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Microbial Contamination of the Operation Theatres in Selected Hospitals-Gaza Governorates

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Microbial contamination of the operation theatres in selected hospitals-Gaza governorates

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Dedication

To the spirit of my father

To my mother

To my brothers ... whose love was of great support to me

Declaration

I certify that this thesis submitted for the degree of Master is the result of my own research, except where otherwise acknowledged, and that this thesis (or any part of the same) has not been submitted for a higher degree to any other university or institution.

Signature………………… ………………………..

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Abstract

This present descriptive analytical cross-sectional study was conducted in operating rooms at governmental and private hospitals in Gaza Strip. The study aimed to determine the prevalence of microbial contamination in operating rooms from different animate and inanimate objects at two stages (pre-operative and post-operative), types of contaminant bacteria and its antibiotic sensitivity profile. Swabs were collected from 21 items distributed in three dimensions (equipment, environment, and persons). A total of 243 swabs were collected, and cultured using enriched and selective media in clinical laboratories. The total number of swabs collected from governmental and private hospitals was 142 (58.4%) and 101 (41.6%) respectively. The results showed that 24.7% of the collected swabs found to be contaminated, where equipment items were responsible for 44.94%, environment items were responsible for 48.31% and person items were responsible for 6.62%. The rate of contaminated samples in the pre-op. stage was 22.58%, and it was 26.89% in the post-op. stage samples. The microbial contamination was higher in post-op swabs in comparison to the pre-op swabs but did not reach statistical significance differences. The results also revealed no statistical significant differences in the prevalence of microbial contamination at operating rooms between governmental and private hospitals. However, there is slightly increase in the total rate of contamination in the governmental hospitals (12.76%) in comparison to the total rate in the private hospitals (11.93%). Eight different bacterial genera were recovered from the tested swabs including Staphylococci, Enterobacter, Klebsiella, Escherichia, Pseudomonas, Acinetobacter, and Streptococci. The most common bacterial species recovered were S. aureus (40.6%) followed by Enterobacter (23.4%) which together represent about two third (64%) of all the isolated bacteria. Most tested bacterial isolates were resistant to many of the tested antibiotics, mainly ampicillin, amoxicillin, trimethoprim, cefalexine, cefuroxime, and nalidixic acid, which may decrease the alternatives of treatment and decrease the chance of fighting against those kinds of bacteria. In conclusion, these results reveal a high percentage of contamination in the operating theatres investigated, which is regarded as a serious problem, especially if we are talking about an area that should be virtually clean and contains as minimum as possible microbes or even sterilized in order to minimize the possibility of developing postoperative infections. These results imply that more attention should be paid to increase awareness about infection control

standards and re-evaluating the current scrubbing procedures at the operating theatres in hospitals.

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List of Abbreviations

A. baumannii	*Acinetobacter baumannii*
API	Analytical Profile Index
BCP	Bacterial carrying particle
CDC	Communicable Disease Centre
CFU	Colony forming unit
CoNS	Coagulase-negative staphylococci
CVS	Cardiovascular surgery
EGH	European-Gaza hospital
EPA	Environmental Protection Agency
GOT	General operation theatre
GRE	Glycopeptide-resistant enterococci
GS	Gaza Strip
HAI	Hospital associated infections
H_2O_2	hydrogen peroxide
HCAIs	Health Care Associated Infections
HEPA	High-efficiency particulate air
LAF	Laminar air flow
MDR	Multidrug-resistant
MOH	Ministry of Health
MRSA	Methicillin Resistant *Staphylococcus aureus*
NCCLS	National Committee for Clinical Laboratory Standards
NGOs	Non Governmental Organizations
NIs	Nosocomial infections

NNIS	National Nosocomial Surveillance System
OR	Operating room
OSHA	Occupational safety and health administration
PFGE	Pulsed-field gel electrophoresis
PIR	Post operation infection
Post-op	Post-operation
Pre-op	Pre-operation
RAPD	Random amplification of polymorphic DNA
RFLP	Restriction fragment length polymorphism
S. aureus	*Staphylococcus aureus*
S. epidermidis	*Staphylococcus epidermidis*
SPSS	Statistical Package for the Social Sciences
SSIs	Surgical site infections
VRE	Vancomycin-resistant enterococcus
WB	West Bank

Chapter One

Introduction

Chapter One

Introduction

1.1. Background

The environment in the hospitals play an important role in the occurrence of hospital associated infections (HAI). The hospital environment consists of many components. Many have a direct bearing upon HAI including design of ward and operating theatre facilities, air quality, water supply, food and handling of medical waste and laundry.
The operation room is a complex environment, traditionally considered at high infections risk, for both the patients and health care workers they can contract diseases because of the exposure for relatively long times to various dangerous chemical, physical and biological factors. Contamination of operating theatres is one of the most life-threatening sources of nosocomial infection for patients, especially in transplant surgery, heart surgery, cystoscopy and transurethral resection of prostate and bladder tumors (Ensayef *et al.*, 2009).

The biological contamination in the operating rooms is mostly imputable to airborne and blood borne microorganisms, whose primary source represent the staff, patient and operating team (Gioffre *et al* ., 2007). Until the late 1980s, most infection control officers, operating room nurses and surgeons thought that the type of operative procedure undertaken was the most critical factor in predicting the post operative surgical site infection rate (Nicholas, 2004).
Health care associated infections are an important cause of morbidity and mortality in hospitals. Each year more than 2 million patients acquire health care–associated infection, resulting in 90,000 deaths and high health care costs (William. *et al.*, 2006).
Many countries suffer high post operation infection (PIR) in their hospitals, especially in developing countries. In Brazil for example, 15% PIR was reported, while in Europe and USA the highest PIR was 5% (OSPA and OMS, 2001; PRE 21 ES, 2004; and CDC, 2003 respectively). The incidence of PIR depends on many variables including, the type of operating rooms (OR), ventilation system and the type of surgery performed (Melhado, *et al.*,2003).

Exogenous infection of surgical wounds are caused predominantly by *Staphylococcus aureus*, and *Staphylococcus epidermidis* are shed into environment by individual skin scales and, while healthy carriers have been found to shed few staphylococci, airborne contamination is inevitable owing to staff movement encountered during operation theatre activities (Campo, 2004).

According to data from the National Nosocomial Surveillance System (NNIS), the distribution of pathogens isolated from surgical site infections (SSIs) has not changed, where *Staphylococcus aureus*, coagulase negative staphylococci, *Enterococcus* spp., and *Escherichia coli* remain the most frequently pathogens. Outbreaks or clusters of SSIs have also been caused by unusual pathogens, such as *Rhizopus oryzae*, *Clostridium perfringens*, *Rhodococcus bronchialis*, *Nocardia farcinica*, *Legionella pneumophila*, *Legionella dumofttii* and *Pseudomonas multivorans.* The rare outbreaks have been traced to contaminated adhesive dressings elastic bandages, colonized surgical personnel tap water, or contaminated disinfectant solution (Alicia *et al*., 1999).

1.2. Problem Statement

Modern operating rooms are considered to be aseptic environments. The use of surgical mask, frequent air exchanges, and architectural barriers are used to reduce airborne microbial populations. Breaks in surgical technique, host contamination, or hematogenous seeding are suggested as causal factors in these infections (Howorth, 1985).
Post-operative wound infection delays recovery and often increases length of stay and may produce lasting sequelae and require extra resources for investigations, management and nursing care. Therefore, its prevention or reduction is relevant to quality patient care (Edmiston, 2005; Scaltriti, *et al*., 2007).

Surgical-site infections are still a major problem in modern medicine. These infections may be deep or superficial. The superficial ones are easier to deal with, but the deep ones can be complicated, leading to re-operation, or even be life threatening. Factors causing surgical-site infection are multifarious; type of operation, surgeon's skill, insertion of foreign material or implants, appropriateness of surgical preparation, adequacy and timing of antimicrobial prophylaxis, the immune state of the patient and contamination of the inanimate environment. To reduce these infections, bacteriological management of operating theatres has been advocated. There is no international consensus on the methods, types of sampling and tolerable limits of bioburden in operating theatres (Dharan & Pittet, 2002).

Before the mid-19th century, surgical patients commonly developed postoperative "irritative fever," followed by purulent drainage from their incisions, overwhelming sepsis, and often death. It was not until the late 1860s, after Joseph Lister introduced the principles of antisepsis, that postoperative infectious morbidity decreased substantially (Alicia *et al.*, 1999).

The Gaza Strip is known as one of the most populated areas in the world (365/km^2) with an estimated population of about 1.48 million according to the estimates that performed in July 2007 (Palestinian Central Bureau of Statistics, 2008). In Gaza Strip, there are main 6 governmental and four private main hospitals, where most of the general and special surgical operations are routinely performed every day. These hospitals and the health branch in general suffering very hard from the complete siege on the Gaza strip, where many basic and sophisticated equipments and instruments are unavailable or present in scarce. Moreover, the last war on Gaza strip even made this situation worse. There is routinely microbiological investigations of the operation theatres in the Gaza strip that performed by the infection control units in these hospitals. However, there is no available or published data in this regard (Personal communication). According to the researcher knowledge, there is no previous performed or published studies investigating the microbial contamination of the operation theatres in governmental and/or non-governmental hospitals in the Gaza strip.

Based on NNIS system reports, Surgical Site Infections (SSIs) are the third most frequently reported nosocomial infection, accounting for 14% to 16% of all nosocomial infections among hospitalized patients. Among surgical patients, SSIs were the most common nosocomial infection, accounting for 38% of all such infections. Of these SSIs, two thirds were confined to the incision, and one third involved organs or spaces accessed during the operation. When surgical patients with nosocomial SSI died, 77% of the deaths were reported to be related to the infection, and the majority (93%) were serious infections involving organs or spaces accessed during the operation (Alicia *et al.*, 1999).

Due to the above mentioned facts, the researcher found that it is very important to perform this study in the Gaza strip hospitals.

1.3. Justifications of the Study

Operating room is one of the most hazardous environments in the health care delivery system. So, microbial contamination in the operating room is generally considered to be a risk factor for surgical site infection in clean surgery.

Wound site infections are a major source of post operative illness, accounting for approximately a quarter of all nosocomial infection. Surgical site infection accounts for between 10 to 20% of healthcare associated infections and increases the length of hospital stay and utilization of healthcare resources (Holt, 2007). These post operative infections number is approximately 500,000 per year, among an estimated 27 million surgical procedure, and account for approximately one quarter of the estimated 2 million nosocomial infections in the united states each year. These post operative infections result in longer hospitalization and higher costs (Scaltriti *et al.*, 2007).

In the Gaza strip, there is a lack of information or published data regarding the microbial contamination of operating theaters and its impact on the types and severity of post operative infections. The results and reports that coming from the preventive medicine departments revealed that the main contaminant bacterial species in the operating theatres are *S. albus, S. epidermidis, S. aureus, E. coli, Klebsiella* sp, *Pseudomonas* sp, *Enterobacter* and *Acinetobacter* (personal communication, 2009). However, there is no exact numbers or percentage of these positive bacterial cultures in any of these hospitals that selected for this study. For these reasons, the researcher designed and conducted this present study in order to estimate and determine the percentage and type of microbial contamination in the operating theatres in these selected governmental and non-governmental hospitals at the Gaza strip. Another important aim of this study to suggest recommendations to alleviate or reduce microbial contamination to a safe level that reduce or prevent the post operative infections.

1.4. Objectives of the Study

This study aimed to determine the prevalence of microbial contamination from animate or inanimate objects in the operating rooms in the major governmental and private hospitals at the Gaza governorates.

The specific objectives of the study are:

1. To find out the differences in the prevalence of microbial contamination between governmental and private hospitals' operating rooms .
2. To determine the differences in the prevalence of microbial contamination related to the stage of sample collection (pre-op and post-op) .
3. To identify the main bacterial species isolated from contaminated samples from operating rooms at governmental and private hospitals.
4. To identify the antibiotic profile results for isolated bacteria from contaminated samples.
5. To suggest recommendations that may help in decreasing the prevalence of microbial contamination at operating rooms.

1.5. Research Questions

1. What is the prevalence of contamination in operating rooms at governmental and private hospitals in Gaza Strip?
2. Are there significant differences in the prevalence of microbial contamination between governmental and private hospitals' operating rooms?
3. Are there significant differences in the prevalence of microbial contamination related to the stage of sample collection (pre-op and post-op)?
4. What are the main bacterial species isolated from contaminated samples from operating rooms at governmental and private hospitals?
5. What is the antibiotic sensitivity profile results for isolated bacteria from contaminated samples?

1.6. Context of the Study

Information regarding health care services and the people who receive these services are very important for proper planning and affording better services. This study was conducted in Gaza Strip with its unique culture and socio-demographic contents, therefore the researcher illustrated below some information regarding the Palestinian population, health status, and health care system.

1.6.1. Demographic Context:

Palestine is situated on the Eastern coast of the Mediterranean Sea. It is of an ancient and of strategic important location. Now, Palestine comprises two areas separated geographically: the West Bank and Gaza governorates, the total area is 6,020 sq. Km. with total population living in is 3,762,005 individuals in 2005 with capita per sq Km 625. Gaza governorates is a narrow piece of land lying on the coast of the Mediterranean sea. Its position on the crossroads from Africa to Asia made it a target for occupiers and conquerors over the centuries. The last of these was Israel who occupied the Gaza governorates from Egyptians in 1967. Gaza governorates are very crowded place with area 365 sq. Km and constitute 6.1% of total area of Palestinian territory land. In mid year of 2005 the population number is to be 1,389,789 mainly concentrated in the cities, small village, and eight refugee camps that contain two thirds of the population of Gaza governorates. In Gaza governorates, the population density is 3,808 inhabitants/km2 that comprises the following main five governorates: North of Gaza, Gaza City, Mid -Zone, Khan-younis, and Rafah. West Bank is divided into four geographical regions. The North of West Bank includes the districts of Jenin, Tulkarem, Qalqylia, Salfit and Tubas districts. The Center includes the districts of Ramallah and Al-Bireh, and Jerusalem. The South includes the Bethlehem and Al-Khaliel districts, and the sparsely populated Jordan valley including Jericho. The population density is 420 inhabitants/ km2 and constitutes 93.9% of total area of Palestinian territory land (Palestine, MOH, October, 2006).

The total number of population in Palestine in 2007 was 3,761,646 [Gaza Strip (GS) 1,416,539 (37.7%); and West Bank (WB) 2,345,107 (62.3%)] (PCBS, 2007).
According to UNRWA reports, by the end of 2005, the total number of Palestine refugees registered in the Agency’s area of operation according to UNRWA registration statistics was 4,349,946, which represents an overall increase of 2.7 % over 2004 registered population, Agency-wide. The registered population was distributed as follows: Jordan 1,827,877, Lebanon 404,170, Syria 432,048, Gaza governorates 986,034, and the West Bank 699,817. Approximately one third of the registered refugees live in 58 official camps and the remaining population lives in unofficial camps, towns and villages side to side with host country population. The distribution of camp refugee population varies significantly from one field to another, with the highest rates in Lebanon and Gaza governorates and the lowest in Jordan (UNRWA, 2005).

1.6.2. Health Care System:

In principle, the Ministry of Health (MOH) has the prime responsibility for the health of the entire population, in which human resources are a critical issue. It's main objective is to balance Human Resource Development HRD and health personnel needs. This requires a strong leadership to assure harmony between HRD and national plans and policies.

The MOH is the health authority responsible for supervision, regulation, licensure, and control of the whole health services.

The MOH provides both primary and secondary health services and purchases tertiary services from private providers domestically and abroad.

Over the past years, the Palestinian health care system has been developing side by side with the development of Palestinian society in general. Five stages of development can be identified:

1. Since the early days of Israeli Military Occupation in the West Bank and Gaza strip, the Israeli Military Occupation have continuously attempted to takeover the existing Palestinian health care structures and to make them increasingly dependent on the Israeli health care system. In the early years of occupation, little development had taken place at most if the efforts of the Palestinian structures which were not taken over by the Israeli Military Authorities were directed towards maintaining their existence and providing needed health care services under numerous restrictions imposed by Israeli Military Authorities. The Israeli restrictions took many forms, ranging from delays in licensing of projects to the point where such activities as health education became activities requiring permission from the military occupation authorities. During the period (June 1967 to the early 1970s) few Palestinian structures were erected.
2. Starting in the early 1970-s a new trend began to build as many independent health care structures as possible. Despite the many restrictions imposed by the Israeli authorities, a number of indigenous health care organizations, predominantly charitable societies were able to obtain permits to operate in the Occupied Territories. This trend, however was mainly focused on curative health care services. Little emphasis on preventive health activities and primary health care services. Although a number of significant achievements were recorded during that period, the many restrictions imposed by the Israeli Military Authorities rendered further development of that sector virtually impossible.

3. During the late 1970s and early 1980s, another trend began to develop in the Occupied Territories. It was based on a more holistic concept of health, namely that health and illness were not merely biological phenomena and that the health of the population and not just the individual was an integral part of the social, economic, even the political context within which the population lived.
4. In early 1988, with the outbreak of the Palestinian uprising, the Palestinian health structure was put in a state of emergency due to the large number of casualties, which resulted from Israeli army violence. As a result of this situation, a large number of new clinics were established in the West Bank and Gaza Strip in order to meet the increasing need of medical services. The growth in the Palestinian health care structures during the years of the uprising was predominantly confined to the NGOs and charitable sectors.
5. Since 1992, and after Palestinian MOH had taken the responsibilities of health in Palestine, great improvement and development in term of quantity and quality of health services including policies, regulations, infrastructures and human resources development. Since then health care in Palestine is first and foremost the responsibility of the Ministry of Health. Thus, it is essentially a public and a governmental responsibility. Being so, it is regulated by mandates issued by Palestinian National Authority (Palestine, MOH, 2001).

