revealed that the high rate of skin infection (27.9%) were found among the respondents having poor personnel hygiene, malnutrition and low standard of living which are consistent with the present study.

5.2 Incidence of HAI and its type

5.2.1 Incidence rate of hospital-acquired infection (HAI)

The present study observed prospectively 1108 respondents for a period of 7 months, which yielded a total 11886 hospital days at risk. During this period, 104 (9.4%) events of infection occurred among the 1108 respondents, which yielded incidence rate 8.75/1000 hospital days (9.4% infection rate). In Bangladesh, no such study had been carried out so far to find out incidence rate of HAI. A study was conducted in 2012[197] in a public tertiary teaching hospital of Eastern India showed HAI rate is 11.98% (95% confidence interval 7.89–16.07%). *Pneumonia* was the most frequently detected infection (62.07%), followed by urinary tract infections. The study accord to our study. Shalini S et al[205] carried out a study in 2010 in India showed the rate of HAI was 27. 4%. Another similar study was conducted by Hopmans-Kamp et al[171] in 2003 in Netherlands, University of Medical Center, Utrecht, where an incidence rate was found as 17.8/1000 patient days which is much higher than the present study. This may be due to more immunosuppressive patients in Netherlands study. A surveillance study was conducted by Rotstein Colman et al[172] in 1988 at Roswell Park Memorial Institute, New York

for duration of 20 months on cancer patients where the incidence rate was found as 6.27/1000 patient days with highest incidence to acute Myelogenous Leukemia as 30.49/1000 patient days. This may be due to all types of patients in the present study compare to only cancer patients in New York study. Jumulitrat S, et al[173] conducted a prospective study in 2002 in Thailand where they found an incidence rate as 8.0/1000 patient days which is similar to present study. This may be due to socio cultural similarity and inclusion of all types of patients. This study does not accord with the study done by Hussain et al[21], where out of 240 respondents, 72(30%) of the study patients developed HAI which was much higher than present study. This may be due to difference in method of study, irregular practice of standard precaution measures, poor knowledge and lack of awareness about hospital-acquired infection among hospital staff at that time.

5.2.2 Type of hospital-acquired infection (HAI)

In the present study, among 1108 respondents who were at risk, 104 (9.2%) of them developed hospital-acquired infection (HAI). Out of 104 (9.2%) events of infection, 56.7% respiratory infection (RTI), 15.4% urinary tract infection (UTI), 10.6% blood stream infection, 4.8% surgical site infection (SSI), 9.6% ventilator associated pneumoniae (VAP) and 2.9% skin and soft tissue infection (SSTI) were found. A study was conducted by Sugata Dasgupta et al. 2012[197] showed Pneumonia was the most frequently detected infection (62.07%), followed by urinary tract infections and central venous catheter associated bloodstream infections. In 2012**,** Théodora Angèle Ahoyo et al.[198] studied to estimate the prevalence of nosocomial infections. The most frequent infections were related to the urinary tract (48.2%) followed by vascular catheter use (34.7%), and surgical site (24.7%). Shalini S et al[205] in 2010 carried out a study in 2010 in India showed the rates of the urinary, respiratory and the intravascular catheter related infections were 55.52%, 35.78% and 11.52% respectively which is not similar at all with our study. In 1990, Hussain et al[21] conducted a cross-sectional study at DMCH where they found four types of HAI as SSI (36.1%), UTI (23.6%), RI (15.2%) and gastro-intestinal tract infection (12.6%) which differs with present study. This study is also not consistent with Rahman Motiur ASM et al[174] where UTI (36.69%) was found highest followed by SSI. Jumulitrat S, et al[173] conducted a prospective study in 2002 in Thailand where SSI was 31.1% which is much higher than present study.

The study result could reveal that higher proportion of RTI in the present study may be due to indiscriminate use of antibiotics, improper use of invasive device application, poor precaution measures taken by hospital staff.

5.3 Patient Related Factors and HAI

5.3.1 Extreme of age

It is revealed in the present study that 16.7% of the respondents of extreme of age developed HAI. A study conducted by Dr. Anand Saxena et al[199] in 2012 of tertiary care centre in Central India. Age of more than 50 years was found to be a risk factor for developing HAI which is consistent with our study. This study is also constant with the study conducted by Hussain et al[21] where they found that (38.0%) of the patients above 60 years and (35.0%) of less than 14 years developed infection which might be due to difference in grouping of age. The present study also accord with the study done by Beau jean[175] et al in 1997 in the Netherlands on 300 geriatric patients where they found that every third patient developed at least one hospital-acquired infection. The study result reveals that the presence of association of extreme of age in developing HAI may be due to less immunity, economically not better off patients and lack of accessibility to medical service by all irrespective of social and economical status.

5.3.2 Functional state of respondents and development of HAI

It is evident from the present study that majority of respondents (58.0%) could perform their activities independently of whom (5.0%) developed HAI. The respondents (28.0%) who required some assistance, out of them (8.9%) developed infection. On the contrary 14.0% respondents who required assistance most of the time, 28.9% of them developed infection. Physical mobility has been found significantly associated with HAI. Those who were physically independent were less likely to developed HAI. Respondents who require assistance most of the time were twenty times more at risk of developing HAI than who were independent.