1.6.3. Hospitals in Palestine:

MOH is the main health care provider in Palestine with other health care providers, UNRWA, Medical Services for Police and General Security, health services of national and international Non Governmental Organizations (NGOs), and private health sector. MOH is the health authority responsible for supervision, regulation, licensure and control of the whole health services.

In Palestine the secondary healthcare is provided by governmental, non-governmental, UNRWA and private sectors. MOH is responsible for a significant portion of the secondary healthcare delivery system (60-70% of general and specialized hospital beds) and more than this proportion in hospital services (about 70% of hospital services). In 2005, there are 43 general hospitals with 3,726 beds, 10 specialized hospitals with 812 beds, 19 maternity hospitals with 322 beds and four rehabilitation centers with 165 beds (Palestine, MOH, October, 2006).

1.6.4. MOH Hospitals:

The MOH owns and operates 22 hospitals (10 in GS and 12 in the WB), furnished with 2,815 beds (1,499 in GS and 1,316 in the WB).

The general hospitals with 2,163 beds (1,199 in GS and 964 in WB), two psychiatrics hospitals with 319 beds (280 in WB and 39 GS), one ophthalmic hospital in GS with 31 beds and two Pediatric hospitals in GS with 222 beds (Palestine, MOH, October, 2006).

1.7. Definition of Terms

***Operating Room*:** the operating room is a room specifically for use by the anesthesia and surgical teams for performing surgical procedures and must not be used for other purposes (WHO, 2003).

Governmental hospitals: hospitals that are controlled and directed by MOH. They offer different types of health services free for residents who are covered by health insurance.

Private hospitals: hospitals owned by nongovernmental institutions or charity institutions. Usually these hospitals sell their services to customers with low price / fees, depending on the type of service offered.

Microorganism: a form of life that can be seen only with a microscope: including bacteria, viruses, yeast, and single-celled animals. Microorganisms are usually too small to be seen by the naked human eye (WHO, 2001).

Bacteria: living single–cell organisms. Water, wind, insects, plants, animals and humans can carry bacteria, which can flourish on skin, clothes and in human hair, as well as in scabs, scars, the mouth, nose, throats, and intestines (WHO, 2001).

Pathogen: a microorganism (bacteria, parasites, viruses, or fungi) that is infectious and causes disease (WHO, 2001).

Contamination: the presence of potentially infectious pathogenic microorganisms on animate or inanimate objects.(WHO,2003).

Cleaning: the process by which any type of soil including organic material, is removed. Cleaning is accomplished with detergent, water, and scrubbing action.(WHO,2003).

Sanitization: reduce the number of microbes, not total elimination.(WHO,2003).

Airborne infection: the infection usually occurs by the respiratory route, with the agent present in aerosols droplets (WHO,2003)..

Nosocomial infection: nosocomial infections are those that originate or occur in a hospital or hospital-like setting (Black, 1996).

Direct contact transmission: direct transmission occurs when microorganisms are transferred from one infected person to another person without a contaminated intermediate object or person. Opportunities for direct contact transmission between patient (WHO, 2003).

Indirect contact transmission: indirect transmission involves the transfer of an infectious agent through a contaminated intermediate object or person. In the absence of a point-source outbreak, it is difficult to determine how indirect transmission occurs (WHO, 2003).

Sterilization: sterilization is the destruction of all microorganisms and can be achieved by either physical or chemical methods. Sterilization is necessary for medical devices penetrating sterile body sites (WHO, 2003).

Disinfection: disinfection removes microorganisms without complete sterilization. Disinfection is used to destroy organisms present on delicate or heat-sensitive instruments which cannot be sterilized or when single use items are not available. Disinfection is not a sterilizing process and must not be used as a convenient substitute for sterilization. Thermal disinfection is not appropriate for instruments that will be used in critical sites as these instruments must be sterile (WHO, 2003).

Antisepsis: process of reducing the number of microorganisms on skin, mucous membranes or other body tissue by applying an antimicrobial (antiseptic) agent.

Surgical asepsis: preparation and maintenance of a reduced (safe) level of microorganisms during an operation by controlling main sources of infection organisms from the patient, personnel, equipment and the operation room environment.(WHO,2008).

Environmental controls: standard specifying procedure to be followed for the routine care, cleaning and disinfection of environmental surfaces, beds, bedrails, bedside equipment and other frequently touched surfaces.(WHO,2008).

Unidirectional airflow (UDAF): unidirectional airflow is a rectified airflow over the entire cross-sectional area of a clean zone with a steady velocity and approximately parallel streamlines.(WHO,2008).

Laminar air flow (LAF): laminar air flow or unidirectional air flow is a rectified air flow over the entire cross-sectional area of a clean zone with a steady velocity and approximately parallel stream lines (WHO, 2008).

1.8. Thesis Structure

The present study composed of five chapters: introduction, literature review and conceptual framework, materials and methods, results and discussion, conclusions and recommendations.

The first chapter browsed general introduction to the whole study, where a brief background about the subject of this study was provided. The researcher described the problem statement and justification of the study, the main aim and specific objectives of the study, and research questions.

The second chapter included two parts: The first part is the literature review concerning the topic of the study variables and previous studies regarding the sources of contamination in the operating rooms, incidence and types of microbial contamination in the operating rooms, surgical site infection, environmental controls in the operating theatres, and types of air supply were included.
The second part is the conceptual framework where the researcher provided a schematic diagram of the conceptual framework of the study. The researcher mentioned the

theoretical information and description for every item included in the scheme and tried to show how these items are used and interfered in the practical part of the thesis.

In the third chapter that deals with the methodology "material and methods", the researcher described study design, population, sample and sampling method, sampling size, ethical considerations, chemicals and reagents, instruments, isolation techniques, biochemical tests and the tests that used for statistical analysis purposes.

The fourth chapter includes two parts: the first part presented the results of the study that obtained by the researcher after data analysis. The researcher treated the results in form of tables that make it easy for the reader to understand and comment.
The second part presented the discussion. The results in this chapter were discussed in respect to the available published previous studies that directly related to the topic and aims of this study.

Finally, in the fifth chapter, the researcher presented conclusions and recommendations that obtained from this work according to the results and discussions regarding the microbial contamination of the operating theatres in selected hospitals at the Gaza Strip.

Chapter Two

Conceptual Framework

&

Literature Review

Chapter Two

Conceptual Framework & Literature Review

2.1. Conceptual Framework

2.1.1. Introduction

Modern operating rooms are considered to be aseptic environments. The use of surgical mask, frequent air exchanges, and architectural barriers are used to reduce airborne microbial populations. Breaks in surgical technique, host contamination, or hematogenous seeding are suggested as causal factors in these infections.

Contamination of the operating theatres is one of the most life-threatening sources of nosocomial infection for patients, especially in transplant surgery, heart surgery, cystoscopy and transurethral resection of prostate and bladder tumors. Multiple reservoirs have been reported as being responsible for hospital contamination, particularly the operating theatre including unfiltered air and ventilation system.

Post-operative wound infection delays recovery and often increases length of stay and may produce lasting sequelae and require extra resources for investigations, management and nursing care. Therefore, its prevention or reduction is relevant to quality patient care.

Studies support the concept that a reduction in post-operative wound infection is directly related to increased education and awareness of its causes; its prevention is greatly aided by critically evaluated infection control practice.

The present study that designed as descriptive analytical cross-sectional study and performed in two governmental and another two private hospitals at the Gaza Strip using non-probability accidental sampling method was aimed to find out the presence and percentage of microbial contamination in the operation theatres in these hospitals. Also, to compare between this percentage of microbial contamination of these hospitals in term of type and name of hospital, source of sample and if samples collected before or after the operations. Moreover, the present study aimed at finding the type of bacterial genus and species that contaminate the operation theatres and its antibiotic sensitivity profile index.

The instruments and tools used in this study were aseptic technique collection of samples from different sources including animate and inanimate objects at the operation rooms, culturing these samples on special culture media, identification of bacterial species using conventional standard techniques, carrying up disc diffusion test to detect antibiotic sensitivity and using professional statistical program as SPSS.

The theoretical framework of this study, including the items of this study was depicted as schematic diagram in the following figure (2.1).

Thesis Theoretical Framework

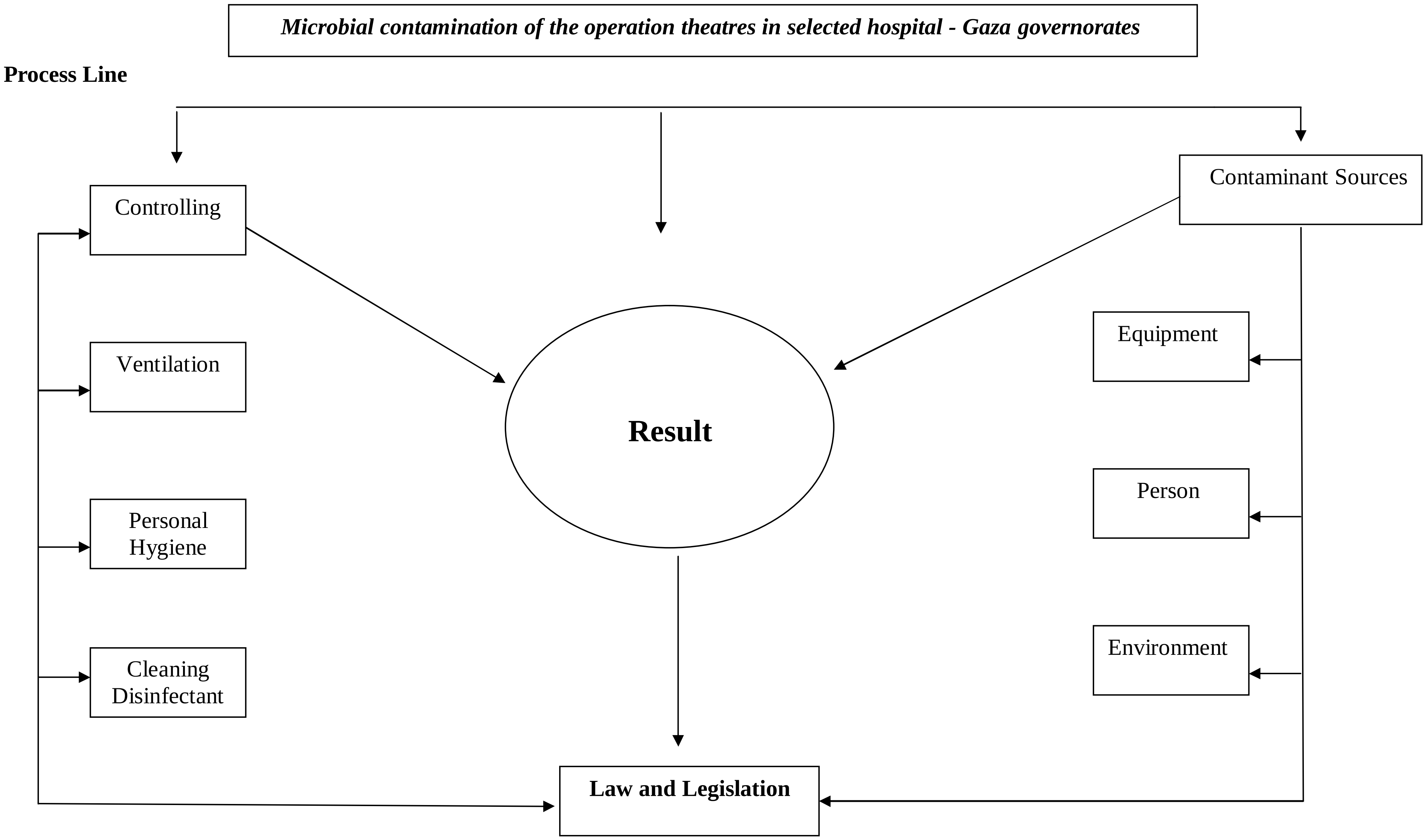

Figure 2.1 Conceptual Framework Diagram

2.1.2. Operating Room (OR)

Simply it is defined as area or space where surgical procedure are performed. It is specifically for use by the anesthesia and surgical teams and must not be used for other purposes. All operation rooms require good lighting and ventilation, dedicated equipment for procedures, equipment to monitor patients, as required for procedure and drugs and other consumables for routine and emergency use that can save life of the operative person (WHO, 2003).

2.1.3. Sources of Contamination in Operating Theatre

2.1.3.1. Air:

Air born transmission occurs when droplet nuclei (evaporated droplets) < 5 micron in size are disseminated in the air. These droplets nuclei can remain suspended in the air for long periods of time. Droplet nuclei are the residuals of droplets and when suspended in the air, dry and produce particles ranging in size from 1-5 micron. These particles can remain suspended indefinitely in the air (WHO 2003).

Air is a potential source of microorganisms that can contaminate surgical wounds, its role in wound infection has been demonstrated in certain clean operation, such as operation in which a foreign body is implanted. Operating room air is often contaminated with microorganisms that are usually attached to other air borne particles such dust, lint, skin squames, or respiratory droplets. Many of these microorganisms are potential pathogens (CDC, 1985).

2.1.3.2. Staff and Patient:

In to days operating environment, more than half of clean surgical – site infection pathogens originate from normal skin flora of patients or staff. Bacteria on skin squames, lint and other dusts get into the air currents deposit on surfaces. They are also spread by direct contact between carrier and wound (Dharan and Pittet, 2002).

Staff working in the operating theatre are the main sources of air born bacteria, and during walking 10 skin scales per minute are released, about 10% of which carry clusters of microorganisms. The average size of desquamated skin cells is about 20 with 10% less than 7 (Gosden *et al.*, 1998). The source of contamination was found that patient skin 2% of cases and theatre personal in 98% of cases. In the latter, 30% of contamination reach the wound directly the air 70% reach the wound via the hands of the surgical personnel or the instrument used (Nelson *et al.*, 1973).

2.1.3.3. Equipment and Instrument:

Equipment and instrument has been used in the operating room represent high risk factor of transmission of infection. Any instrument or equipment entering into a sterile part of the body must be sterilized, where the instrument or equipment will be in contact with mucous membranes or non intact skin, it must have under gone high –level disinfection, and where will be contact with intact skin, allow level of disinfection or cleaning should be used (WHO, 2003).

The operating team is the most important source of the microorganisms which may cause deep infection after total hip replacement. Microorganisms on skin are transferred in the air (Blomgren, *et al.*, 1990).

2.1.3.4. Operation Room Condition:

Operation room condition (ceiling, floor and walls) are the largest horizontal surface, collects viable organisms from the air and become contaminated by direct contact from equipment and shoes with or without covers (Schonholtz, 1976).

2.1.4. Controlling Contamination in Operating Theatre

2.1.4.1. Location of the Operation Theatre:

Operating theatre may be located in either purpose –built units or in converted hospital accommodation. They are busy units and therefore they are built in order to prevent expensive mistakes. They should be separated from the main flow of hospital traffic and from the main corridors; however, it should be easily accessible from surgical wards and emergency rooms (WHO, 2001).

2.1.4.2. Ventilation:

The provision of ventilation system in a hospital operating room is crucial for human comfort and protecting the patient and surgical staff against hazardous emissions. The room air exchange carries several functions to control the space temperature and humidity, to control air movement for minimizing the migration of airborne bacteria, and to remove dilute indoor pollutants including waste anesthetic gases.

The clue is to provide adequate and tactful movement of clean conditioned air to where the operation is performed, and where the sterile instrument and drapes are exposed (CDC, 1985).

Ventilation systems should be designed and maintained to minimize microbial contamination. The air conditioning filters should be cleaned periodically and fans that can spread airborne pathogens should be avoided in high-risk areas.

High-risk areas such as operating rooms, critical care units and transplant units require special ventilation systems. Filtration systems (air handling units) designed to provide clean air should have high efficiency particulate air (HEPA) filters in high-risk areas. Unidirectional laminar airflow systems should be available in appropriate areas in the hospital construction. Ultra clean air is valuable in some types of cardiac surgery/neurosurgery/implant surgery theatres and transplant units.

Airborne contamination decreases with 1) decreased numbers and activity of personal; 2) increased ventilation that dilutes contaminated air with relatively clean filtered air; 3) ultra violet light which kills microorganisms; and 4) proper use of occlusive clothing.

The air in the operating theatre must be at positive pressure compared with adjacent room and corridors. Theatre ventilation must be checked and maintained by trained engineers. In a conventionally-ventilated theatre there should be a minimum of 20 changes per hour. Microbiological air counts should be below 35 bacterial or fungal colony –forming units per cubic meter when the theatre is empty. Ultra-clean air below 0.5 CFU/m^3 of air leaving the final air filters and below 10 CFU/m^3 of air (CDC, 1985) .

2.1.5. Personal Hygiene

2.1.5.1. Hand Hygiene:

As the hands of health-care workers are the most frequent vehicle of nosocomial infections, hand hygiene including both hand washing and hand disinfection is the primary

preventive measure. Thorough hand washing with adequate quantities of water and soap removes more than 90% of the transient, i.e. superficial flora including all or most contaminants. An antimicrobial soap will further reduce the transient flora but only if used for several minutes. Hand washing with (non-medicated) soap is essential when hands are dirty and should be routine after physical contact with a patient. Killing all transient flora with all contaminants within a short time (a few seconds) necessitates hygienic hand disinfection: only alcohol or alcoholic preparations act sufficiently fast. Hands should be disinfected with alcohol when an infected tissue or body fluids touched (WHO, 2006).
Staff must clean for hands by running water then with dry soap or liquid antiseptic and then suitable material for dry of hands. After these procedure the specific hand disinfectant antiseptic recommended: 2-4% chlorhexidine, 5-7% povidone iodine, 1% triclosan. Staff must wear dedicated shoes which must easy to clean and they must wear caps or hoods which completely cover the hair. Mask of cotton, wool, gauze, or paper masks are ineffective. Paper masks with synthetic material for filtration are effective barrier against microorganisms (WHO, 2006).

2.1.5.2. Staff Practice:

Staff team are another sources of contamination, so to control this source aseptic procedure must be used to prevent the access of microorganisms to the surgical field. The surgical team must also take preoperative measures to prevent microbial contamination of the wound. Transfer of microorganisms from hand to the wound is reduced by scrubbing the hands and wearing sterile gloves. The surgical scrub is designed to kill or remove as many bacteria as possible, including resident bacteria. The ideal duration of the surgical scrub is not known, but times as short as 5 minutes appear safe. On hands are scrubbed, sterile gloves act as an additional barrier to transfer of microorganisms to the wound.
Sterile surgical gowns are used to create a barrier between the surgical field and potential sources of bacteria. They reduce wound contamination and clinical infection rates in clean surgery (Wong and Leung, 2004).

2.1.6. Cleaning the Hospital Environment

Routine cleaning is important to ensure a clean and dust free hospital environment. There are usually many microorganisms present in visible dirt, and routine cleaning helps to eliminate this dirt. Administrative and office areas with no patient contact require normal domestic cleaning. Most patient care areas should be cleaned by wet mopping. Dry sweeping is not recommended. The use of a neutral detergent solution improves the quality of cleaning. Hot water (80°C) is a useful and effective environmental cleaner. Bacteriological testing of the environment is not recommended unless seeking a potential source of an outbreak. Any areas with visibly contaminated with blood or body fluids should be cleaned immediately.

Isolation rooms and other areas that have patients with known transmissible infections should be cleaned with a detergent/disinfectant solution at least daily. All horizontal surfaces and all toilet areas should be cleaned daily (WHO, 2003).

The floor should be covered with antistatic material, and the walls should be painted with impervious antistatic paint. This reduces the dust levels and allows frequent cleaning. The surfaces must with stand frequent cleaning and decontamination with disinfectant. (WHO, 2001).

2.1.7. Disinfectant and Sterility

Prior to any reprocessing to achieve disinfection or sterility all instruments and equipment must be cleaned. If not cleaned properly, organic matter may prevent the disinfectant or sterilant from having contact with the instrument and equipment and may also bind and inactivate the chemical activity of the disinfectant. If an instrument and equipment is unable to be cleaned, then it is unable to be sterilized or disinfected. After an instrument has been used, prior to it drying, it should be washed to remove any gross soiling. At this stage, detergent and water is appropriate to use (WHO, 2004).

It is important to perform routine cleaning for environmental surfaces such as (tables, floors, walls, ceiling and lights) to establish a clean environment after each operation. When visible soiling of surfaces or equipment occurs during operation, an Environmental Protection Agency (EPA) approved hospital disinfectant should be used to decontaminated the affected area before the next operation. This is in keeping with occupational safety and health administration (OSHA) requirement that all equipment and environmental surfaces be cleaned and decontaminated after contact with blood or other potentially infectious materials.

2.1.8. Laws and Legislation

Infection control and basic hygiene should be at the heart of good hospital management. Visually unclean environment gives a poor impression of health care institutions, and dirty or contaminated objects act a source of infection (Griffth *et al.*, 2000). In order to achieve a good hygiene and infection control, the operation theatre staff should follow the following rules:

- Hand washing and antisepsis (hand hygiene); use of personal protective equipment when handling blood, body substances, excretions and secretions; appropriate handling of patient care equipment and soiled linen; prevention of needle stick/sharp injuries; environmental cleaning and spills-management; and appropriate handling of waste.
- Personal protective equipment should be chosen according to the risk of exposure.
- Health care workers should assess whether they are at risk of exposure to blood, body fluids excretions or secretions and choose their items of personal protective equipment according to this risk.
- Avoid any contact between contaminated (used) personal protective equipment and surfaces, clothing or people outside the patient care area.
- Discard used personal protective equipment in appropriate disposal bags, and dispose of according to the health care facility protocol.
- Do not share personal protective equipment.
- Change personal protective equipment completely and thoroughly wash hands each time you leave a patient to attend to another patient or another duty (Griffth *et al.*, 2000).

2.2. Literature Review

2.2.1. Introduction:

A microorganism or microbe is an organism that is microscopic (usually too small to be seen by the naked human eye). The study of microorganisms is called microbiology, a subject that began with Anton van Leeu Wenhoeks discovery of microorganisms in 1675, using a microscope of his own design. Microorganisms are incredibly diverse and include bacteria, fungi, archiea and protists.

Contamination of operating theatres is one of the most life-threatening sources of nosocomial infection for patients, especially in transplant surgery, heart surgery, cystoscopy and transurethral resection of prostate and bladder tumors. Multiple reservoirs have been reported as being responsible for hospital contamination, particularly the operating theatre, including unfiltered air, ventilation systems and antiseptic solutions (Fridkin & Jarvis, 1996). Other reports suggest that a range of micro environmental conditions exist even within purified water systems which are intended for laboratory use or for irrigation, leading to variable populations of contaminant bacteria (McFeters *et al.*, 1993). Medical staff still represent an exogenous contaminant source in operating theatres (Emmerson, 1998) and personnel move back and forth between the operating theatre and other parts of the hospital without changing their gowns or slippers. Moreover, patients are not consistently cleaned or shaved before coming to the operating theatre. All these factors play a role in contamination of operating theatres and consequent postoperative infections (Siddiqui & Luby, 1998).

2.2.2. Means of Transmission of Microorganisms:

Understanding the means of transmission of infectious diseases is very important in the prevention of occupational transmission of pathogen. Microorganisms are transmitted in hospitals mainly by contact, droplet and airborne routes. The contact transmission is the most important way of transmission of nosocomial infection, this include direct and indirect contact. Direct contact transmission involve direct body-to body contact with the transfer of microorganisms during surgery to routine care of patient. Indirect contact transmission is the transmission of pathogens by contact with contaminated objects such as dressings, needles and instruments. Transmission by droplets are primarily generated by patients or the team of surgery during coughing, sneezing and talking and during the performance of certain procedure such as suctioning and bronchoscopy. Air born transmission can occur by dissemination of these small particles if they contain pathogens (Wong & Kwok, 2004).

Health Care Associated Infections (HCAIs) are mostly caused by bacteria. Bacteria can exist harmlessly in people, for example on the skin or in the gut. However, some types of bacteria can cause HCAIs when they enter the body, for example through wounds and the use of surgical devices, or when the body's natural balance is disturbed. HCAIs occur in the lungs (23% of all HCAIs), urinary tract (23%), blood (6%), skin (11%). Infections are usually treated with antibiotics. However, many bacteria have developed resistance to antibiotics, which can make infections harder to treat, including; *Escherichia coli* is the most frequent cause of urinary HCAIs and may account for around 12% of all hospital acquired bacteraemias. *Pseudomonas aeruginosa* can cause infections all over the body, but most frequently causes respiratory tract infections in very ill patients. It may account for 10% of all HCAIs. *Klebsiella pneumoniae* and glycopeptide-resistant enterococci (GRE) cause infections primarily in the lungs, urinary tract and abdomen. They are responsible for 8% and 5% of all hospital-acquired bacteraemias, respectively. *Clostridium difficile* causes severe diarrhea. It is transmitted through hand contact (Parliamentary Office of Science and Technology, 2005).

2.2.3. Operating Room (OR):

The operating room (OR) is a room specifically for use by the anesthesia and surgical teams and must not be used for other purposes. OR require good lighting and ventilation, dedicated equipment for procedures, equipment to monitor patients, as required for procedure and drugs and other consumables for routine and emergency use (WHO, 2003). Modern operating rooms are considered to be aseptic environments. The use of surgical mask, frequent air exchanges, and architectural barriers are used to reduce airborne microbial populations. Breaks in surgical technique, host contamination, or hematogenous seeding are suggested as causal factors in these infections (Edmiston *et al.,* 2005).

2.2.4. Mode of Contamination in the OR:

The prevention of surgical site infection remains an important focus in the practice of surgery. As there are many potential host and environmental factors that contribute to surgical bacterial contamination, a multimodal approach to minimize this complication has been developed. Host factors such as nutritional status, immune-system health, medical co-morbidities, age, and residence in a nursing home facility have been shown to affect surgical infection rates (Dominioni *et al.* , 2006& Cheadle *et al*., 2006) Likewise, multiple interventions have been developed to promote sterility both at the surgical site and within the surgical suite. The advent of modern surgical preparation and draping strategies, laminar flow operating rooms, implant sterilization techniques, and preoperative administration of antibiotics have significantly reduced the frequency of peri-operative infections (Knobben *et al*., 2006 & De Lalla, 2006). While we often take great care in addressing factors that are perceived as readily modifiable, other factors may perhaps be overlooked, be thought to be uncontrollable, or be taken for granted as already being ideal. Specifically, the absolute sterility of surgical trays and the instruments that they contain is often assumed. Additionally, the contribution of operating-room air quality to surgical infection rates is generally considered to be minimal or perhaps even inconsequential given the routine use of positive or laminar air-flow systems.

2.2.4.1. The Air :

Microbiological contamination of air in the operating room is generally considered to be a risk factor for surgical site infections in clean surgery (Landrin *et al.*, 2005). Aerosols are solid and liquid particles, and micro-organisms dispread in the air. The aerosols sources could be introduced from the out side when the filters are not efficient, or because of air infiltration due to improper room pressurization.

In OR, however the main sources have an indoor origin are patient, the surgical team and the equipment (Melhado *et al*., 2003).

Air is a potential source of micro-organisms that can contaminate surgical wound. The dose of contaminating micro-organisms required to produce infection is very low when foreign material is present at the site. As few as 10 colony forming units (CFU) are estimated to be the safe bacterial content per cubic meter of air in operating theatre (Pasquarella, 2007).

Microbial shedding increases with activity, grater amounts of air born contamination can be expected with increased movement of surgical team members (AORN, 2006).

Talking for 5 minutes and coughing each can produce 3,000 droplet nuclei; sneezing can generate approximately 40,000 droplets which then evaporate to particles in the size rang of 0.5-12 micrometer particles in a biological aerosol usually vary in size from <1 µm to ≥ 50 µm. These particles may consist of a single unattached organism or may occur in the form of clumps composed of a number of bacteria. Clumps can also include dust and dried organic or inorganic materials (CDC, 2003).

Air born bacteria can reach the wound by direct sedimentation from the air. They also settle onto any surface that is exposed such as instrument and the surgeons gloves, so can then be transferred to the wound. About 30% of bacteria found to be contaminated the wounds as post-operative surgical site infections were directly deposited from the air (Drabu & Miller, 1998).

Evaluation of the quality of air in operating theatres can be performed routinely by microbiological sampling and particle counting. Landrin *et al*., (2005) studied the relationship between these two methods and found that there is no reason to replace microbiological sampling with particle counting for routine evaluation of microbiological contamination in conventionally ventilated operating theatres (Landrin *et al.*, 2005).

2.2.4.2. Contamination by Contact:

The role of contact in the production of post operation infection is of far greater importance than that of contamination by the air.

The greatest amount of bacteria in an operating room comes from the staff, and is often a result of surgical activities. A person releases about 10 million particles within a day. The release rate is 10,000 particles/min while walking. About 5% -10% of the particles of size ranged from (2.0 to 20 µm) carry bacteria. During an operation, most surgeons are close to the operating table. This give a chance of contamination accumulation in this crucial area. Surgeon, when bending over the wound site, is a source equivalent to as many as 1000 air born particles/min (Chow & Yang, 2004).

Gram-positive cocci (i.e., *S. aureus*, group A beta-hemolytic streptococci), also important health-care-associated pathogens, are resistant to inactivation by drying and can persist in the environment and on environmental surfaces for extended periods. These organisms can be shed from heavily colonized persons and discharged into the air. Airborne dispersal of *S. aureus* is directly associated with the concentration of the bacterium in the anterior nares. Approximately 10% of healthy carriers will disseminate *S. aureus* into the air, and some persons become more effective disseminators of *S. aureus* than others. Outbreaks of surgical site infections (SSIs) caused by group A beta-hemolytic streptococci have been traced to airborne transmission from colonized operating-room personal to patients (CDC, 2003).

2.2.4.3. Contamination by Common Vehicle:

The use of fluids to disinfect and irrigate wounds in the operating room is common practice. Many surgeons use aqueous benzalkonium chloride, this material, although a satisfactory antiseptic, is easily contaminated with Pseudomonas species (George *et al.*, 1976).

The study conducted in Korea to identify the level of contamination in saline used in the operation and also examine the correlation between the contaminated saline and the length of the operation, and unclean atmospheric factor. Subjects of this study include 13 cases of operation performed at the operative theatre of a hospital in Seol area. Test samples and related data were collected from this medical facility by the author and nurse who worked in the operating room. Multiple batches of saline sample were collected at various time intervals during the operation and filtered through the membrane filters viable microorganisms retained on the filters were cultured on the appropriate culture media and the level of existing cells in saline were enumerated according to koch method. The data analyzed, Pearson's correlation coefficient was obtained for the examination of relationship between the length of operation and number of microorganisms existing in saline and for the comparison of the differences in numbers if the microorganisms in saline sample collected at the various operation stages, e.g. pre-incision, excision and skin suturing stages. The result of this study was: 1) The length of the operation and number of microorganisms in the saline used in the operation appeared to be significantly correlated (r = 0.5467, P< 0.001); 2): In case of saline exposed to air, but not used in the operation, the length of exposure to the air and the number of microorganisms in saline also showed an apparent correlation (r = 0.5087, P<0.001); 3): The frequencies of occurrence of microorganisms in saline used in operation and in saline exposed to the air in the given time showed significant differences (t = 3.73, P = 0.0000); 4): In case of saline used in the operation, there is significant differences in its numbers of microorganisms between the operative stages, pre-incision, excision, and the skin suture (F=17.7500, P = 0.000); 5): In case of saline exposed only to the air in a given time, there is significant differences in its numbers of being contained microorganisms between operative stages, pre incision, excision, and skin suture (F = 6.3807, P = 0.0003) (Yoon, 1995).

Ensayef *et al.*, (2009) showed that contamination of the operating theatre is a major cause of nosocomial infection. The study aimed to evaluate the incidence of bacterial contamination of operating theatres in Al Imam Ali Hospital in Baghdad, and the source of contamination. From 1216 swabs collected from surfaces, equipment and antiseptic solutions from different operating theatres in 2001 and 2002, the rates of positive cultures were 3.7% in 2001 and 4.0% in 2002. *S. epidermidis* was the most common isolate in 2001 followed by *P. aeruginosa*, whereas in 2002 coliform bacteria were the highest, followed by *P. aeruginosa*. No clear pattern of isolates was found in different types of operating theatres, although coliforms and *P. aeruginosa* were mostly found in the delivery operation theatre.

Montuori, *et al.*, (2007) illustrated the microbiological, physical and chemical results of an investigation concerning the environmental conditions of operating theatres in 38 public hospitals of the Campania Government. The analysis of the results has been made by considering specific standards suggested by national and international regulations. The results showed that 84% of the operating theatres presented normal microbiological values, in relation to the total bacterial load, while 16% did not. By considering the microclimatic monitoring, 55% of the operating theatres showed normal values while 45% at least a microclimatic index did not. In relation to the concentrations of anaesthetics gases the survey pointed out that the nitrous oxides was within non prescribed environmental limits (50 ppm for N_2O).

Griffith *et al.*, (2000) reported a four-part study to assessing cleanliness in up to 113 environmental surfaces in an operating theatre and a hospital ward. Surfaces were assessed visually, using microbiological methods and ATP bioluminescence, result from a preliminary random survey indicated variability in clean lines. These results were then used to select sites for monitoring before and after routine cleaning, over a 14- day period, using published microbiological and ATP specifications 70% and 76% of these sites were unacceptable after cleaning. Visual assessment was a poor indicator of cleaning efficacy with only 18% considered unacceptable. Sites most likely to fail in the ward were in the toilet and kitchen, area which are frequently implicated in the spread of infectious intestinal disease. Operating theatre sites had lower ATP results but 61% of sites would be considered unacceptable. There were no significant difference in general microbiological or ATP result over all before and after routine cleaning, there was significant decrease in Staphylococcal and Enterobacter counts in the ward but not in the operating theatre after cleaning. The routine cleaning programs used did not include a biocide and cleaning using a hypochlorite based sanitizer gave much values .

Aqarwal *et al.,* (2003) mentioned that dirty operating rooms, often contaminated with blood and other infected material, are not only a source of discontent among surgeons and other surgical personnel, but they also pose a potential risk of transmission of viral or bacterial diseases to the wearer and cleaner of the boots. Operating room boots were examined for the presence of blood by visual inspection; the presence or absence of blood was confirmed by a specific biochemical test. Bacterial isolation and quantitative from boots were performed with conventional methodology. The result indicated that a spot sketch revealed that 44% of all operating room boots tested were contaminated with blood and that the majority were contaminated with bacteria. Sixty three percent of surgeons using the facility had blood-contaminated boots, and a significant number of boots belonging to the other personal were also contaminated with blood and bacteria normally associated with skin microbiota or the environment. Comfort shoes with perforation on their upper surface and plastic boots commonly found in operating rooms were most heavily contaminated.

Scaltritis *et al*., (2007) approved the relationship between the microbiological and dust contamination, the air quality during 23 surgical operations that were studied in three conventionally ventilated operating theatres. Air dust particles, > or = 0.5 and > or = 5 micron in size, were measured using a light –scattering particle analyzer. The overall dust load was (98%) composed of fine particulate matter, these particle positively correlated with operation length, the surgical technique was the main predictor for the concentration of particles > or = 5 micron, with the higher risk from general conventional surgery composed with scope surgery. Also the frequency of door opening, taken as an index of staff and visitor movement, was the main negative predictor of over–threshold values of both fine and larger dust particles but, conversely, was positive predictor of raised bacteria counts.