Functional status is determined by the ability to perform activities of daily living (ADLs), eating, dressing, bathing, ambulating, and toileting and instrumental ADLs (IADLs) shopping for groceries, meal preparation, housework, laundry, getting to places beyond walking distance, managing medications, managing finances, and using a telephone.[200] It is estimated that up to 8 percent of community dwelling elders need assistance with one or more ADLs.

Among those age 85 and older, the percentage who live at home but need assistance or who live in a nursing home increases significantly to 56 percent of women and 38 percent of men.[200] Chronic illness and comorbidities can directly impact functional status in the elderly. Chronic health care conditions that are most prevalent in the elderly include heart disease, hypertension, arthritis, diabetes, and cancer.[201] Acute illness due to chronic disease and chronic co-morbidities accounts for a significant number of hospitalizations in the elderly.

This study result does not accord with a study conducted by spindel J Steven et al[50] on "Infections caused by *Staphylococcus aureus* in a Veterans, Affairs, Nursing Home Care Unite: A-5 year experience" where no significant difference was found in two groups of patients of moderate and high level nursing in developing HAI by methicillin-sensitive and methicillin-resistance *Staphylococcus aureus*. In the present study about 42.0% of the respondents having functional state II and III developed maximum events of infection (36 events) which may be due to repeated exposure to nursing staff, attendants and uncontrolled visitors made transmission easiest for cross infection. The Glasgow coma score in surgical ICU was not maintained routinely, as such the relation of level of consciousness and development of HAI could be not studied.

5.3.3 Visitors/patient/day and development of HAI

The more the number of visitor, the higher the probability of developing HAI was. The present study result revealed that about half of the respondents were visited by 2 visitors followed by 26.2% by 1 visitor and 10.1 % did not have any visitor. On the contrary, 6.3% respondent was visited by more than 3 visitors and 8.7% by 3 visitors. In relation to development of HAI, 60% respondents having more than 3 visitors developed infection followed by 39.6% respondents having 3 visitors developed infection. On the contrary, 2.0% of respondents having no visitors developed infection. The study result found that there is strong association between visitor and development of infection as it was found statistically highly significant. The respondents having >3 visitors had around 118 times more risk of developing infection than those who had fewer/no visitor. The present study result accord with the study done by Hussain et al[21] where 37.5% respondents developed infection having 9 visitors/day in comparison to 21.8% with 0-2 visitor/day. According to khan Hossain Mohiuddin et al[22] where number of visitor/day/patient was associated in developing HAI ($t=13.526$, $p<0.001$). The study reveals that respondents having more visitors than others developed maximum number of events of infection since direct transmission of infection

become easier with respondents visited by large number of visitors. Regarding the number of visitors, researcher used to depend upon patients, patients attendant or hospital staff to some occasions.

5.3.4 Food and drinking water and hospital-acquired infection

Supplying fresh and hot food from authorized source as well as mineral bottle drinking water is mandatory in this hospital. In the study it was also found that every respondent were in the opinion that they were provided fresh and hot food as well as supplied with water from mineral water bottle. The study result revealed that no respondents were found to suffer from food and water borne disease during the time of hospitalization. This may be due to strict compliance of hospital instruction not to consume any food or water other than hospital source.

5.3.5 Underlying Illness and development of HAI

It is found in the present study that among the study respondents, 182(16.4%) had underlying illness in comparison to 926 (83.6%) who did not have. Out of 182(16.4%) respondents having underlying illness, 50(4.5%) had coronary heart disease, 46(4.2%) with Diabetes Mellitus, 38 (3.4%) with Malignancy, 26(2.3%) with Chronic Genitourinary diseases and 22(2.0%) with ventilator associated pneumoniae. Considering the presence of underlying illness, it is evident that 44 (24.2%) respondents developed HAI in comparison to 60(6.5%) respondents without underlying illness. The study result revealed the association between underlying illness and HAI, which was found statistically highly significant.

The present study consistent with the study conducted between 2006-2009 by B. Guzmán-Herrador et al[202] showed patients who developed nosocomial pneumoniae (NP) had a 2.6 higher risk (95% confidence interval: 2.1–3.0) of dying compared with those who did not develop NP.

The present study does not accord with the study conducted by Spindel J. Steven et al[176] where no difference was found with Diabetes Mellitus, Malignancy, COPD, chronic cardiac disease, chronic genitourinary disorders in developing methicillin-resistant and methicillin-sensitive *Staphylococcus aureus* infection, otherwise consistent with the study done by Cardoso T.et al[177] where 78(20.3%) patients had Hospital-acquired Respiratory infection (HARI) of whom 62.8% having underlying illness like, cancer, DM, cardiac, renal, COPDE, hepatic and nervous system illness (p=0.04). Old age means weakened immunity. In the present study, 102 (9.2%) of the respondents were retired and most of them were aged and got

admitted with underlying medical condition developing 44 events of infection because of weakened immunity out of 104 events which may be suggestive of having association with underlying illness.