2.2.5. Aseptic Barrier in the Operating Room

Hubble *et al.,* (1996) clarified the relative contribution of hats, masks, and clothing to the control of wound contamination in both ultra clean (enclosed vertical laminar–flow) and conventional (plenum ventilated) air flow theatres. Personnel wore varying combination of dress in both types of theatre. Colony forming units (CFU) were measured on settle plates at the head and waist height, and in the air by a centrifugal air sampler, bacterial counts in conventional theatres were consistently high and were not significantly influenced by theatre dress, there was a 22 fold increase in CFU on settle plates at waist height when neither hat nor mask were worn, a 15-fold increases when a hat but no mask was worn, rather than cuffed polyester with microfilament barrier-fabric gowns, CFU counts rose by a factor of six. The bacterial inoculum in conventionally ventilated theatres, or in ultra clean theatres if hat or mask are omitted or balloon–cotton clothing worn, is theoretically sufficient to infect a prosthetic arthroplasty.

McCullough, (1993) approved that surgical gowns are worn in the operating room to reduce the incidence of nosocomial wound infections in patients and to prevent the exposure of medical personnel to pathogens in blood and other body fluids from the patient. New test methods have been developed by the American Society for Testing and Materials to identify gowns that provide barriers against liquid and microbes. This article evaluated the liquid and microbial barrier properties of 13 reusable and disposable gowns and investigated the cumulative effects of laundering and sterilizing on the barrier efficacy of reusable gowns by means of the Impact Penetration (splash) Test, the Synthetic Blood Resistance Test, the Viral Resistance Test, and the Elbow Lean (demonstration) Test. The result indicated that Single-layer regular gowns and double-layer fabric reinforced gowns offer different degrees of liquid resistance; that is, they show some resistance to splashes and pooling of liquids on the surface. Gowns reinforced with films, membranes, and coatings are generally liquid-proof, meaning that they resist visible penetration of synthetic blood under pressure. Some of these gowns are also resistant to viral penetration.

Pasquarella, *et al.,* (2007) studied aerobic bacterial surface contamination with and without the use of body exhaust gown in operating rooms equipped with mixed turbulent ventilation and separate operating and anesthetic areas during 62 hip joint arthroplasties, In 31 operation conventional gowns were used, and 31 were performed with body exhaust gowns. Bacterial surface contamination was monitored in the operating and anesthetic area using 9 cm diameter settle plates (1+1) and nitrocellulose membrane (2+2) transferred after sampling to nutrient pads. Compared with conventional clothing, the use of body exhaust gowns did not significantly reduce the microbial contamination (P=0.1-0.7).

Verkkala, (1998) in his study compared the usefulness of a conventional bacteriological technique with that of a particle counting under lower air contamination and better aseptic conditions achieved with special staff garments and covering for the patient. In a series of 66 consecutive coronary artery bypass operation performed by the same team and in the same theatre using different types of patient and staff clothing, the impact of a reduced bacteriological and particulate contamination were assessed. The volumetric air contamination of particles >5µ and bacteria–carrying particles were monitored 30 cm above the sternal wound. The bacterial contamination and bacterial wound infection in the sternal and leg wound were assessed as well. The result showed that with the alternative garment and textile system, the air counts fell from 25 (CFU)/m to 7 CFU/m (p<0.0038). The contamination of the sternal wound was reduced by 46% and that of the leg wound by >90%. In order to give continuous contamination feed back during the whole operation to the theatre staff, particle counts >5 were monitored and visualized. Air particle counts decreased rapidly from 850 particles/m and stabilized to approximately 50 particles/m when the alternative clothing system was used (P<0.001). Low particle counts >5m should offer the possibility to in directly estimate air bacteria carrying particle counts during the entire operation. Less than 20% of the counts in this size group carries bacteria. The low air contamination was achieved even in an ordinary ventilated theatre when individual team members used clean air suits in combination with impermeable patients drops, when air particle level <50 particles/m is reached, the bacterial air contamination is in the order of that orthopedic hip operation. The staff must during the entire operation adjusted their activity to air asepsis.

Berqers, (1993) studied the influence of surgical mask usage on bacterial contamination of the operative field during 30 cardiac catheterization procedure. Mask position was varied during each procedure according to a pre-designed random table. The number of bacterial colonies recoverable when no mask was worn was significantly higher than that detected when a full mask was worn (P<0.002). Shedding of *S. epidermidis* was greater when no mask was worn (mean size colonies 10 min^{-1}) than shedding with full mask (mean 2.7

colonies 10 min^{-1}; *P*<0.004). Although mask placement below the nose was associated with higher mean colony counts than that above the nose, these differences were not statistically significant.

The study conducted by Mitchell *et al.*, (1978) about the reduction of skin bacterial in theatre air with comfortable – non – woven disposable clothing for operative –theatre staff. When men wore operating suits made of the non-woven fabric dispersal of skin, bacteria was reduced by 72%. When all the operating theatre staff wore suits and dresses of this fabric, air bacterial counts during operating sessions were reduced by 55%; no reduction occurred when the fabric was worn by only the scrubbed team. The lowest level of microbial contamination of the air in the operating theatre occurred when both the un scrubbed and scrubbed theatre staff wore clothes of non-woven fabric.

2.2.6. Surgical Instrument as Source of Contamination

Rutala, (1998) demonstrated the microbial load and the type of microorganisms on used surgical instrument following standard cleaning, which consist of the use of washer sterilizer followed by sonic cleaning. The study was prospective experimental study, where surgical instruments were immersed in peptamin tween broth, the broth agitated, and then filtered through a 0.45 µm filter. Quantitative cultures were performed, and all microbes were identified by using standard techniques. Results showed that the microbial load remaining on used surgical instruments after cleaning was as follow: 36 (72%) instrument 0 to 10 (CFU), 7 (14%) instrument 11 to 100 CFU, and 7 (14%) instruments > 100 CFU. Organisms contaminating the instruments included coagulase–negative staphylococcus (56%), followed by Bacillus (22%) and Diphtheroids (14%). No other microbes were isolated from more than 4% of the instruments.

Kelkar *et al.*, (2003) described that post operative infection can be caused by a contaminated environment, unsterile equipment, contaminated surfaces, and infected personnel as well as contaminated disinfectants. The study carried out for a period of 21 months, to assess environmental bacteria carrying particle (BCP), load and surface samples weekly (n=276); the autoclaving system once a month and repeated whenever the process failed (n=24); the air conditioning filters fore fungal growth once in four month (n=15), and the disinfectant solution for contamination once in two months (n=10). Additionally, the personnel involved directly in surgery were screened fore potential pathogens such as *S. aureus* and β hemolytic streptococci. Results were: in 14 (5.07%) occasions, the environment in the operating rooms had a significant risk of air borne infections. Sterilization of instrument in the autoclaves was unsatisfactory on 4 (16.66%) occasions. Samples from the filters of the air–conditioning units yielded potentially pathogenic fungi on 3 (20%) occasions. Personnel sampling revealed that 5 (8.77%) individuals harbored β hemolytic streptococci in the throat and 4 (7.01%) harbored *S. aureus* in the nasal cavity . The sample of disinfectant in use were not contaminated.

Hussein *et al.,* (2001) demonstrated that the conventional surgical sucker forms a focus for air born pathogens. Similarly the potential contamination of theatre light handles. Culture bacterial swabs taken from the light handles before and after 15 procedure, the result was in all 15 procedures, no aerobic bacterial contamination was noted.

Loftus *et al.,* (2008) mentioned that potentially pathogenic, multi drug–resistant bacterial organisms are transmitted during the practice of general anesthesia to both the anesthesia work area and intravenous stopcock. The current prevalence of hospital-acquired infections and evolving amplification of bacterial resistance are major public health concerns. A heightened awareness of intraoperative transmission of potentially pathogenic bacterial organisms may lead to implementation of effective preventative measures. Sixty-one operative suites were randomly selected for analysis. Sterile intravenous stopcock sets and two sites on the anesthesia machine were decontaminated and cultured aseptically at baseline and at case completion. The primary outcome was the presence of a positive culture on the previously sterile patient stopcock set. Secondary outcomes were the number of colonies per surface area sampled on the anesthesia machine, species identification, and antibiotic susceptibility of isolated organisms. The result indicated that bacterial contamination of the anesthesia work area increased significantly at the case with a mean difference of 115 colonies per surface area sampled. Transmission of bacterial organisms, including Vancomycin-resistant Enterococcus, to intravenous stopcock sets occurred in 32% of cases. Highly contaminated work areas increased the odds of stopcock contamination by 4.7 (95% CI, 1.42-15.42; P = 0.011). Contaminated intravenous tubing was associated with a trend toward increased nosocomial infection rates (odds ratio, 3.08; 95% CI, 0.56-17.5; P = 0.11) and with an increase in mortality (95% CI odds ratio, 1.11-infinity; P = 0.0395).

Robison, *et al.*, (1993) approved that the surgical suction tip forms a reservoir for microorganisms during total hip replacement in conventional operating theatres. They assessed the colonization of the tip in an ultra clean – air operating theatre in 39 patients, bacterial colonization was found in 41% of them with one or more bacteria.

2.2.7. Operating Rooms Facilities as a Source of Contamination

William *et al.*, (2001) stated that cultures from more than 50% of the computers included coagulase- negative staphylococci (100% of key board), diphtheroids (80%), micrococcus species (72%) and bacillus species (14%). Other pathogen cultured include Oxacillin-Resistant *S. aureus* (ORSA) (4% of key board), Oxacillin- Susceptible *S. aureus* (OSSA) (4%), Vancomycin –Susceptible *Enterococcus* species (12%) and non fermentative gram-negative rods (36%).

One study was conducted by Cormican *et al.*, (1994) about the microbial flora in –use blood pressure cuffs. They placed new blood pressure cuffs in six operating rooms, and one in recovery room. A defined area of the cuff in contact with the patient was sampled before issue and at the end of the operating day for a period of five days. Swabs were plated, incubated and evaluated.

The result indicated that 48 different microorganisms were isolated from the forty two samples, where 71% percent (n = 61) were staphylococci . One isolate of the *S. aureus* was found to be resistant to Methicillin, (MRSA), Gentamycin and erythromycin .

The remaining twenty five organisms were thought to be skin and environmental representatives, although they may pose a risk to certain groups of patient.

Nelson *et al.*,(2006) found that the bacteria most frequently involved in surgical site infection (SSI) could be found on telephones in the operating Room (OR). A total of 26 cultures were taken from telephones with 14 operating rooms and two sub-sterile rooms at a large teaching medical centre. Bacteria were identified using standard laboratory procedure. Of the 52 isolates discovered, the following bacteria were identified: *Acinetobacter calcoaceticus–baumanni* complex (1.9%), *Pseudomonas aeruginosa* (1.9%), *Agrobacterium radiobacter-tumefaciens* (1.9%), Coagulase- negative staphylococci (82.7%), micrococcus (3.8%), Streptococcus non-group D (5.8%) and one unidentified Gram-negative rod (1.9%).

2.2.8. Surgical Site Infection

Any infection that involves superficial and deep incision sites should be reported as deep incisional surgical site infection.

Surgical site infection (SSI) is a major complication following surgery. Microbial contamination of the surgical site is a necessary precursor for infection. For most SSIs, the source of pathogens is the endogenous flora of the patients skin, mucous membranes, or hollow viscera. It is generally suspected that the main factor causing SSI after clean operation is bacterial contamination of the operating theatres air Pasquarella *et al*, (2007).

A study was conducted by Coskun and Aytac (2007) about the evaluation of nosocomial infections (NIs) following cardiovascular surgery (CVS). The study used all patients who were found to have NIs after CVS. A total of 14502 cardio vascular operation were performed and 416 (2.9%) patients had NIs. The most prevalent infection were surgical site infection (42%) and urinary tract infection (22%). The most frequently isolated microorganisms were coagulase-negative staphylococci (19%), *E. coli* (16%), and *S. aureus* (16%). A total of 99 patients died. The mortality rates were high in patient with blood-stream infection (58%) and lower respiratory tract infection (37%).

Ayliffe and Collins (1967) results showed that seven post-operative wounds were infected with a strain of *S. aureus*, probably acquired from a theatre orderly who suffered from a dry generalized eczema. The orderly was a nasal and heavy skin carrier, and was shown to be a disperser of the epidemic strain. Infection was probably acquired from air born contamination in operating theatre, since the orderly did not scrub-up. The epidemic strain (phage type 80/81 at 1.000 routine test dilution) was sensitive to penicillin and resistant to tetracycline and novobiocin. Neomycin resistance was variable. This strain was found to lose resistance to neomycin when sub-cultured in the absence of the antibiotic.

Another study was conducted by Knobben *et al.*, (2006) regarding the evaluation of measures to decrease intra operative bacterial contamination in the orthopedic implant surgery. In their study, superficial surgical site infection and deep periprosthetic infection also was investigated during a 78-month follow up period. Four swabs were taken from instrument at the beginning and the end of the procedure for 207 procedure. Removed bone material (acetabulum and femur in case of the hip joint; femur and tibia in case of the knee joint) was also test fore contamination, initially, 70 operation performed under original control condition were included, after which the first behavioral measure was introduced (i.e. better use of the plenum). Culture were taken during 67 operation using better use of the plenum (Group1), followed by disciplinary measures and the installation of a new laminar flow system. Seventy operations were monitored after this second intervention (Group2). The control group showed intra-operative contamination in 32.9% (23/70) of cases, group 1 showed contamination in 34.3% (23/67) of cases and group 2 showed contamination in 8.6% (6/70) of cases. Prolonged wound discharge and superficial surgical site infection decreased significantly in group 2, as did the incidence of deep periprosthetic infection; however the latter did not reach statistical significance. The study showed that the combination of systemic and behavioral changes in an operating room significantly decreases the incidence of intra-operative bacteria.

Ahmed *et al.*, (1998) studied surgical site infections (SSI) due to *Staphylococcus aureus* among 256 male and 158 female patients (mean age, 28 years) undergoing elective surgery at the Soba University Hospital (Khartoum, Sudan). During an 11-month study period, all patients were analyzed for nasal carriage of *S. aureus* at the time of admission. Follow-up of the development of SSI proceeded until 4 weeks after the operations. In addition, nasal swabs were obtained periodically during the same period from 82 members of the staff. In order to discriminate autoinfection from cross infection, bacterial isolates were typed by random amplification of polymorphic DNA (RAPD), pulsed-field gel electrophoresis (PFGE) of DNA macro restriction fragments, and restriction fragment length polymorphism analysis (RFLP) of the protein A and coagulase genes. Preoperative cultures revealed the presence of *S. aureus* in the noses of 98 patients (24%). The overall number of post-surgical wound infections in the entire group was 57 (14%), 24 of which were due to *S. aureus*. Only 6 of the 98 nasal *S. aureus* carriers suffered from wound infections by the same species. In these six cases the infecting strain could not be genetically discriminated from the nasal inhabitant, substantiating autoinfection. However, nasal carriage of *S. aureus* is not a significant risk factor for the development of SSI in this setting (6 of 98 patients with autoinfection versus 18 of 316 patients with cross infection; P = 0.81), most probably due to the fact that non-carriers are at a significant and relatively large risk for acquiring an independent *S. aureus* SSI. The other *S. aureus* strains causing SSI showed a high degree of genetic heterogeneity, demonstrating that it is not an epidemic strain that is causing the SSI. Among the staff personnel screened, 47.4% did not carry *S. aureus* in the nose at any time during the study period, whereas 13.2% persistently carried a single strain in the nose. Another 39.5% could be classified as intermittent carriers. When strains derived from staff personnel were genetically typed, it was demonstrated that most of the strains represented genetic variants clearly differing from the isolates causing SSI. On the other hand, possible cross colonization among staff personnel and even cross infection from staff personnel to patients or from patient to patient were demonstrated in some cases, but epidemic spread of a single strain or a few clonally related strains of *S. aureus* could be excluded.

Kuehme, *et al*., (2007) investigated the degree of bacterial contamination in the sternal wound during cardiac surgery and the sternal skin flora after operation in order to increase our understanding of the pathogenesis of sternal wound infections. Cultures were taken peri- and postoperatively from sternal wounds and skin of 201 cardiac surgery patients. Results showed that 89% of the patients grew bacteria from the subcutaneous sternal tissue. 98% of the patients showed bacterial growth on the surrounding skin at the end of the operation. We found both commensal and nosocomial bacteria in the sternal wound. These bacteria had different temporal distribution patterns. Coagulase-negative staphylococci (CoNS) and Propionibacterium acnes (PA) were by far the most prevalent bacteria during and after the operation. Furthermore, 41% of patients had more than 10 000 CFU/pad CoNS on the skin. There was no correlation between length of operation and number of bacteria. Men displayed higher bacterial counts than women on the skin. From their study, the authors found that skin preparation with ethanol/chlorhexidine is unable to suppress the physiological skin flora for the duration of a heart operation.

2.2.9. Environmental Controls in Operating Theatres

Dharan and Pittet (2002) approved that surgical site infection is the leading complication of surgery. Normal skin flora of patients or health care workers causes more than half all infections following clean surgery, but the importance of airborne bacteria in this setting remains controversial. Modern operating theatres have conventional plenum ventilation with filtered air where particles >5µ are removed. For orthopedic and other implant surgery, laminar–flow system are used with high-efficiency particulate air (HEPA) filters where particles >0.3µ are removed. The use of ultra-clean air has been shown to reduce infection rates significantly in orthopedic implant surgery. Environmental bacterial sampling in operating theatres should be limited to investigation of epidemics, validation of protocols or change made in material which could influence the microbial contamination.

Chow & Yang (2004) showed that surgical site infection risk due to airborne bacteria is a key area of consideration in developing operating theatre ventilation design and monitoring procedures. This study reviews the recent extensive research into operating theatre ventilation development in relation to the design concepts in operating theatre layout, pressurization and ventilation, particularly the evolvement of ultra-clean ventilation. The findings that led to the current technical standards and the developments of microbial measurements and numerical techniques are discussed. Since the late 1980s, computational fluid dynamics has been a fast developing tool used in the prediction of room air distribution and contaminant dispersion.

Anderson *et al.,* (1998) examined the contamination in two newly built operating theatres; one with laminar air flow (LAF) equipment for cardio-thoracic operations, and one with conventional ventilation for urological operations. Both theatres had an identical number of air exchanges (17/h), identical microclimatic conditions and they employed the same cleaning procedures. In the LAF-ventilated operating theatre bacterial contamination of the air was effectively reduced to less than 10 CFU/m3 in all 125 samples (1 m3 per sample) tested. In most samples, 118/125, the bacterial count was less than 5 CFU/m3, despite the presence of ten persons. The conventionally ventilated theatre reached values up to 120 CFU/m3 during the most active period of the day when approximately seven persons were present. The LAF ventilation reduced both the content of particles in the air and contamination by bacteria on the floor. In both theatres cleaning procedures had only a low impact on CFU in the air and on the floor. The use of diathermia markedly increased the level of small particles in the air, and this may influence the air quality in the operating theatres.

Bohn *et al.,* (1996) demonstrate that the air exhaust hoods did not lower air borne microbial contamination detectable with this air sampling in this study compared to standard head cover and mask, in a modern conventional operating room. The study was carried out by studying the effect of a portable HEPA-filtered air exhaust system (Stackhouse Freedom Surgical Helmet System) on airborne microbial contamination in a modern conventional operating room. Microbial air sampling was done with a two-stage Anderson sampler at the wound site during 46 total joint replacements. All operations were performed by the same surgeon in the same operating room at a large community hospital. The result indicated that in 18 cases done without air exhaust hoods, the number of bacterial and fungal CFU ranged from 0.6 to 11.7 (mean, 3.6). Air sampling during 28 operations with the operating team in air exhaust hoods revealed a mean of 3.6 CFU (range, 0 to 11.4). Bacterial CFU averaged 3.4 without hoods and 3.2 with exhaust hoods. Coagulase-negative staphylococci were the most common isolates (48% of isolates with hood, 55% without hood).

Bechtol (1979) illustrated that an integrated body exhaust/clean air operating room system evaluated in terms of the microbiologic and particulate contamination control afforded. The clean air unit was of a vertical unidirectional airflow design and employed high-efficiency particulate air filters to provide air low in both microbes and particulates. The body exhaust portion of the system was composed of an exhaust tube the surgeon's mask, a transparent plastic faceplate, and a microbe-retentive surgical gown and hood. Measurements were made of airborne and surface contamination at the wound site and of microbial burden levels associated with the surgical team. Sampling techniques were designed to parallel those used in a previous study of a horizontal flow/body exhaust system so as to provide comparative data on the effect of airflow configuration on wound site contamination. The data showed the vertical flow room to exhibit significantly lower (P less than 0.05) contamination levels than the horizontal flow enclosure.

Friberq *et al.*, (1999) examined that airborne contamination with bacteria-carrying particles (CFU/m^3) and their sedimentation rate (CFU/m^3/h) was compared in an operating room (OR) equipped with two turbulent ventilation systems. One was a thermally based system with inlet of cool clean air at the floor level and evacuation of the air at the ceiling by convection (17 air changes/h). The other was a conventional plenum pressure system with air supply at the ceiling and evacuation at the floor level (16 air changes/h). The study was made during rigidly standardized sham operations (N = 20) performed in the same OR by the same six member team wearing non-woven disposable or cotton clothing. Airborne contamination in the wound and instrument areas was related to the surface contamination rate in the same areas and in addition, on the patient chest and in the periphery of the OR. With the exception of the periphery of the OR, the surface and air contamination rates were highly correlated in both ventilation systems (P = 0.02-0.0006, r2 = 0.52-0.79). This was also true particularly when disposable clothing was used while the correlation was weaker in cotton clothing experiments. An equation describing the relation between surface and air counts is given. Typically, the surface counts were numerically 16-fold the air counts, i.e., the number of colonies sedimenting on four 14 cm-diameter agar plates during 1 h will almost equal the number of airborne CFU / m^3. They proposed, that sedimentation plates represent not only a technically easier method than air sampling but when correctly used, are also the most realistic indicator of airborne bacterial OR contamination in areas critical for surgery.

Pasquarella, (2007) evaluated the efficacy of a mobile laminar air flow (LAF) unit in reducing bacterial contamination at the surgical area in an operating theatre supplied with turbulent air ventilation. Bacterial sedimentation was evaluated during 76 clean urological laparotomies; in 34 of these, a mobile LAF unit was added. During each operation, settle plates were placed at four points in the operating theatre (one at the patient area and three at the perimeter), a nitrocellulose membrane was placed on the instrument table and an additional membrane near the wound. During the operation, particle counting was performed to detect 0.5µ. Mean bacterial sedimentation of the nitrocellulose membrane on the instrument table was 2730 CFU under standard ventilation condition, whereas it decreased significantly to a mean of 305 CFU when the LAF unit was used, i.e. within the suggested limit for ultra clean operating theatres (P=0.0001) the membrane near the wound showed a bacterial sedimentation of 4031 CFU with the unit (P=0.0001). Particle counts also showed a reduction when the LAR unit was used. No significant difference was found at the four points in the operating theatre between samplings performed with, and without the LAF. Use of a mobile LAF unit with turbulent air ventilation can reduce bacterial contamination at the surgical area in high –risk operation (e.g. prosthesis implant).

Gosden *et al.,* (1998) showed that small number of organisms can cause orthopaedic implant infection, which give rise to a considerable degree of morbidity and mortality. They showed that peri-prosthetic infection rates have been correlate with the number of air born bacteria within 30 cm of the wound. This is influenced by factors such as the number of operating theatre personal, their clothing and the type of ventilation system used. Factors in minimizing the number of post operative implant infections such as the use of ultra clean air, ultra violet radiation, different types of surgical clothing and prophylactic antibiotics

Brandt *et al.,* (2008) evaluated whether (OR) ventilation with (vertical) laminar airflow impacts on (SSI) rates. In their retrospective cohort-study based on routine surveillance data, sixty-three surgical departments participated voluntarily in the German national nosocomial infections surveillance system "KISS" (a total of 99,230 operations). Active SSI surveillance was performed according to the methods and definitions given by the US National Nosocomial Infection Surveillance system. Surgical departments were stratified according to type of OR ventilation used: (1) turbulent ventilation with high-efficiency particulate air-filtered air, and (2) HEPA-filtered (vertical) laminar airflow ventilation. Multivariate analyses were performed by the generalized estimating equations method to control for the following variables as possible confounders: (a) Patient-based: wound contamination class, ASA score, operation duration, patients' age and gender, endoscopic operation; (b) Hospital-based: the number of beds in the hospital, its academic status, operation frequency, and long-term participation in KISS. The result was the risk for severe SSI after hip prosthesis implantation was significantly higher using laminar airflow OR ventilation (1.63 < 1.06; 2.52>), as compared with turbulent ventilation. The adjusted odds ratios for the other operative procedures analyzed were: knee prosthesis 1.76 < 0.80, 3.85>; appendectomy 1.52 < 0.91, 2.53>; cholecystectomy 1.37 < 0.63, 2.97>; colon surgery 0.85 < 0.49, 1.49>; and herniorrhaphy 1.48 < 0.67; 3.25>. Unexpectedly, in this analysis, which controlled for many patient and hospital-based confounders, OR ventilation with laminar airflow showed no benefit and was even associated with a significantly higher risk for severe SSI after hip.

2.2.10. Environmental Aspects

WHO established a procedure for the correct use of the O.R and all staff is trained to follow them. This procedure could be summarized in the following points:

- Keep all doors to the O.R closed, except as needed for the passage of equipment, personnel and the patient.
- Store some sutures and extra equipment in the O.R to decrease the need fore people to enter and leave the O.R during a case.
- Keep to a minimum the number of people allowed to enter the O.R, especially after an operation has started.
- Keep O.R uncluttered and easy to clean.
- Between cases, clean and disinfect the table and instrument surfaces.
- At the end of each day, clean the O.R: start at the top and continue to the floor, including all furniture, over head equipment and lights, use a liquid disinfectant at a dilution recommended by the manufacture.
- Sterilize all surgical instruments and supplies after use and store them protected and ready for use in case of emergency (WHO, 2003).

2.2.11. Types of Air Supply

Air is supplied to the operating theatre by:

- ***Plenum Ventilation:*** This is the most frequently used system in general purpose operating rooms. The bacterial counts at the wound site should be no more than 50-500 (CFU) /m3.
- ***Laminar Flow Ventilation*** (Ultra Clean Ventilation): This system is unidirectional and delivers air flow over the operating table of 300 air changes per hour. A bacterial count of 10 CFU or less per cubic meter at the wound site is achieved.
- ***Wall Mounted Air Conditioners:*** These are installed in some tropical countries more for comfort than for clean air delivery. They should not be used as air delivery systems. The units are usually mounted on the hot outside wall and the air is directed down and back onto the unit itself (towards the wall). The operating table does not receive any significant air changes and the bacterial counts remain unaffected.
- ***Free-standing Air Conditioners:*** These are cooling units with no filtration of air and therefore do not fulfill the criteria for air delivery systems, especially for an operation theatre (http://www.ems.org.eg).

Chapter Three

Materials and Methods

Chapter Three

Materials and Methods

3.1. Introduction

The present study was conducted to find out the presence and prevalence of microbial contamination in the surgical operation theatres in selected hospitals at the Gaza government and non-government hospitals. Animate and inanimate objects from each hospital were collected pre-operation and post-operation for isolation of suspected microorganisms. The tools of the present study included collection of specimens, culturing on selective different media, incubation at specific temperature, presumptive diagnosis, confirmative diagnosis, and antibiotic susceptibility testing for isolated bacteria.

3.2. Study Design

The study design is descriptive analytical cross–sectional design. Sample is non-probability accidental sample collected to assess the microbial contamination of the operation theatres in selected hospitals at Gaza governorates.

3.3. Target population

The target population of this study composed of specimens that had been collected from animate objects from operating room surgeons and inanimate objects such as: surgical equipments, instruments, room walls and floors from the operation theatre in the hospitals that included in this study.

3.4. Setting of The Study

This study was performed at two major governmental hospitals namely, Al –Shifa hospital in Gaza city and European Gaza hospital (EGH) in Khanyounis city and another two non-governmental hospitals namely Dar Al-Salam hospital in Khanyounis and Al- Quds hospital in Gaza city.

3.5. Data collection period

Samples collection, transporting, and laboratory experiments including culturing, isolation, identification and antibiotic sensitivity testing of animate and inanimate objects were collected during the period from November 2008 to March 2009.

3.6. Study Population

The population of the present study was the operation theatres present in the two governmental hospitals (Al-Shifa and EGH) and the another two non-governmental hospitals (Dar Al-Salam and Al-Quds) at the Gaza Strip.

3.6.1. Eligibility Criteria:

Inclusion criteria: Only Al-Shifa and EGH hospital (both are governmental), Dar Al-Salam hospital and Al-Quds hospital (both are non-governmental) were included in this study.

Exclusion criteria: The other governmental and non-governmental hospitals distributed in Gaza strip were excluded from this study.

3.7. Ethical Considerations

Approval for conducting the present study was obtained from MOH. Another approval sheet was also obtained from the director of each hospital included in this study to permit and authorize the researcher to conduct her study on the targeted hospitals (Annex no1). The researcher purchased all the consumable materials needed to perform the experimental part of the study as bacterial culture media, biochemical reagents and different kits. These laboratory experiments were carried out at each central laboratory of each hospital included in this study according to an official agreement from the director of each hospital.
Regarding the animate specimens that have been collected from the surgeons at operation theatres from their hands, clothes and face mask. Neither name nor personal data were given to a second part or published. All ethical considerations were maintained, including respect of people, truth and confidentiality.

3.8. Sampling and Sample Size

Samples were collected from two major governmental hospitals (Al-Shifa and EGH) and another two major non-governmental hospitals (Al-Quds and Al-Salam). Each hospital was visited three times for sample collection. In each visit, the researcher collected samples (swabs) from designated items from operating rooms in the main operation theatre in each hospital. These swabs included both animate and inanimate objects (swabs collected from surgeons, surgical equipments and instruments, and environment), were collected first before starting surgeries (pre-operation) and second after finishing surgeries (post-operation). The researcher planned to collect a total of 320 swabs from all hospitals that included in the study (160 swab pre surgery "pre-operation" and 160 swab after surgery "post-operation"). At the end of March 2009, the total accepted swabs were 243 swabs. The researcher could not acquire the planned number of swabs due to the Israeli war against Gaza which started at 26th of December 2008 (during data collection) and the consequent announcement of emergency situation at Gaza hospitals to handle and treat the causalities of the offensive war.

3.9. Tools of The Study

In order to achieve the objectives of the present study, the researcher relied on the laboratory experimental analysis and tests as the main tool of the research. These experiments included cultivation and isolation of different contaminants in animate and inanimate specimens, identification of these isolated bacterial strains to the genus and species level by conventional and modern techniques, and performing the antibiotic susceptibility testing for each bacterial isolate.

3.9.1. Chemicals and Reagents:

All chemicals and reagents used in this study were of analytical grade. It was produced by different companies. Culture media were produced by Difco (USA) and Himedia (India), reagent kits as API20E and API20 Staph strip were produced by Biomerieux (France). Other disposable materials like Petri dishes, cotton swabs and plastic loops were produced by different companies and purchased by local distributors in Gaza city. Main chemicals used were Gram stain reagents, hydrogen peroxide, absolute ethanol and antibiotic disks.

3.9.2. Culture Media:

Culture medium	*Ingredients*	*Source*
Bacto violet red bile agar (Difco) for coliform group bacteria and *E. coli*	Bacto yeast extract ,3.0; Bacto peptone ,7.0; Bacto No3,1.5; Bacto Lactose,10.0; Sodium chloride,5.0; Bacto Agar,15.0; Neutral red and 0.03; Bacto crystal violet ,0.002. 41.5 grams of the powder were suspended in one liter distilled water	Difco (USA)
Bacto Baird Parker agar (Difco) for *S. aureus*	Bacto Tryptone,10.0; Bacto Beef extract, 5.0 ;Bacto Yeast extract ,1.0; Glycine, 12.0; Sodium pyruvate, 10.0; Lithium chloride, 5.0 and Bacto agar, 20.0. 63 grams of the powder were suspended in 950 ml distilled or deionized water	Difco (USA)
Blood Agar	Tryptose ,10.0 ;Sodium Chloride , 5.0 ; Agar ,15. Forty grams of the powder were suspended in one liter of distilled water	Himedia (India)
MacConkey agar	Peptic digest of animal tissue, 1.5 ; Pancreatic digest of casein ,1.5 ; Pancreatic digest of gelatin ,17 ; Lactose ,10.00 ; Bile salts mixture , 1.50 ; Sodium chloride ,5.00 ; Crystal violet ,0.001 ; Neutral red ,0.03 ; Agar 13.5 50.0 grams of the powder were suspended in one liter of distilled water	Difco (USA)
Muller Hinton Agar	Casein acid hydrolysate,17.50; Starch,1.50; Agar, 17.0 38.0 grams of the powder were suspended in one liter of distilled water	Difco (USA)

3.9.3. Media Preparation:

The weight of each media powder that was used to prepare one litter was calculated according to the manufacturer's instructions. Suspended media was heated to boiling to dissolve completely. Sterilized by autoclaving at 15 Ibs pressure (121 °C) for 15 minutes. Cooled to 45 °C before pouring in sterilized plastic Petri dishes. Bacto violet red bile agar is not autoclaved and can be used directly after cooling. For blood agar base medium, the medium was cooled to 50 °C before aseptically adding 5% v/v sterile defibrinated blood. Mixed well and poured into sterile Petri dishes. The final PH is specific for each media and was adjusted according to the manufacturer's instructions. In general the PH was between 7.0 to 7.4 depending on each media. Plates were stored in plastic bags at 2 to 8 °C up to 4 weeks.

3.9.4. Sample Preparation:

Samples were collected with sterile cotton-tipped swabs from the surfaces, equipments, operation rooms walls, floor, medical and surgical instruments and surgeons working in the operating theatres, before and after operations. Swabs were cultured directly onto plates media or in case the laboratory is away from the operation theatres, they were transported using transport media. All the collected swabs were cultivated within 30 minutes after collection at room temperature or within two hours when transport media was used.

3.10. Microbial Identification

The collected swabs were cultured directly on prepared MacConkey agar, Blood agar and Baired Parker agar media by streaking method. The inoculated plates were incubated aerobically at 35 - 37 °C for 18 - 24 hours. Then colonial culture characteristics including colony morphology, mucus secretions, color, pigment production, sugar fermentation as lactose fermentation, hemolysis, and swarming growth were examined according to the biochemical activity of isolated organism and the differential and selective characteristics for each media used. When there is no growth seen on plates, re-incubation at the same conditions for further 24 hours was done before discarding the plates as negative result.

In principle, identification of the isolated bacteria was based on the conventional techniques and procedures that described in Bergey's manual of systemic bacteriology (Kreig, *et al.,* 1984). Further the researcher used the specific identification kits as API systems for Staphylococci and Enterobacteriaceae for confirmation of the isolates to the species level (Anon, 1991).