5.3.6 Invasive device and development of HAI

It is evident in the present study that 404 (36.5%) of the respondents had the application of invasive device and among them 84 (20.8%) developed HAI. on the contrary 20 respondents (2.8%) developed HAI out of 704 (63.5%) of not having invasive device. By specific device is concerned, among 84 (20.8%) respondents who developed HAI, 2(3.3%) had nasogastric tube, 48 (21.8%) with intravenous catheter, 18 (21.4%) with urinary catheter, 14 (38.9%) with mechanical ventilator and 2 (50%) with orthopedic fixation device. In the present study, the association between development of HAI and application of invasive device was found statistically highly significant. The duration of invasive device application is concerned, this study has found association in developing HAI and the difference was statistically significant. In 2014, a retrospective study Keshni Naidu et al. [203] in Fiji's ICU (2011-12) showed 66% had isolates from a respiratory specimen (endotracheal tube) 49% from a urinary specimen (indwelling catheter or clean catch), 67% from a blood specimen (peripheral or central line), and 41% from a surgical site (wound swab or surgical drain). Respiratory tract infection was highest which is consistent with our study. Our study is not similar with the study conducted in 2012 by Théodora Angèle et al[198] showed the most frequent infections were related to the urinary tract (48.2%), vascular catheter use (34.7%), and surgical site (24.7%). The present study result does accord with the study conducted by visitor D Rosenthal[178] where application of invasive device had association in developing HAI. The present study is also consistent with study findings of a cohort study, which was conducted by Coello R, et al[179] who found the association of application of nasogastric tube, urinary and intravenous catheter as risk factor in developing HAI. The present study concludes that due to application of invasive devices the patients are more exposed to intervention procedure, inappropriate device handling, knowledge of precaution of staff which favors the entry of agents having the potential for developing infection.

In few of the causes, the duration of application of invasive procedure was noted by observing the patients on the ground rather than examining the case sheet as it was discontinued there.

5.3.7 Prior antimicrobial therapy and development of HAI

Perhaps, the most important is prior antimicrobial therapy, especially broad-spectrum agents which has been shown to suppress normal microbial flora and select for microorganisms resistant to the antibiotic used. The present study depicts that 8.2% respondents not having prior antimicrobial therapy developed HAI in comparison to 11.7% of respondents of having history of prior antimicrobial therapy. The study result revealed that there is no association between prior antimicrobial therapy and development of HAI as it was found statistically not significant. The present study does not accord with the study findings where a prospective study was conducted over a period of 25 months by Tronillet JL. et al[180] to determine the factors responsible for ventilator-associated pneumonia (VAP) where the association of prior antimicrobial therapy was one of the independent variables for developing infection (OR-13.5). Graffunder M. Eileen et al[181] also found the association of prior antimicrobial therapy in developing HAI. A prospective study conducted by pujol M et at[182] where prior antibiotic therapy was found associated with development of HAI ($p<0.001$). The study reveals that association was not found which may be due to short duration of study, smaller sample size and lack of authentic information from respondents about taking antibiotics where previous prescription could not be shown by some of the respondents.

5.3.8 Previous hospitalization within 6 months and development of HAI

In the present study, 378 (34.7%) respondents had the history of previous hospitalization and 730 (65.3%) did not have. 50 (13.2%) of the respondents of having the history of previous hospitalization developed HAI in comparison to 54 (7.4%) of the respondents who did have the history of previous hospitalization within 6 months. The study result shows the association between previous hospitalization and development of HAI as it was found statistically significant ($p<0.01$). The study result is consistent with the study conducted by Graffunder M. Eileen et al[181] where association of previous hospitalization and development of HAI was found. The researcher has limitation in getting information on previous hospitalization, as few respondents to some occasion could not show the discharge certificate where their verbal answer was taken as fact.

5.3.9 Immunosuppressive therapy and development of HAI

In the present study, the administration of immunosuppressive therapy and development of HAI shows that out of 88 respondents having immunosuppressive therapy, 31.8% developed HAI while out of 1020 respondents of not having such therapy, 7.5% developed infection.

The study shows the association of immunosuppressive therapy and development of HAI and the difference was statistically highly significant. This study is consistent with Napolitano M. Lena[183] that the infected patients were more likely to have received steroids before developing infection (RR=3.45, 95% CI 1.38-8.59).

5.3.10 Immunosuppressive condition and HAI

It is evident from the present study that out of 326 respondents, 29.4% were with immunosuppressive condition while out of 782 respondents 70.6% did not have such condition. Among the respondents having immunosuppressive condition, 3.2% had malignancy, 6.5% had Diabetes mellitus, renal failure 4.5%, chronic genitourinary disease 1.1%, COPD 1.3%, nervous system disorder 5.8%, chronic cardiac disease 4.2% and 2.9% had injury to skin and mucous membrane. Among the respondents having immunosuppressive condition, 24.5% developed HAI in comparison to 3.1% who did not have such condition. The association was found statistically highly significant.

Further to this, the specific immunosuppressive condition is concerned, 17.5% respondents with malignancy, 20.0% with diabetes, renal failure 15%, chronic genitourinary disease 2.5%, COPD 5.0%, nervous system disorder 22.5%, chronic cardiac disease 15.0% and 2.5% having injury to skin and mucous membrane. A study conducted by Cardoso T et al,[177] where patients who developed hospital-acquired respiratory infection (HARI) had cancer, DM which is similar to present study as HAIs were influenced in both the cases by immunosuppressive conditions where respondents were more susceptible to infection.