3.10.1. Presumptive Identification:

Gram staining

Gram staining is based on the ability of bacteria cell wall to retaining the crystal violet dye during solvent treatment. The cell walls of Gram-positive microorganisms have a higher peptidoglycan and lower lipid content than the call walls of Gram-negative bacteria. Bacteria cell walls are stained by the dye crystal violet. Iodine is subsequently added as a mordant to form the crystal violet-iodine complex so that the dye cannot be removed easily. This step is referred to as dye fixation. However, subsequent treatment with a decolorizing agent, a mixed solvent of ethanol removes the lipid layer from the Gram-negative cells. The removal of the lipid layer enhances the leaching of the primary stain from the cells into the surrounding solvent. In contrast, the solvent dehydrates the thicker Gram-positive cell walls, closing the pores as the cell wall shrinks during dehydration. As a result, the diffusion of the violet-iodine complex is blocked, and the bacteria remain stained. Finally, a counter staining with basic fuchsine is applied to the smear to give decolorized Gram-negative bacteria a pink color.

Catalase test

Principle*:* to detect the presence of the enzyme catalase. Catalase enzyme is found in most bacteria. It catalyses the breakdown of hydrogen peroxide (H_2O_2) with the release of free Oxygen.

$$2\ H_2O_2 \text{ ---------> } 2\ H_2O + O_2$$

Procedure: one drop of 3% H_2O_2 was added to a glass slide with a loopful of growth from each culture to be tested. The development of an immediate froth of bubbles is indicative of a positive catalase test. The test was performed on a blood-free medium.

Coagulase test

This test applied after Gram staining on the genus Staphylococci to differentiate between *S. aureus* species (coagulase positive) and other coagulase negative species (Zarzour & Belle, 1978).

A tube coagulase method was performed where about 0.5 ml of EDTA plasma was added into a glass test tube, and an bacterial inoculum was added and emulsified in the plasma. The suspension incubated at 37 °C for one to four hours before reading. The formation of visible gel or clot means positive coagulase reaction.

Oxidase test

This test is used to the genus of bacteria that cytochrome oxidase positive producer as the genus *Pseudomonas* and *Aeromonas*. A drop or two of tetramethyl-p-phenylenediamine-dihydrochloride (oxidase reagent) was placed on surface colonies and observed for the evolution of a black discoloration characteristic of the colonies of *Pseudomonas* or *Aeromonas* (Koneman *et al.*, 1992)

Indole test

Principle: indole is one of the degradation products from the metabolism of the amino acid tryptophan. Bacteria that possess the enzyme tryptophanase are capable of cleaving tryptophan, thus producing indole, pyruvic acid, and ammonia. Indole can be detected in tryptophan test medium by observing the development of a red color after adding a solution containing ρ-dimethylaminobenzaldehyde (Kovac's reagent) (Koneman *et al.*, 1992).

Methyl red test

This test provides a valuable characteristic for identifying bacterial species that produce strong acids from glucose. Briefly and according to Barry *et. Al.*, (1982) a 0.5 ml aliquot of broth is used with a relatively heavy inoculum of the test organism. One or 2 drops of methyl red reagent are added after 18 to 24 hours of incubation at 35 °C, and the development of red color indicates a positive test (Koneman *et al.*, 1992).

Voges-Proskauer test

This test is based on the conversion of acetyl methyl carbinol (acetoin) to diacetyl through the action of potassium hydroxide and atmospheric oxygen. Diacetyl is converted into a red complex under the catalytic action of α-naphthol and creatine. Most species of the Enterobacteriaceae are Voges-Proskauer positive, with rare exceptions, are methyl red negative and vice versa (Koneman *et al.*, 1992).

Citrate utilization test

The principle of this test is to determine the ability of an organism to utilize sodium citrate as the sole source of carbon for metabolism and growth. Simmon's citrate medium (contains the indicator bromothymolblue) is used for this purpose that incubated after inoculation with test organism at 35 °C for 18 to 24 hours. Production of blue color indicates the presence of alkaline products and a positive citrate utilization test result (Koneman *et al.*, 1992).

Urease test

Urease is an enzyme possessed by many species of bacteria that can hydrolyze urea to ammonia, carbon dioxide and water. Ammonia reacts to form ammonium carbonate, resulting in alkalization and an increase in the pH of the medium. The agar slant is streaked with the test bacteria and incubated at 35 °C for 18 to 24 hours. Rapid urea splitters as *Proteus* species produce red color within 1 to 2 hours. Negative result indicating by remaining of the original yellow color of the medium (Koneman *et al.*, 1992).

3.10.2. Confirmative Identification:

API 20E System for the Identification of Enterobacteriaceae

Principle: The API-20E test kit for the identification of enteric bacteria (BioMerieux, Inc., Hazelwood, MO) provides an easy way to inoculate and read tests relevant to members of the Family Enterobacteriaceae and associated organisms. A plastic strip holding 20 mini-test tubes is inoculated with a saline suspension of a pure culture (as per manufacturer's directions). This process also rehydrates the desiccated medium in each tube. Afew tubes are completely filled (CIT, VP and GEL), and some tubes are overlaid with mineral oil such that anaerobic reactions can be carried out (ADH, LDC, ODC, H_2S, URE).

Procedure: Suspensions were prepared by emulsifying bacterial isolates in 0.85% saline to the equivalent of a 0.5 McFarland turbidity standard. After incubation in a humidity chamber for 18-24 hours at 37°C, the color reactions are read (some with the aid of added reagents), and the reactions (plus the oxidase reaction done separately) are converted to a seven-digit code. The code is fed into the manufacturer's database via touch-tone telephone, and the computer voice gives back the identification, usually as genus and species or manually using a reference book giving a specific code for each genus and species. The reliability of this system is very high, and one finds systems like these in heavy use in many food and clinical labs.

The amino acids tested are arginine, lysine and ornithine. Decarboxylation is shown by an alkaline reaction (red color of the particular pH indicator used). The carbohydrates tested are glucose, mannitol, inositol, sorbitol, rhamnose, sucrose, melibiose, amygdaline and arabinose. Fermentation is shown by an acid reaction (yellow color of indicator). Hydrogen sulfide production (H2S) and gelatin hydrolysis (GEL) result in a black color throughout the tube. A positive reaction for tryptophan deaminase (TDA) gives a deep brown color with the addition of ferric chloride; positive results for this test correlate with positive phenylalanine and lysine deaminase reactions which are characteristic of *Proteus*, *Morganella* and *Providencia*.

API 20 STAPH System for the Identification of Staphylococci

API Staph is a standardized system for the identification of the genera Staphylococcus, Micrococcus and Kocuria, which uses miniaturized biochemical tests and a specially adapted database.

Principle: The API Staph strip consists of 20 microtubes containing dehydrated substrates. These microtubes are inoculated with a bacterial suspension, prepared in API Staph Medium, that reconstitutes the tests. During incubation, metabolism produces color changes that are either spontaneous or revealed by the addition of reagents. The reactions are read according to the Reading Table and the identification is obtained by referring to the Analytical Profile Index or using the identification software.

ID 32 STAPH (Identification system for staphylococci)

ID 32 STAPH (Biomerieux) is an identification system for the genera *Staphylococcus, Micrococcus, Stomatococcus* and *Aerococcus,* using standardized and miniaturized biochemical tests with a specially adapted database. The ID 32 STAPH strip consists of 32 cupules, 26 of which are used as test cupules and contain dehydrated test substrates. After 24 hours of incubation, the reaction are read, either using the ATP expression or *API* instruments, or visually. Identification is obtained using the identification software. The test was performed according to the instructions of the kit supplier.

3.11. Antimicrobial Susceptibility Testing by Disk Diffusion Method

Antibiotic sensitivity test for the isolated strains in this present study was performed using the disk diffusion method according to the guidelines and instructions of The National Committee for Clinical Laboratory Standards (NCCLS, 2000 a & b).

Briefly, Muller-Hinton agar plates with 4 mm thickness were prepared according to the manufacturer instructions and used to cultivate the tested organism. Bacterial suspension was prepared in sterile Normal saline to match 0.5 McFarland turbidity standard. After there, a sterile cotton swab was dipped into the bacterial suspension and rolled around the inner surface of the test tube culture to remove any excess liquid media before inoculating into the surface of the agar plate. Plates left for drying before placing the suitable type and number of antibiotic disks according to the tested organism.

Then, plates were incubated 18 – 24 hours at 37 °C. The inhibition zone around each disk was measured and recorded in millimeters. These inhibition zones of individual antibiotic disk were compared to a standard chart available from the manufacturer for each organism. The antibiotic that used are Amoxicillin, Ampicilline, Ceftazidine, Cefalexine, Cefruoxime, Ceftrixalone, Ciprofloxacin, Amikacin, Doxyciline, Nalidixic acid, Ofloxacillin and Trimethoprim.

3.12. Statistical Analysis

The results that obtained from the collected swabs from animate and inanimate objects in all studied hospitals were tabulated, encoded and statistically analyzed using the Statistical Package for the Social Sciences (SPSS) version 13 (SPSS Inc., Illinois, USA).

Differences in prevalence of bacterial contamination in governmental and non-governmental hospitals, between animate and inanimate objects, between pre-operation and post-operation were compared by Student's t-test. A two-tailed *P*-value of < 0.05 was considered statistically significant.

Chapter Four

Results and Discussion

Chapter Four

Results and Discussion

4.1 Introduction

The present study was conducted in main two governmental and two nongovernmental hospitals in the Gaza Strip. The main aims of this study were the investigation of the overall prevalence of microbial contamination in the operation theatres of these selected hospitals, prevalence of microbial contamination from animate and inanimate objects that collected pre-op. and post-op.. Furthermore, this study aimed to investigate the main bacterial genera and species that have been isolated from contaminated samples and its antibiotic sensitivity profile. From the researcher's personal communications and up to his best knowledge and available published resources, I could say that this study may be considered the first study that address this problem concerning the microbial contamination of operation theatres in the Gaza Strip.

4.2 Presentation of the Results:

4.2.1 Distribution and Size of Sample:

The sample of this study consisted of (243) swabs collected from the operating rooms from the operation theatres of four hospitals in the Gaza Strip, two major governmental hospitals (Al-Shifa and EGH), and two major nongovernmental hospitals (Al-Quds and Dar Al-Salam). Samples were collected in two points of time, before starting the operation and after finishing it (pre-op. and post-op.). Samples were collected in three different days from governmental hospitals, and collected in two different days from nongovernmental hospitals according to the specificity for every hospitals in their weekly operation days. The results of sample distribution and its size is illustrated in figure (4.1 and 4.2). Total swabs that were collected from Al-Shifa hospital were 61 (31 pre-op. and 30 post-op.), 81 swabs were collected from EGH (41 pre-op. and 40 post-op.), 51 swabs were collected from Al-Quds hospital (26 pre-op. and 25 post-op.) and 51 from Dar Al-Salam hospital (26 pre-op. and 24 post-op.). The total number of collected swabs from governmental hospitals was 142 (58.4%) and the total number of collected swabs from nongovernmental hospitals was 101 (41.6%).

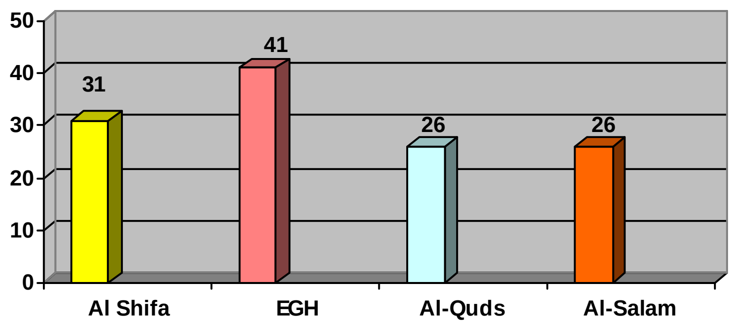

Figure 4.1: distribution of sample at pre-op stage

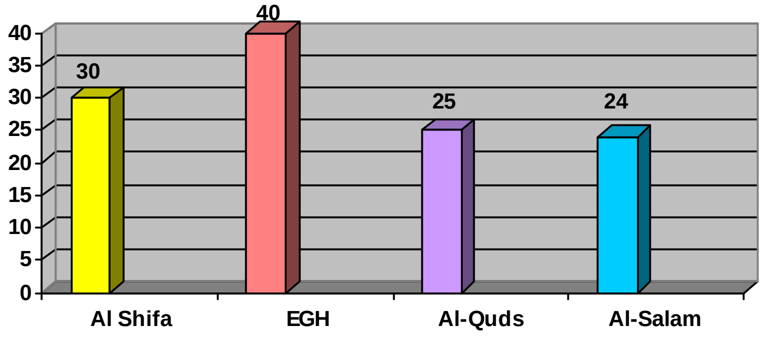

Figure 4.2: distribution of sample at post-op stage

Table (4.1): Distribution of total collected samples according to source of sample & type of hospital (n = 243)

	Equipment													**Environment**						**Person**			
	Onset & source	OR bed	Cidex solution	Gloves	Instrument trolley	Anesthesia trolley	Sterilizing pan	Washing pan	Suction tip	Oxygen device	Laryngoscope	X-Ray screen	Coutery	Floor	Door	Wall	Waste container	Air condition	Overhead light	Hand	Clothes	Face mask	**Total**
Shifa	Pre	1	0	0	2	3	3	0	3	2	1	1	1	3	2	3	0	0	2	2	1	1	**31**
	Post	2	0	2	2	3	0	0	3	1	0	1	1	3	2	1	1	0	3	2	1	2	**30**
EGH	Pre	3	1	0	3	3	3	2	2	1	3	1	3	2	2	3	2	0	3	2	1	1	**41**
	Post	3	1	2	2	3	2	2	2	0	3	1	3	3	3	2	2	0	3	1	1	1	**40**
Al-Quds	Pre	2	0	0	1	2	2	0	2	1	1	2	2	2	2	2	1	2	2	0	0	0	**26**
	Post	2	0	1	0	1	2	0	2	2	1	2	2	2	1	2	1	1	2	0	1	0	**25**
Al-Salam	Pre	2	1	0	2	2	1	0	2	2	1	0	1	2	2	2	2	1	2	0	0	1	**26**
	post	2	1	0	2	2	0	0	2	0	1	0	2	2	2	1	1	1	1	1	1	2	**24**
Total / item		**17**	**4**	**5**	**14**	**19**	**13**	**4**	**18**	**9**	**11**	**8**	**15**	**19**	**16**	**16**	**10**	**5**	**18**	**8**	**6**	**8**	**243**
Total / dimension		**137**												**84**						**22**			

4.2.2 Distribution of Samples According to the Source:

Table (4.1) showed that total accepted swabs were (243), collected from (21) items divided on three dimensions; in two stages (pre-op. and post-op.) from each hospital. Distribution of swabs were as follows:

- ***Equipment dimension:*** composed of (12) items, total swabs collected in pre-op. and post-op. stage were (137) swabs.
- ***Environment dimension:*** composed of (6) items, total swabs collected in pre-op. and post-op. stage were (84) swabs.
- ***Persons dimension:*** composed of (3) items, total swabs collected in pre-op. and post-op. stage were (22) swabs.

In the equipment dimension, the highest number of swabs (19) was collected from anesthesia trolley, followed by suction tip (18 swabs) and operation bed (17 swab). The highest swabs number in environmental dimension was collected from operation floor item (19 swab), followed by operation door and wall (16 swab for each). In regard to the items collected from personnel dimension, the highest swabs number were collected from hands and face masks (8 swab for each).
Risk factors related to operating rooms include patient-associated risks, the operating room environment, ventilation systems, cleansing and sterilization, and operating room personnel (Pittet and Ducel, 1994).

4.2.3 Prevalence of microbial contamination at governmental and nongovernmental hospitals:

To answer the first question in the present study: ***"What is the prevalence of microbial contamination in operating rooms at governmental and nongovernmental hospitals in Gaza Strip?"***, the researcher used frequency and percentage calculations for the positive contaminated samples (after culturing and diagnosis in the laboratory) found in the target hospitals. The results are illustrated in table (4.2).

Table (4.2): Distribution of contaminated samples according to hospital and onset

Place onset		Al-Shifa (61)	EGH (81)	Al-Quds (51)	Al-Salam (50)	Total (243)
Pre-op.	Frequency	5	5	7	11	28
	% hospital	8.19%	6.17%	13.72%	22.00%	22.58%
	% grand total	2.05%	2.05%	2.88%	4.53%	11.52%
Post-op.	Frequency	7	14	2	9	32
	% hospital	11.47%	17.28%	3.92%	18.00%	26.89%
	% grand total	2.88%	5.76%	0.82%	3.70%	13.16%
Total	Frequency	**12**	**19**	**9**	**20**	**60**
	% hospital	19.67%	23.45%	17.64%	40.00%	100.00%
	% grand total	4.93%	7.81%	3.70%	8.23%	24.68%

From this table (4.2), the results showed that the overall percentage of total contaminated samples from the four hospitals at both stages (pre-op. and post-op.) was 24.68% (60/243) out of grand total samples. In regard to the onset of sample collection, the total contaminated samples in the pre-op. stage from the four hospitals were 28 (22.58%) out of 124 samples, which equals (11.52%) of grand total. However, the total contaminated samples in the post-op. stage from the four hospitals were 32 (26.89%) out of 119 samples, which equals (13.16%) of grand total. The overall percentage of microbial contamination was higher in post-op swabs in comparison to the pre-op swabs. This is acceptable and expected to find more contamination after doing surgery in comparison with samples collected before performing the surgery.

The overall percentage of contaminated samples from each hospital was as follow:

- ***Shifa hospital:*** total samples collected were 61, out of them, 12 were contaminated which equals (19.67%) of hospital samples, and (4.93%) of grand total. Five pre-op. samples were contaminated (8.19%) of this hospital samples, which equal to (2.05%) of grand total. Further, 7 post-op. samples were contaminated (11.47%) of this hospital samples, which equal to (2.88%) of grand total.

- ***EGH:*** total samples collected were 81, out of them 19 were contaminated which equals (23.45%) of hospital samples, and (7.81%) of grand total.