5.3.11 Antimicrobial therapy during hospitalization and HAI

It was revealed out of present study that 11.9% respondents of having antimicrobial therapy during hospitalization developed HAI while 2.6% developed who did not have therapy. The association of antimicrobial therapy during hospitalization and development of HAI was found as the difference was statistically highly significant. The longer the antibiotic uses, the higher the incidence of HAI. Duration of antimicrobial use after admission and development of HAI shows that 5.7% respondents developed infection of duration up to 5 days followed by 7.6% by 6-10 days, 26.3% by 11-15 days, 36.4% by 16-20 days and 70% by more than 20 days. The association of duration of antimicrobial use and development of HAI was found statistically highly significant (t=9.675, p=0.000). This may be due to insufficiently high dose, inappropriate route, and antibiotic as treatment prophylaxis, which alter the endogenous micro

flora during antibiotic treatment enhancing replacement of susceptible organisms by resistant strains of organisms from the hospital micro flora. A study conducted by P. Cornejo-Juárez et al.[204] in 2015 showed the overall prevalence of MDR-HAI was 39.5% and 51 (88%) had a MDR organism isolated (p = 0.05).

The present study accords with Struelens J. Marc[184] where antimicrobial therapy during hospitalization was found as a factor for promoting antimicrobial resistance due to failure in achieving bactericidal drug levels at the site of infection due to alteration of endogenous micro flora.

In few of the cases the duration of antimicrobial therapy was noted by asking the patients on the ground rather than examining the case sheet since few of the respondents were having it while that was discontinued in case sheets.

5.3.12 Development of HAI by type of operation

The present study result find that 20.2% out of 233 patients who undergone routine operation developed HAI, on the contrary 26.8% developed infection out of 71 respondents who undergone emergency operation. The association of development of HAI associated with type of operation was found statistically not significant. The present study does accord with the study done by Hussain Tahmina et al,[21] where no association was found in developing HAI between emergency and ordinary cases as the difference was not statistically significant($p>0.05$).

Stage of operation and HAI

Among 304 respondents undergone operation, 18.1% developed HAI in postoperative period while 6.1% out of 804 respondents developed infection who did not undergo operation. The association of development of HAI and stage of operation was found statistically significant. This study accords with Hussain et al,[21] where they found higher postoperative cases (49%) developed HAI in comparison to non-operative cases (15.9%) and the association was statistically significant ($p=0.000$). The present study reveals that higher postoperative infection may be due to failure of aseptic measures during operation, breach of asepsis in the post operative period, prolonged stay in hospital due to operation and exposure to a large number visitors.

5.3.14 Site of operation

It is revealed from the present study, among 1108 respondents 43.1% were for cardiac surgery, 5.9% were undergone operation for gastrointestinal tract, 24.7% for Musculo-skeletal tissue, wound debriment, surgical toileting, incision, drainage and others, 14.8% for KUB and 11.5% involved nervous system.

Distribution of respondents developing HAI by specific site of operation shows that 21.7% developed infection involved cardiac surgery, 17.9% developed infection involved gastrointestinal tract, 33.6% nervous system, 25.8% KUB and 31.5% involved Musculo-skeletal tissue, wound debriment, surgical toileting, incision and drainage and others. The study result shows that there was no association between development of HAI and specific site of operation as the difference was found statistically not significant.

5.3.15 Respondents stay on Hospital days

The present study result reports that out of 1108 respondents, 104 (9.4%) developed HAI and 1004 (90.6%) did not developed. Respondents stay on hospital days on development of infection is concerned where out of 104 respondents, 3.2% by 3-10 days, 3.2% by 11-20 days, 1.3% by 21-30 days 0.7% by 31-40 days and 0.5% by 41-50 days and 0.4% by 50-60 days developed infection. The mean hospital days for development of hospital-acquired infection were 19.96 days with standard deviation (SD) 13.11 days.

The distribution of respondents without infection by hospital days on discharge shows that out of 1004 respondents, 52.7% by 10 days, 26.9% by 11-20 days, 8.8% by 21-30 days, and 2.2% were discharged by 31-40 days, the mean hospital days on discharge (for non infected patients) was found as 9.77 days with standard deviation 7.13 days. The difference of hospital days was found statistically significant. According to Plowman et at,[186] where length of stay as 8 days for uninfected patients was similar to present study also consistent with infected patients with longer duration of stay. The present study is not consistent with Khan Hussain Mohiuddin et al[22] where the average hospital stay for infected patients was more than 40 days but similar in comparison to non infected with 10 days and the association of hospital days in developing HAI was found statistically highly significant (t=7.845, p=0.000). The present study accords with Hopmans-Kamp E M.et al[171] where the mean hospital days for developing HAI was around 20 days while for non infected patients around 8 days. The present study also accord with Napolitano M Lena[183] where the study found the length of hospital stay more than

14 days. The study concludes that the respondents staying time in hospital days was found as a potential predictor for developing HAI probably because of unnecessary antibiotic therapy, MDR strain, number of visitor, immunosuppressive condition, invasive procedure which contributed most in developing infection.

5.4 Hospital Related factors and HAI

5.4.1 Different wards and HAI

HAI were found to be different across different wards after admission. In the present study it was found that majority respondents 33.94% were treated in cardiology ward followed by 14.8% were treated in general surgery ward, 3.97% in orthopedic ward, 8.44% in Urology ward, 11.0% in Neurology ward and 9.39% in ICU.

The proportion of development of HAI was found highest in ICU (30.8%) followed by oncology 12.5%, Neurology (10.7%), Cardiology 9.3% , Urology (5.1%), General Surgery (3.7%), others (2.5%) and orthopedic (4.5%) wards. A prospective study done by Shafer SQ et al[186] in neurology ward of city Hospital, USA, where the proportion was found 6.8% which is lower than present study.[186] According to Vincent J.L et al[187] and Vosylius S et al[188] where 44.8% and 37.0% of ICU patients respectively were found infected with HAI which was higher than present study. According to Pories S.E. et al,[189] who conducted a study on "The epidemiologic feature of nosocomial infection in patients with trauma" where majority of infection was found among patients of orthopedic (51%) and general surgery (25%) which is not consistent with present study but nearly similar to neurology wards (13.0%). The present study concluded that the higher proportion of infection in ICU may be due to immunosuppressive condition, prolonged antimicrobial therapy, prolonged stay, invasive procedures and visitors.

5.4.2 Frequent transfer and HAI

The present study shows that frequent transfer from one ward to another played no role in developing HAI. Out of 110 respondents who were transferred from one ward to another, 14.5% developed infection while out of 998 respondents who were not transferred, 8.8% developed infection. The association of contracting HAI by patients, transfer was found statistically not significant. This frequent transfer was common with those patients who were admitted on emergency basis for operative treatment or ICU service, repeated operation procedure, sudden deteriorating of patients condition. After these emergency services, patients

might be transferred to post operative or related wards. Some times transfer required for specialized service. As the study hospital was a highly specialized hospital frequent transfer was a common for emergent patients. As it was a prospective study, irrespective of maximum efforts in locating and observing frequently transferred patients, researcher had to depend on the opinion of staff for few cases to maintain continuity in daily observation. The study concluded that no association of developing HAI might be precaution during transfer of patient, staff precaution, hospital environment, crowd less condition during transferring.

5.4.3 General cleanliness and HAI

General cleanliness is the image of hospital, which satisfies patient's right at the moment of admission while it is also one of the important factors to minimize patients, suffering by reducing the occurrence of HAI. The present study shows that 70.4% of the respondents who were lodged in wards whose general cleanliness was satisfactory, while 29.6% respondents were lodged in dirty wards. Around 9% respondents developed HAI lodged in wards whose general cleanliness was satisfactory in comparison to around 10.4% respondents developed infection kept in wards which was not satisfactory. The association of general cleanliness and development of HAI was found statistically not significant. The study reveals that general cleanliness always be maintained because of staff awareness due to administrative strictness regarding source of infection and strict authority.

5.4.4 Cleaning object/material and HAI

The object/materials that come in contact with patients should be considered as potentially contaminated. Cleaning of patients-care items, beside equipment, and frequently touched surfaces of patients named as contact precaution played a major role for HAI. The study result finds that 73.0% of the respondents were cleaning of object/material were done regularly in comparison to 27.0% respondents were it was not done regularly. Further to the findings, 9.5% of respondents developed infection where cleaning of object/material was done regularly contrary to 9.2% of respondents where cleaning of object/material were not done regularly. The association was found statistically not significant.

5.4.5 Standard precaution taken by staff and HAI

In the hospital, the most important reservoirs of infection are infected patients. The main mode of transmission of infection is via hands of health care workers which may become contaminated by contact with body sites of the personnel themselves or devices, items or

environmental surfaces contaminated with body fluids containing infecting organisms. In the present study the state of standard precautions (such as, hand washing, gloving, masking, gowning and appropriate device handling taken by doctors and nurses were assessed only by observation in six critical care unit 1 time/day by researcher . It was very toughest job for researcher to observe all the precautions against HAI simultaneously daily of the whole hospital. So the researcher selected only critical areas where staff precautions are very much essential and need to be followed. The researcher observed the hospital staff during the time of routine follow up of patients and during the time of dressing in the wards. The present study revealed that regular practices of standard precautions taken by doctors and nurses were observed. Researcher found as hand washing by doctors are 43% whereas nurses are 41% almost similar. Some consultants were found not to follow hand hygiene regularly. Infection control nurses were not always able to advise to consultant to use hand hygiene practice and nurses were found lack of knowledge.

Masking 47% by doctors, 74% by nurses, Gloving 51% by doctors and nurses 44%. In the critical areas one nurse is engaged for one patients nursing. In case of absence of any nurse, the nearby nurses were found to touch another patient without changing her gloves which could be potential source of transmission of pathogen from one patient to another.
Gowning from doctors were only 47% whereas by nurses were 73% which is quite high than doctors. The reasons might be as doctors had to round to different wards at a time so they were not intended to change their gown.

Regarding appropriate device handling, 45% were followed by doctors during standard procedure and 39% by nurses. But in some occasions, during interventional process, doctors, surgeons are found to follow strictly standard precautions to prevent HAI.

A study conducted by Hand Washing Liaison Group, [102] UK on “Hand washing. A measure with big effects” where hand washing was found among 9.0% of physician. Another study conducted at South Texas Regional Medical Center in Wilford Hall, USA where 40.0% health workers were found to wash their hands[103]. Plowman et al [54] in their study found that hand washing could reduce the hospital-acquired infection by about half. This might be due to their sense of precaution measures, strict compliance and good surveillance system in wilford Hall Medical Center.

5.4.7 Logistic regression for predicting independent risk for developing HAI

In the present study, it has been found that the factors like immunosuppressive condition, functional state of the respondents, number of visitor/patient/day, underlying illness, invasive device application, duration of antimicrobial therapy have been found as independent risk factors. However, it is predicted that functional state 1, fewer or no visitor, short duration of antimicrobial therapy were found protective otherwise, these were found as independent risk for developing HAI. A study conducted by Coello et al,[50] where surgical wound pressure ulcers, and intravenous catheterization were found as independent risk factors with hazard ratio (and 95% CI) of 2.9 (1-6.3), 3.0 (1.6-5.7) and 4.7 (1.4-15.6) respectively. According Pujol M.et al[45] where the independent risk factor for nosocomial bacteremia was found intravenous catheterization as independent risk factor (OR=2.7, CI=1.1-6.6).