  Five pre-op. samples were contaminated (6.17%) of this hospital samples, which equal to (2.05%) of grand total. However, the post-op. samples that contaminated were 14 samples which equal to (17.28%) and (5.76%) of this hospital and of grand total samples respectively.

- ***Al-Quds hospital:*** total samples collected were 51, out of them 9 were contaminated with a percentage equal to (17.64%) of this hospital samples, and (3.7%) of grand total. Regarding the pre-op swabs from this hospital, we could notice that 7 samples were contaminated with a percentage of (13.72%) of this hospital samples, and (2.88%) of grand total samples. Further, two of post-op samples were contaminated with a percentage equal to (3.92%) of this hospital samples, and equal to (0.82%) of grand total samples. This is unexpected result were mostly we found that the percentage of microbial contamination (for governmental hospitals and also for overall studied hospitals together) is higher in post-op samples in comparison to the pre-op samples.

- ***Dar Al-Salam hospital:*** total samples collected were 50, out of them 20 were contaminated which equals to (40.0%) of this hospital samples, and to (8.23%) of grand total. There were 11 pre-op samples contaminated with a percentage of (22.0%) of hospital samples, and (4.53%) of grand total. Finally in this hospital, there were 9 post-op samples contaminated which equal to (18.0%) of hospital samples, and to (3.7%) of grand total. Here once again there is slightly higher percentage of pre-op contaminated samples in comparison to post-op samples.

These results reveal a high percentage of contamination in operating rooms in the target hospitals both in the pre-op and post-op stage, which is a serious problem, especially if we talk about an area that should be virtually clean and contain as minimum as microbes all the time for the safety of clients. This could carry high risk for developing post operative surgical site infections.

Surgical site infection (SSI) is a major source of morbidity and mortality and is an important outcome indicator after surgery. SSIs are the second most frequent nosocomial infection in the general hospital population. A study showed that subjects who develop SSI were five times more likely to be re-admitted and re-operated on than those without infection and were also reported to be twice as likely to die during the post-operative period. (Kirkland *et al.,* 1999; Kownhar *et al.,* 2008). Also, SSI are the third most commonly reported nosocomial infection and they account for approximately a quarter of all nosocomial infections (Mangram *et al.,* 1999). They have been responsible for the increasing cost, morbidity and mortality related to surgical operations and continue to be a major problem even in hospitals with most modern facilities and standard protocols of preoperative preparation and antibiotic prophylaxis (Yalcin *et al.,* 1995). Surgical site infection rate has varied from a low of 2.5% to a high of 41.9% (Lilani *et al.,* 2005).

In a study conducted in Bangladesh, 91 different inanimate samples collected from surgery wards and general operation theatre (GOT) as well as animate samples from surgery personnel were subjected to aerobic culture with the aim of identifying source of infections in surgical cases. Pathogenic bacteria were isolated from 34 samples out of these 91 samples comprising a percentage of 37.4%. This is also a high contamination rate as we found in our study (Rahman *et al.,* 2003). In contrast, in a study conducted in Iraq aimed to evaluate the incidence of bacterial contamination of operating theatres in Al Imam Ali Hospital in Baghdad, and the source of contamination, the authors found that the rates of positive cultures were 3.7% in 2001 and 4.0% in 2002 from 1216 swabs collected from surfaces, equipment and antiseptic solutions from different operating theatres (Ensyef *et al.*, 2009). This is a very low contamination percentage in comparison to our study and other published studies in the literature (Duhaime *et al.*, 1991; Edmiston *et al.*, 2005; Wybo *et al.*, 2007).

In another study performed in India, an outbreak of post-operative wound infections due to Mycobacterium abscessus was described. During a 5-month period 45 post-surgical patients developed wound infection, manifested by wound breakdown, cellulitis, and discharge and progressing slowly to suppuration and sinus formation. The source of infection was identified as contaminated tap water. Their study revealed serious deficiencies in the disinfection and sterilization techniques employed in the operating theatre (OT), including major defects in the autoclaving machine. The report highlights the necessity of strict monitoring of disinfection and sterilization techniques in surgical units and OTs. (Chadha et al., 1998).

In a study conducted in the USA, in order to investigate the distribution of bacteria in the operating room environment, cultures were obtained during 111 unselected shunt operations throughout a 10-month period revealed overall percentage of 8.3% positive cultures, with mostly isolated bacteria were coagulase-negative Staphylococcus and *S. aureus* (Duhaime *et al.,* 1991). In another study performed in Sweden, Loefgren *et al*., found among the 3267 patients undergoing total abdominal hysterectomies and vaginal hysterectomies, 341 (10.4%) were considered to have developed a postoperative infection. The authors found that the risk factors for postoperative infection were non-use of antibiotic prophylaxis, hospital, age less than 40 years, and BMI > 30 kg/m^2 (Loefgren *et al.*, 2006).

Another prospective study aimed to determine the surgical site infection (SSI) rate and associated risk factors in a general surgical ward after operations in Pakistan found an overall rate of 13.0% SSI. The rate is increasing according to the type of operation. The rate of wound infection was 5.3% in clean operations, 12.4% in clean-contaminated, 36.3% in contaminated and 40% in dirt-infected cases. The authors found that age, use of surgical drain, duration of operation and wound class were significant risk factors for increased SSI (Sangrasi *et al.*, 2008).

The high percentage of positive samples in this study could be attributed to the 1): complete siege on the Gaza strip since more than two years that may cause serious deficiencies in disinfection solutions, antiseptics and sterilization employed in the operating theatres. Furthermore, shortage of spare parts make the maintenance of instruments and equipments is very difficult. 2): Most of the study samples were collected shortly after the last war against Gaza strip (Where Gaza strip was and still under the complete siege). In that time, hundreds of surgical operations were performed in a very difficult situation and under unusual conditions to save - as much as possible - the life of severe injured people. 3): relatively small size of study population (243 samples). This is clear and in accordance with our results where in two studies, a 37.4% and only 4% positive samples found among 91 and 1216 samples respectively (Rahman *et al.,* 2003; Ensyef *et al.,* 2009).

These result should raise the need for revising the cleaning and scrubbing procedures in our operating rooms both in governmental and nongovernmental hospitals to alleviate causes of contamination and maintain a high level of cleanliness and safety for the clients.

4.2.4. Distribution of contaminated samples according to source:

The overall collected samples (243) from 21 items divided on three dimensions; equipment, environment and personnel; and performed in two stages (pre-op. and post-op.) from each hospital (table 4.3).

In the equipment dimension, the overall percentage of contamination was 45% (27/60) out of the total positive contaminated samples. Of these 27 contaminated samples, 11 (40.7%) from pre-op. samples and 16 (59.3%) from post-op. samples.

The overall percentage of contamination in environmental dimension was 48.3% (29/60) of the total positive contaminated samples. Of these 29 contaminated samples, 15 (51.7%) from pre-op. samples and 14 (48.3%) from post-op. samples. Whereas only 6.67% (4/60) positive samples were isolated from samples that were collected from personnel dimension with 2 (50%) from both pre-op. and post-op. samples.

The rate of contamination in environmental dimension was slightly higher than that in equipment dimension. This difference was not statistically significant (*P*-value > 0.05). However, both environmental and equipment dimension showed a significant higher rate of contamination as compared to the personnel dimension (*P*-value < 0.05).

The highest contaminated swabs (15.0%) were found on the floor sample, two from Al Shifa hospital pre-op stage and two from post-op stage, one from EGH from post-op stage, one from Al-Quds pre-op stage, and two from Dar Al-Salam pre-op stage and one from post-op stage. The floor source was highly significant in comparison to other sources (*P*-value < 0.05), except for the suction tip source where the *P*-value was > 0.05.

Eight (13.33%) contaminated swabs were found in suction tip, two from Shifa hospital post-op stage, one from EGH pre-op stage and one from post-op stage, one from Al-Quds pre-op stage, and one from Dar Al-Salam pre-op stage and two from post-op stage. It was the highest contaminated source in the equipment dimension and higher than any source in the environment or person dimensions except for the floor source (15%).

The third high rate of contaminated swabs (10.0%) were found on operating room wall, two from EGH pre-op stage and one from post-op stage, one from Al-Quds pre-op stage, and one from Dar Al-salam pre-op stage and one from post-op stage.

Table (4.3) distribution of contaminated samples according to source (n = 60)

source		Equipment												Environment						Person				
place	**onset**	OR bed	Cidex solution	Gloves	Instrument trolley	Anesthesia trolley	Sterilizing pan	Washing pan	Suction tip	Oxygen device	Laryngoscope	X-Ray screen	Coutery	Floor	Door	Wall	Waste container	Air condition	Overhead light	Hand	Clothes	Face mask	**Total onset**	**Total hospital**
Shifa	Pre				*	*				*				* *									5	**12**
	Post					* *			* *					* *	*								7	
EGH	Pre							*	*							* *				*			5	**19**
	Post	*	*			*	*		*		*		*	*	*	*	*		*	*	*		14	
Al-Quds	Pre	*							*					*	*	*	*	*					7	**9**
	Post											*						*					2	
Al-Salam	Pre	*				*			*	*				* *	*	*	*	*				*	11	**20**
	Post	*			*				* *					*	*	*	*	*					9	
Total pre		2	0	0	1	2	0	1	3	2	0	0	0	5	2	4	2	2	0	1	0	1	28 46.67%	**60**
Total post		2	1	0	1	3	1	0	5	0	1	1	1	4	3	2	2	2	1	1	1	0	32 53.33%	
Total Grand		4 6.66 %	1 1.66 %	0	2 3.33 %	5 8.33 %	1 1.66 %	1 1.66 %	8 13.33%	2 3.33 %	1 1.66 %	1 1.66 %	1 1.66 %	9 15.0 %	5 8.33 %	6 10.0 %	4 6.66 %	4 6.66 %	1 1.66 %	2 3.33 %	1 1.66 %	1 1.66 %	60 100.0%	

* = frequency of contaminated sample

The doors and anesthesia trolley have both the fourth highest rate of contaminated swabs with five samples were found to be positive with a percentage of 5 (8.33%). For operating room doors, these contaminated samples were distributed as one from Al Shifa hospital post-op stage, one from EGH post-op stage, one from Al-Quds pre-op stage, one from Dar Al-salam pre-op stage and one from post-op stage. For anesthesia trolley, one from Shifa hospital pre-op stage and two from post-op stage, one from EGH post-op stage, and one from Dar Al-salam pre-op stage.

Four (6.66%) contaminated swabs were found in surgical bed (one from EGH post-op stage, one from Al-Quds pre-op stage, and two from Dar Al-salam in pre-op and post-op stage), waste container (one from EGH post-op stage, one from Al-Quds pre-op stage, one from Dar Al-salam pre-op stage and one from post-op stage), and air condition (one from Al-Quds pre-op stage and one from post-op stage, one from Dar Al-salam pre-op stage and one from post-op stage). 2 (3.33%) contaminated swabs were found in surgical trolley (one from Al Shifa hospital pre-op stage, and one from Dar Al-Salam post-op stage), oxygen device (one from Al Shifa hospital pre-op stage, and one from Dar Al-Salam pre-op stage), and surgeons' hands (one from EGH pre-op stage, and one from post-op stage).
The least contaminated samples (one for each with a percentage of "1.66%") were recovered from cidex solution, sterilizing pan, washing pan, laryngoscope, X Ray screen, coutery instrument, over-head light, surgeon clothes, and surgeon face mask. However, there was no any contaminated sample recovered from the gloves of surgeons at any hospital both in pre-op or post-op stages.

From the above results, there were major five sources of contamination distributed on the environment and equipment dimensions. It is clear that the floor in operating rooms was the most common source of bacterial contamination as it equals (15.00%) of sources, followed by suction tip where it equals (13.33%) of sources, followed by the walls in operating rooms where it equals (10.00%) of sources, followed by anesthesia trolley and operating room door where each one equal (8.33%) of sources.

Risk factors related to operating rooms include patient-associated risks, the operating room environment, ventilation systems, cleansing and sterilization, and operating room personnel. In this study, equipment items found to be responsible for 45% of the total contamination in OR. The suction tip was the highest source of contamination and it was responsible for 13.33% of the total contamination. This result is lower than the study results of Bently, *et al.,* (1993) which showed that suction tip was responsible for 41.0% of bacterial colonization. Anesthesia trolley was responsible for 8.33% of the total contamination, which could be fatal to patients as anesthesia procedures introduce bacteria directly to the respiratory system. This result supports the study of Loftus, (2008) which mentioned that potentially pathogenic, multi-drug resistant bacterial organisms are transmitted during the practice of general anesthesia to both the anesthesia work area and intravenous stopcock. In this study, we found a low rate of contaminated gloves (1.66%). Tanner and Parkinson found in their study entitled " double gloving to reduce surgical cross-infection" that there is no direct evidence that additional glove protection worn by the surgical team reduces surgical site infections in patients, however the review has insufficient power for this outcome. So, The addition of a second pair of surgical gloves significantly reduces perforations to innermost gloves (Tanner & Parkinson, 2007). However, Edmiston *et al.,* (2005) found that failure of the traditional surgical mask to prevent microbial shedding is likely associated with an increased risk of perioperative contamination of biomedical implants, especially in procedures lasting longer than 90 minutes. (Edmiston *et al.,* 2005). In another study in the USA conducted to estimate the Time-dependent contamination of opened sterile operating-room trays, the authors concluded that Culture positivity correlated directly with the duration of open exposure of the uncovered operating-room trays. Also, they found that light traffic in the operating room appeared to have no impact on the contamination risk. Coverage of surgical trays with a sterile towel significantly reduced the contamination risk (Dalstrom *et al.,* 2008). Telephones in the OR considered one of the important equipment that needed all the time. It was not included in our study but Nelson and his colleagues studied the microbial flora on operating room telephones and found that telephones in the OR can serve as reservoirs for SSI-causing bacteria with predominant of coagulase-negative staphylococci as main source of contamination (Nelson *et al.,* 2006). In our study, the rate of microbial contamination from instrument table samples was 3.33%. This result is lower than the finding of other studies where positive cultures were found in 7 of 77 (9.1%) instrument table cultures (Duhaime *et al.,* 1991).

The quantity of door and walls contaminated bacteria needed to cause disease is unclear. The only relevant surface contamination data stated that floors with microbial contamination greater than 50 CFU/ml relate to poor cleanliness (Pryor *et al.,* 1967).

These results should raise the need for evaluating the cleaning and scrubbing procedures at OR to decrease the level of contamination. Air conditioning was responsible for 6.66% of total contamination. This result is very low compared to the study of Gosden, *et al.*, (1989) which showed that 30.0% of bacteria found to be contaminated the wounds as post-op surgical site infections were directly deposited from the air. Also our finding is much lower than the findings of the study result of Kellar, *et al.*, (2003) which showed that samples from the filters of air conditioning units yields potentially pathogenic microbes in 20.0% occasions. Normal skin flora of patients or healthcare workers causes more than half all infections following clean surgery, but the importance of airborne bacteria in this setting remains controversial. Modern operating theatres have conventional plenum ventilation with filtered air where particles ≥5 mm are removed. For orthopedic and other implant surgery, laminar-flow systems are used with high-efficiency particulate air (HEPA) filters where particles ≥ 0.3 mm are removed. The use of ultra-clean air has been shown to reduce infection rates significantly in orthopedic implant surgery. Few countries have set bacterial threshold limits for conventionally ventilated operating rooms, although most recommend 20 air changes per hour to obtain 50 ±150 colony forming units/m3 of air. Environmental bacterial sampling in operating theatres should be limited to investigation of epidemics, validation of protocols, or changes made in materials which could influence the microbial content (Dharan & Pittet, 2002). Gram-positive staphylococcal isolates were frequently isolated from air samples obtained throughout the operating room, including areas adjacent to the operative field (Edmiston *et al.*, 2005). Clinical trials carried out in Britain, Europe, and the United States have confirmed that between 80 and 90% of bacterial contaminants found in the wound after surgery come from (CFU) present in the air of the operating theatre. When the numbers of (CFU) are reduced, there is a corresponding reduction in the incidence of would sepsis (Howorth, 1985). The overhead light was responsible for 1.66% of the total contamination, which is very low. This result is consistent with the study of Hussein *et al.*, (2001) which showed that no bacterial contamination was found in swabs collected from overhead light handles.

Person items were responsible for 6.62% of the total contamination, which is very low compared to the other sources in this study (equipments and environment). This result raised the need for more attention from persons entering OR during surgeries to decrease the chance for contamination, because persons moving in and out could be transmitters of contamination. This result is supported by the report of CDC (2003) which mentioned that outbreaks of surgical site infections caused by group A β-hemolytic Streptococci have been transmitted from operating room personnel to other persons. The hands were responsible for 3.03% of total contamination. An study investigated the role of nail polish and ring fingers found no evidence of the effect of removing nail polish or finger rings on the rate of surgical wound infection (Arrowsmith *et al.,* 2001). Masks were responsible for only 1.66% of total contamination which is very low and indicates the importance of wearing masks for all persons entering OR during surgeries. This result is supported by the study of Bergers, A. (1993) which showed that the number of bacterial colonies when no mask was worn was significantly higher than that detected when a full mask was worn. The study of Hubble *et al.*, (1996) showed that there was 22 fold increase in (CFU) when neither hat nor mask were worn, and 15 fold increase in CFU when masks were not worn. Operative field contamination could be happened by the sweating of surgery staff. The sweating surgeon may be more likely to contaminate the surgical field than the non-sweating surgeon. It is important for orthopedic surgeons, especially those performing joint replacement surgery, to be aware of this and to take measures to minimize sweating in the operating theatre (Mills *et al.,* 2000).

4.3.5. Differences in the prevalence of microbial contamination between governmental and nongovernmental hospitals:

To answer the second question in this study ***"Are there statistically significant differences at 0.05 level in the prevalence of microbial contamination between governmental and Private hospital's operating rooms?"***, the researcher used Independent sample ***t***. test to examine the differences in mean scores for governmental and private hospitals. The results are illustrated in table (4.4).