5.5 Development of HAI by microorganisms

5.5.1 Microorganisms causing hospital-acquired infections

It has been found in the present study that 10 different types of organisms were identified among 104 (9.4%) out of 1108 respondents and *Klebsiella pneumoniae* 34 (32.7%) the most common.

Other infecting species were *Acinetobacter baumannii* 18 (17.3%), *Esch. coli* 18 (17.3%), *Ps. aeruginosa* 14(13.5%), *Staphylococcus aureus* 6 (5.8%), *Streptococcus pneumoniae* 4(3.8%), *Streptococcus pyogenes* 4(3.8%), *Enterococcus faecalis* 4(3.8%) and *Enterobacter sp.* 2(2.0%).

The present study support with the study carried out by Claudia Wollheim et al.[206] in Brazil 2006 where *Klebsiella pneumoniae* (43.7%) was the prevalent agent. Also similar study conducted by Sadeta et al.[207] in 2012 showed common agent was *Klebsiella pneumonia.*

The present study does not accord with a study conducted by Rahman Motiur ASM et al[18] where *Staphylococcus aureus* was found as the most common isolated pathogens (20.83%) with *Klebsiella pneumoniae* (20.13%), *Pseudomonas aeruginosa* (16.67%), and *Escherichia coli* (15.27%). Another study conducted by Laupland KB. et al[90] to find out ICU-acquired bloodstream infection in Calgary Health Region, Canada where the most isolated pathogen was *Staphylococcus aureus* (18.0%) followed by *Enterococcus faecalis* (8.05%) which is also not similar to present study. Another study conducted by Vincent J.L.et al[47] where *Staphylococcus aureus was* (30.1%) and *Pseudomonas aeruginosa* (28.7%). the present study does not accord with this study.

Chapter-6

CONCLUSION & RECOMMENDATIONS

CONCLUSION

As this study was conducted in a highly sophisticated hospital in Bangladesh, therefore the general scenario on this issue of other hospitals could reflect from the present study findings. HAI is not a local problem but considered as national issue of great importance requiring a high priority. There should be involvement of national leaders and national and international health agencies regarding this problem identification by incidence survey which would offer on dynamics changes of rates, pathogens, antibiogram and risk factor for disease and adverse outcome for taking actions for prevention and control. It should be kept in mind that the infected patients are ultimate sufferer and this is due to our failure to apply established knowledge and techniques to prevent HAI. Formal instruction in the prevention of HAI should be part of normal education of professional groups such as medical graduates and nurses.

Now a number of newer costly antibiotics have become resistant. Overuse of antibiotics could be behind this high rate of drug resistance. The rate of HAI in United Hospital needs attention from all corners to keep the occurrence at minimum level. From the present study, the following conclusions were made:

The incidence of hospital-acquired infection was found not be influenced by any of the socio-demographic factors, which demands further study.

Respiratory tract infection (57%) was the commonest HAI followed by urinary tract infection (UTI). The incidence rate of HAI was found 8.75/1000 hospital days which is not be higher in comparison to other studies but much higher than CDC recommendation rate where infection rate should be below 3%. The incidence rate was found to be largely influenced by visitors, functional state of respondents, underlying illness, invasive procedure, prolonged antimicrobial therapy during hospitalization as independent risk factors. Not a single event of hospital-acquired infection was found due to food and water born transmission which might be due to strict compliance of consumption of fresh and hot food as well as water provided from hospital itself.

The highest incidence of HAI at ICU detailed an account of application of invasive procedure, immunosuppressive therapy, immunosuppressive condition, underlying illness,

indiscriminate prolonged antimicrobial therapy, visitors and lack of standard precaution observed by hospital staff specially hand washing. In the present study, length of hospital stay (hospital days) was found to play role significantly for developing HAI as the mean hospital days differ significant range both for infected and non infected patients. This reflects the leading role to cause HAI for longer hospital stays by respondents where special attention needs priority.

The majority events of infection were caused *by Klebsiella pneumoniae followed by Acinetobacter baumannii, Esch. coli* and *Pseudomonas aeruginosa w*hich could be attributed to poor precaution measures. Emergence of resistant organisms has become a global threat.

RECOMMENDATIONS

As HAI rate is high than standard limit, so ultimate goal is to reduce or control the risk to the patients acquiring HAI. These findings might be utilized toward planning a surveillance program for HAI in this health care facility as a first step toward a better infection control strategy. Taking this view, the following recommendations were drawn to control HAI and in keeping the HAIs at minimum level:

Updating Knowledge and Raising Awareness among Hospital Staff

Knowledge in regards to HAI and its impacts on patients' suffering cost involvement and spread of infection to community could be disseminated through ongoing training activities, workshop and seminar. Hospital staff might be integrated with existing surveillance system for acquiring knowledge on routine reporting system for better control. Awareness could be raised among doctors and other staff about the consequence of HAI and importance of timely control and prevention.

Effective Surveillance system

An effective surveillance system should be introduced to recognize unusual change in the level of incidence of HAI and the impending spread of an outbreak. In addition this would help in assessing the efficacy of the regular preventive measures practiced the hospital. An effective reporting system could be incorporated into the surveillance system for HAI.

Standard Precaution Measures, Visitors and High risk area

Standard precaution measures especially hand washing ensuring of prevention of transmission pathogens, cross infection, control of visitors, proper invasive procedure are strongly recommended. However, this should complimented by ensuring strict compliance. Hospital Infection Control committee should be vigilant in pursuing hospital-acquired infection by establishing effective surveillance programme and providing pragmatic guidance and leadership in the prevention and control of HAI. Improving safety in high-risk areas where the most serious and frequent injuries and exposures to infectious agents occur.

Further Research issues

The following areas of researcher are particularly relevant to HAI in United Hospital Limited:

(1) Epidemiological studies are strongly recommended to provide information so that appropriate resources can be allotted for effective control and prevention.

(2) Large scale of study should be conducted to find out overall magnitude of the problems.

Policy Implication

The above recommendations need motivation at all level of policy development. An outline of effective surveillance system and activities of effective Infection Control Committee are strongly recommended. This could be complemented by routine feedback system. Prolonged, misuse, indiscriminate antimicrobial therapy during hospitalization demands formulation of antibiotic policy and its effective implementation.

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ANNEXTURE A: QUESTIONNAIRE

I am trainee researcher now studying in PhD thesis (Microbiology) at University of Rajshahi. I would like to collect some information's about **"Risk Factors of Hospital Acquired Infections among patients admitted in a selected Hospital in Dhaka".** All your information's will be kept secret and it will be used for research purpose only.

Patients ID: Date of interview: Sex: Male/Female

Word/Bed/Cabin:

Part 1- Socio Demographic information.

1.1 How old are you (In complete year)?

1.2 Which religion do you follow?
1) Islam 2) Hindu 3) Christian 4) Buddhist 5) Others (Specified)

1.3 What is your occupation?
1) Service holder 2) Businessman 3) House wife 4) Student 5) Retired
6) Not applicable (Not yet any occupation due to tender age)

1.4 What is your current marital status?
Married and presently living with spouse 2) Widow 3) Widower 4) Divorced
5) Un-married 6) Not applicable

1.5 What is the size of your family (Household members)?
1) Two members (Husband and wife) 2) Three members (Husband, wife and one kid) 3) Four members (Husband, wife and two kids) 4) Five members (Husband, wife and three kids) 5) Six members (Husband, wife and four children) 6) Above six (Husband, wife and more than four children) 7) Not applicable (Single living)

Part 2- Patient and Hospital related information.

2.1 What is your present health problem for which you have been admitted?

2.2 At the time of admission, do you have any of the following complaints of infection?
1) Fever more than 99^0F 2) Cough productive or nonproductive 3) Burning sensation during passing urine? 4) Loose motion 5) Yellow coloration of urine conjunctiva 6)

Soaking of dressing of a wound / presence of pus of a wound 7) Others (specified) 8) Not any of the above

2.3 Have you got any history of previous hospitalization within six months?

1) Yes 2) No

2.4 What is your present functional status (Ability of performing bathing, clothing, toileting, ablution, use of bed and eating)?

1) Can perform activities at your own 2) Require some assistance to perform 3) Require assistance in most of the activities

2.5 Do you have history of taking antibiotic within three months before admission?

1) Yes 2) No

2.6 How many of your visitors used to visit everyday?

1) One visitor 2) Two Visitors 3) Three visitors 4) >3 visitors 5) No visitor

2.7 Are you supplied with freshly prepared hot food?

1) Yes 2) No 3) Not applicable

2.8 What type of water you are supplied for drinking purpose?

1) Tap water 2) Bottle water 3) Separately supplied drinking water

Thank You

Date:

ANNEXTURE B: CHECK LIST

I am trainee researcher now studying in PhD thesis (Microbiology) at University of Rajshahi. I would like to collect some information's about **"Risk Factors of Hospital Acquired Infections among patients admitted in a selected Hospital in Dhaka".** All your information's will be kept secret and it will be used for research purpose only.

Patients ID: Date of observations: Sex: Male/Female

Word/Bed/Cabin:

Underlying Patient/Hospital related information

1.1 Date and time of admission:

1.2 Date of discharge:

1.3 Length of Hospital stays (Hospital days) on the day of discharge:

1.4 Hospital days on the day of development of infection:

1.5 Number and type of underlying illness (as diagnosed by the treating physician): 1) Cerebrovascular disease 2) Chronic genitourinary disease 3) Diabetes Mellitus 4) Malignancy 5) Chronic obstructive pulmonary disease 6) Coronary heart disease 7) Any other conditions (specified) 8) Not any of the above.

1.6 Extremes of age:

1) 1 year and bellow 2) 60 years and above 3) Not applicable

1.7 Immunosuppressive therapy:

1) Use of cytotoxic drug 2) Steroid therapy 3) Irradiation 4) No therapy

1.8 Immunosuppressive condition: 1) Malignant disease 2) Diabetes Mellitus 3) Renal failure 4) Leukemia 5) COPD 6) Injury to skin and mucous membrane 7) Liver failure 8) None of the above

1.9 Information on Medical Surgical Procedures

1.9.1 History of Surgery at present:

If yes, type, and date of operation

1.9.1.1 Type of operation:

1) Routine 2) Emergency

1.9.1.2 Name and Date of operation:

1) Name: Date:

1.9.2 Application of any invasive device: 1) Yes 2) No

If yes, name and duration:

1.9.2.1 Name of Device:

1) Nasogastric tube

2) Intravascular catheter

3) Orthopedic fixation device
4) Mechanical ventilation
5) Urinary catheter
6) Others (specified)

1.9.3 Antimicrobial therapy during hospitalization:

1) Yes 2) No

If yes, name of the antibiotic and duration of use:

1.9.3.1 Name of antibiotic:

1.9.3.2 Antimicrobial therapy prior to infection:

1) Yes 2) No 3) Not applicable

1.10 Infection related information

1.10.1 Laboratory and imaging evidence of infection (if done) at the time of admission or immediately thereafter at the request of attending physician:

1.10.1.1 Evidence of laboratory investigations:

Total WBC	% of poly	ESR	Culture report	Remarks

1.10.1.2 Evidence of of imaging:

X-Ray Chest	Report	Remarks

1.10.2 Clinical evidence of infection more than 48 hours after admission:

1) Present 2) Not present

Laboratory and imaging evidence of infection during the period of hospitalization.

1.10.3.1 Laboratory investigations:

Total WBC	% of poly	ESR	Culture report	Remarks

1.10.3.2 Report of imaging:

X-Ray Chest	Report	Remarks

1.11 Infection after admission (when HAI develops): 1) Nonoperative 2) Postoperative

1.12 Date of Hospital Acquired Infection:

1.13 Type of infection (when HAI developed):

1. Surgical site infection
2. Urinary Tract Infection
3. Blood Stream Infection
4. Respiratory Infection
5. Skin and Soft Tissue Infection

6. Others (specified)

1.14 Hospital Environment:

1.14.1 Frequent transfer of patient from one ward to another:

1.14.2 Inanimate environment:

1.14.1.1 General cleanliness of the ward and dept.:

1) Good 2) Satisfactory 3) Dirty

1.14.4.2 Food hygiene:

1) Maintained 2) Mot maintained

1.14.4.3 Water supplied for drinking purpose:

1) Tap water 2) Drinking water supplied separately

1.14.4.4 What is the state of regular cleaning of object / material (patient care items, bedside equipment and frequently touched surface receive daily cleaning)?

1) Regularly done 2) Not regularly done

1.14.5 State of Standard precautions taken by hospital staff:

1.14.5.1 Hand washing:

1) Regular 2) Irregular 3) Not applicable

1.14.5.2 Gloving:

1) Regular 2) Irregular 3) Not applicable

1.14.5.3 Masking:

1) Regular 2) Irregular 3) Not applicable

1.14.5.4 Gowning:

1) Regular 2) Irregular 3) Not applicable

1.14.5.5 Appropriate device handling:

1) Regularly maintained 2) Irregularly maintained 3) Not applicable

1.14.5.6 Appropriate handling of linen:

1) Regularly maintained 2) Irregularly maintained 3) Not applicable

1.14.5.7 Culture report: Growth / No growth

If growth name of the organism:

Name of Antibiotics	Sensitive	Intermediate sensitive	Resistant
Amikacin			
Amoxyclavonic acid/Amoxycillin			
Ceftriaxone			
Ceftazidime			
Cotrimoxazole			
Ciprofloxacin			
Cefepime			
Cefixime			
Gentamicin			
Imipenem			
Netilmycin			
Tazobactum			
Aztreonam			
Doxycycline (DO)			
Penicillin			
Linezolid			
Oxacillin			
Vancomycin			

Thank You

Date:

Annexure-C

Fig.-8.1: Growth of *E. coli* on MacConkey agar media.

Fig.-8.2: Growth of *K. pneumoniae* on MacConkey agar media.

Fig.-8.3: Growth of *P. aeruginosa* on MacConkey agar media.

Fig.-8.4: Growth of *Staph. aureus* on Blood agar media.

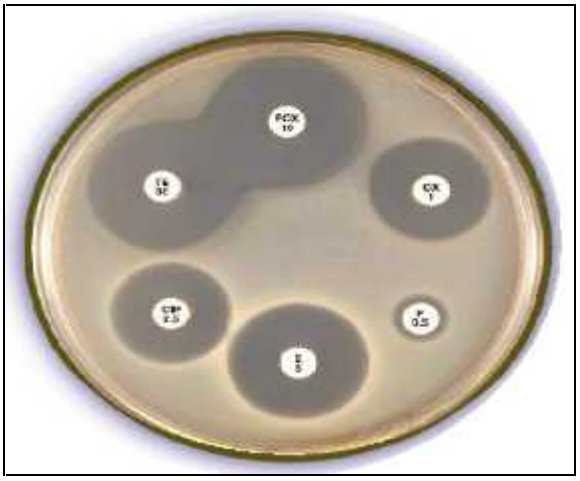

Fig.-8.5: Antimicrobial susceptibility test of *Staph. aureus*

Fig.-8.6: Biosafety Cabinet for microbial culture

Fig.-8.7: Microgen strip for biochemical test. (Before bacteria)

Fig.-8.8: Microgen strip for biochemical test. (After bacteria)

Fig.-8.9: Blood culture vial for BACTEC 9120 Instrument

Fig.-8.10: Antibiotic disc for antimicrobial susceptibility testing

Fig.-8.11: 6.5% Sodium chloride & Bile aesculin for Enterococcus sp.