From this table, the results showed that there was no statistical significant differences at 0.05 level in the equipment item between the mean scores of governmental hospitals (m = 8.00) and private hospitals (m = 5.50), where *t* value was (0.822) and *P*-value was (0.556) which is not statistically significant.

Table (4.4): Differences in mean scores between governmental and private hospitals (n = 60)

Item	Hospital type	mean	St. deviation	*t*	P-value
Equipment	Gov.	8.00	4.2426	0.822	0.556*
	Private	5.50	0.7071		
Environment	Gov.	6.00	2.8284	- 0.781	0.520 *
	Private	8.50	3.5355		
Personnel	Gov.	1.50	0.7071	1.414	0.293 *
	Private	0.50	0.7071		
Total	Gov.	15.00	7.7782	0.153	0.894*
	Private	14.50	4.9497		

* not significant

Also, there was no statistical significant differences at 0.05 level in the environment item between the mean scores of governmental hospitals (m = 6.00) and the mean scores of private hospitals (m = 8.50), *t* value was (- 0.781) and *P*-value was (0.520) which is not statistically significant. The same above results were found too with the person item between the two types of hospitals where there was no statistical significant differences at 0.05 level (*P*-value = 0.293). Collectively, there was no statistical significant differences at 0.05 level in the total scores between the mean scores of governmental hospitals (m = 15.00) and the mean scores of private hospitals (m = 14.50), where *t* value was (0.153) and the *P*-value was (0.892) which is not statistically significant.

In conclusion, the above results revealed that there was no statistical significant differences in the prevalence of microbial contamination at operating rooms between governmental and private hospitals. However, there is slightly increase in the total rate of contamination in the governmental hospitals (12.76%) in comparison to the total rate in the private hospitals (11.93%).

These results are surprising, as customers usually believe that private hospitals offer better services and maintain a higher standard of cleanliness than governmental hospitals.

To answer the third question ***"Are there statistically significant differences at 0.05 level in the prevalence of microbial contamination related to stage of sample collection (pre-op or post-op)?"***, the researcher used Independent sample *t*. test to examine the differences in mean scores between samples collected at pre-op stage and samples collected at post-op stage. The results are illustrated in table (4.5).

Table (4.5): Differences in mean scores between pre-op and post-op (n = 60)

Item	Onset	mean	St. deviation	*t.*	P-value
Equipment	Pre-op	5.50	0.7071	- 0.822	0.556*
	Post-op	8.00	4.2426		
Environment	Pre-op	7.50	4.9497	0.137	0.911 *
	Post-op	7.00	1.4142		
Person	Pre-op	1.00	0.0000	0.000	1.000 *
	Post-op	1.00	1.4142		
Total	Pre-op	14.00	5.6569	- 0.312	0.784 *
	Post-op	16.00	7.0711		

*not significant

From the above table, the results showed that there was no statistical significant differences at 0.05 level in the equipment item between the mean scores of pre-op stage (m = 5.50) and the mean scores of post-op stage (m = 8.00), where *t* value was (- 0.822) and the *P*-value was (0.556) which is not statistically significant. Also, there was no statistical significant differences at 0.05 level in the environment item between the mean scores of pre-op stage (m = 7.50) and the mean scores of post-op stage (m = 7.50), where *t* value was (0.137) and *P* value was (0.911) which is not statistically significant.

The same result was found with the personnel item where there was no statistical significant differences at 0.05 level between the mean scores of pre-op stage (m = 1.00) and the mean scores of post-op stage (m = 1.00) (*P*-value =1.0 which is not statistically significant).

In total, there was no statistical significant differences at 0.05 level in the total scores between the mean scores of pre-op stage (m = 14.00) and the mean scores of post-op stage (m = 16.00), where *t* value was (- 0.312) and *P* value was (0.784) which is not statistically significant.

In conclusion and even there was higher rate of microbial contamination in post-op samples comparing to the pre-op samples (53.33% vs. 46.66% from total positive samples; 13.17% vs. 11.52% from total ground samples, respectively), The above results revealed that there was no statistically significant difference in the prevalence of microbial contamination at operating rooms in both governmental and private hospitals in regard to the stage of sample collection.

This result was surprising, as it was expected that microbial contamination in the pre-op stage will be lower than contamination in the post-op stage. This result should raise the attention toward re-evaluation of OR preparation and scrubbing procedures in all target hospitals.

4.2.6. Types and frequency of bacterial genera isolated from contaminated samples:

To answer the fourth question ***"What are the main bacterial species isolated from contaminated samples from operating rooms at governmental and private hospitals in Gaza Strip?"***, the researcher used proper culture and identification procedures at public health laboratory of MOH, then analyzed the findings. Eight different bacterial genera were recognized (some were diagnosed at the species level) distributed on 64 isolates from the four hospitals. These isolates were recovered from the 60 contaminated samples, where 4 samples gave two types of bacteria. From table (4.6), the results showed that *S. aureus* was present 26 (40.625%) times in the four hospitals, 15 (23.437%) times in pre-op stage, and 11 (17.187%) times in post-op stage.

This number of *S. aureus* isolates was the highest isolated rate in comparison with the other genera. *S. aureus* was isolated from all four hospitals with high rate from both Al-Salam and Al-Quds hospitals. The second highest isolated bacteria after was the genus *Enterobacter*. It existed 15 (23.437%) times in the four hospitals, 2 (3.125%) times in pre-op stage, and 13 (20.312%) times in post-op stage. The highest percentage of this bacteria was isolated from EGH (13 isolates "20.3%") in comparison to the other hospitals that showed less rate or even absence of this bacteria.

The third highest isolated bacteria were Coliform group (mainly *E. coli*), *Klebsiella* spp. and *Acinetobacter* spp., with five isolates for each genera. Coliform present 5 (7.812%) times in the four hospitals, 2 (3.125%) times in pre-op stage, and 3 (4.687%) times in post-op stage. *Klebsiella* spp. present 5 (7.812%) times in the four hospitals, in the post-op stage, while it was not found in pre-op stage. Most of *Klebsiella* isolates (3) were found in contaminated samples from Al Shifa hospital. Moreover, *Acinetobacter* spp. present 5 (7.812%) times in the four hospitals, 4 (6.250%) in pre-op stage, and 1 (1.562%) times in post-op stage. The most isolates of *Acinetobacter* spp. (4) were recovered from Al-Salam hospital.

Pseudomonas spp. present 3 (4.687%) times in the four hospitals, 2 (3.125%) times in pre-op stage, and 1 (1.562%) times in post-op stage. Same result was obtained with the bacteria *S. epidermidis* which present 3 (4.687%) times in the four hospitals, 2 (3.125%) times in pre-op stage, and 1 (1.562%) time in post-op stage. Finally, the least encountered bacteria were Streptococci which present 2 (3.125%) times in the four hospitals, 1 (1.562%) in pre-op stage, and 1 (1.562%) in post-op stage. In pre-op stage, there were less bacteria present (28, 43.750%) comparing with the number of bacterial isolates in post-op stage (36, 56.250%).

In conclusion, the most common bacterial species recovered were *S. aureus* (26, 40.62%) followed by *Enterobacter* (15, 23.43%) which together represent about two third (64.0%) of all isolated bacteria.

Table (4.6): Main bacterial genera isolated from operating rooms. (n = 60)

Place	Onset	*S. aureus*	*Coliform*	*Klebsiella*	*Pseudomonas*	*Streptococci*	*Enterobacter*	*Acinitobacter*	*S. epidermidis*	Total / onset	Total grand
		Frequency & percentage									
Shifa	Pre	(2) 3.125%	(2) 3.125%	0	(1) 1.562%	0	0	0	0	(5) 7.812%	(14) 21.87%
	Post	(3) 4.687%	(3) 4.687%	(3) 4.687%	0	0	0	0	0	(9) 14.062%	
EGH	Pre	(1) 1.562%	0	0	0	0	(1) 1.562%	(1) 1.562%	(2) 3.125%	(5) 7.812%	(21) 32.81%
	Post	0	0	(2) 3.125%	(1) 1.562%	0	(1 2) 18.750%	0	(1) 1.562%	(16) 25.000%	
Al-Quds	Pre	(6) 9.375%	0	0	(1) 1.562%	0	0	0	0	(7) 10.937%	(9) 14.06%
	Post	(2) 3.125%	0	0	0	0	0	0	0	(2) 3.125%	
Al-Salam	Pre	(6) 9.375%	0	0	0	(1) 1.562%	(1) 1.562%	(3) 4.687%	0	(11) 17.187%	(20) 31.25%
	Post	(6) 9.375%	0	0	0	(1) 1.562%	(1) 1.562%	(1) 1.562%	0	(9) 14.062%	
Total pre		(15) 23.437%	(2) 3.125%	0	(2) 3.125%	(1) 1.562%	(2) 3.125%	(4) 6.250%	(2) 3.125%	(28) 43.750%	(64) 100.0%
Total Post		(11) 17.187%	(3) 4.687%	(5) 7.812%	(1) 1.562%	(1) 1.562%	(13) 20.312%	(1) 1.562%	(1) 1.562%	(36) 56.250%	
Grand Total		(26) 40.625%	(5) 7.812%	(5) 7.812%	(3) 4.687%	(2) 3.125%	(15) 23.437%	(5) 7.812%	(3) 4.687%		

4.2.7. Antibiotic sensitivity pattern of bacterial genera that isolated from contaminated samples:

To answer the fifth question *"**What is the antibiotic profile results for isolated bacteria?**"*, the researcher chose one specimen randomly from each one of the common isolated bacteria and performed the antibiotic sensitivity testing by standard procedures for the common isolated types of bacteria that showed high frequency. They including *S. aureus*, *Enterobacter* spp., *Klebsiella* spp., and *Acinetobacter* spp. The results are illustrated in table (4.7).

S. aureus specimen was resistant to high number of antibiotics used including Trimethoprim, Amoxicillin, Cefalexine, cefruoxime, ciprofloxacin, and Nalidixic acid, while they were found to be sensitive to Ampicilline, Amikacin, and offloading.

In regard to the second highly isolated bacteria which is *Enterobacter* specimen, it was also resistant to many of tested antibiotics including Amoxicillin, Ampicilline, Ceftazidime, and Cefalexine, while they were sensitive to Trimethoprim, Ceftrixalone, ciprofloxacin, Amikacin, Doxyciline, and Ofloxacin.

Table (4.7): Antibiotic sensitivity pattern of selected isolated bacteria

Type of Antibiotic / Genus of bacteria	Trimethoprim	Amoxicillin	Ampicilline	Ceftazidime	Cefalexine	Cefruoxime	Ceftrixalone	Ciprofloxacin	Amikacin	Doxyciline	Nalidixic acid	Ofloxacin
Staphylococcus aureus	R	R	S	I	R	R	I	R	S	I	R	S
***Enterobacter* spp.**	S	R	R	R	R	I	S	S	S	S	I	S
***Klebsiella* spp.**	I	I	R	S	I	R	I	S	S	I	R	S
***Acinetobacter* spp.**	R	R	R	S	R	I	I	S	S	S	R	I

S = sensitive, R = resistant, I = intermediate

Klebsiella spp. specimen was resistant to Ampicilline, Cefruoxime, and Nalidixic acid, while it was sensitive to Ceftazidime, Ciprofloxacin, Amikacin, and Ofloxacin. Finally, the last tested bacteria, *Acinetobacter* spp. specimen was also resistant to high number of tested antibiotics including Trimethoprim, Amoxicillin, Ampicilline, Cefalexine, and Nalidixic acid, while it was sensitive to Ceftazidime, Ciprofloxacin, Amikacin, and Doxyciline.

Most of the isolates from all four bacterial genera found to be resistance to most of ß-lactam antibiotics tested, including Penicillin group (Amoxicillin and Ampicilline) and Cephalosporin group (Cefalexine, Cefruoxime, 2nd generation); whereas the 3rd generation Cephalosporin (Ceftrixalone "Rocephin") showed moderately to highly activity against most isolates. Also, the Nalidixic acid (quinolon antibiotic) showed very low activity against most tested bacterial isolates.

However, the aminoglycoside antibiotic Amikacin, showed highest activity against all tested isolates. Amikacin that working as protein synthesis inhibitor mainly against gram negative bacteria, administered as injection both intramuscularly and intravenously. It could be given also orally but only for gastroenteritis because it poorly absorbed and has only local effect. In addition, Doxyciline which has the same action as Amikacin (protein synthesis inhibitor) showed intermediate activity against tested isolates. Moreover, the fluoroquinolones group antibiotics used (Ciprofloxacin and Ofloxacin) showed high activity against most of tested bacterial isolates. Finally, the bacteriostatic Trimethoprim and Ceftazidime showed low activity against most tested bacterial isolates.

In conclusion, the above results showed high resistance from both four types of tested bacteria to many of tested antibiotics, which may decrease the alternatives of treatment and decrease the chance of fighting against those kinds of bacteria.

From 60 contaminated swabs that obtained in our study, there were 64 bacterial isolates, distributed into 8 bacterial species. a percentage of 43.75% of contaminated swabs were isolated in the pre-op stage and 56.25% were isolated in the post-op stage.

S. aureus was the highest species isolated from contaminated swabs, and it accounts for 40.625% of the total species. What was unexpected in this result that this isolated bacteria (*S. aureus*) was higher in the pre-op stage (23.43%) compared to the post-op stage (17.18%). The Centers for Disease Control and Prevention (CDC) reports that in 1999, the most prevalent causes of SSIs were *S. aureus*, coagulase-negative staphylococci, Enterococcus species, and *E. coli*. A study published in 2003 reports that extremes of costs for SSIs may exceed $92,363 for patients with SSIs caused by methicillin-resistant *S. aureus* (MRSA) (Nelson, *et al.*, 2006).

The rate of *S. aureus* in our study is much higher than the study of Coskum & Aytae (2007) which showed that *S. aureus* was responsible for 16.0% of nosocomial infections following cardiovascular surgeries, and the study of Ensayef, (2009) which showed that *S. aureus* was responsible for 17.4% of surgical wound infections. However, many studies have reported *S. aureus* as the commonest isolate from the postoperative wound infection (Ahmed *et al.*,1998; Mangram *et al.*,1999; Lilani *et al.*, 2005; Nilson *et al.*, 2006). In a study evaluated the etiological agents of SSI and their resistance patterns at a city government hospital in India, The authors found that the most common bacteria were *S. aureus* (n = 23; 37%) and *P. aeruginosa* (n =23; 37%) which is in agreement with our findings (Kownhar *et al.*, 2008). Number of studies in the literature indicate gradual increase in the emergence of antibiotic resistant microorganisms in surgical patients. Special interest in *S. aureus* surgical site infection is mainly due to its predominant role in hospital cross infection and emergence of virulent antibiotic resistant strains (Lilani *et al.*, 2005). In our present study, when we looking to the antibiogram pattern, we could see that all *S. aureus* isolates were resistant to most of the common antibiotics tested including penicillin and cephalosporin group. This may complicates the problem and decrease the chances for antibiotic treatment. *S. aureus* is believed to originate from the patient's own anterior nares. So, most of SSIs could arise from the patient's own strain or as contaminant from the personnel specially surgeons. For this reason, it is important to control pre-operative nasal carriage of *S. aureus* to avoid the risk of MRSA in surgical wounds, which could possibly influence the outcome of SSIs (Kownhar *et al.*, 2008).

Both coagulase-negative staphylococci and *S. aureus* are the most commonly implicated bacteria in SSIs (i.e., 20% and 14% respectively). Subsequently, coagulase- negative staphylococci is one of the most frequently isolated bacteria in the laboratory. These bacteria are of little virulence but are frequently implicated as the cause of infections in patients who are either immuno-compromised or have medical implants (Nelson *et al.*, 2006). In this study, *S. epidermidis* accounts only for 4.687% of isolated bacterial species. This result is much lower than the study result of Ensayef, (2009) which showed that *S. epidermidis* was the most common bacterial specie isolated in (2001) and accounts for 39.1%. Coagulase-negative staphylococcus was the most common organism isolated from all sites in an operating room environment (Duhaime *et al.*, 1991). In the same study of Ensayef, coliform was the highest isolated bacterial specie in (2002) and it accounts for 62.5%, while in this study, coliform accounts for 7.812% of isolated bacterial species. There is even much lower isolated percentage than our finding in another studies with a rate of 4.8% (Kownhar *et al.*, 2008).

Enterobacter accounts for 23.437% of the total bacterial species. Its prevalence was much higher in the post-op stage (20.312%) compared to the pre-op stage (3.125%). In contrast to *S. aureus*, *Enterobacter* is more sensitive to the common antibiotics tested in this study. *P. aeruginosa* accounts for 4.687%, while in Ensayef, (2009) it accounts for 30.4% in (2001) and 25.0% in (2002). Another studies also find higher rate of *P. aeruginosa* in SSIs but not in operation room equipment or environment (Rahman *et al.*,2003; Kownhar *et al.*, 2008). The high prevalence of *P. aeruginosa* in these studies may be due to the fact that it can survive well in moist environments, often causing severe tissue damage due to its invasiveness.

Acinetobacter accounts for 7.812% of the total bacterial species. This rate is higher than the finding of Kownhar *et al.* who found that 3.2% from positive isolates were *Acinetobacter* spp. (Kownhar *et al.*, 2008). *Acinetobacter baumannii* has been stealthily gaining ground as an agent of serious nosocomial and community-acquired infection. Multidrug-resistant (MDR) *A. baumannii* are emerging as important nosocomial pathogens. These organisms have a capacity for long-term survival in the hospital environment. Historically, *Acinetobacter spp*. have been associated with opportunistic infections that were rare and of modest severity; the last two decades have seen an increase in both the incidence and seriousness of *A. baumannii* infection, with the main targets being patients in intensive-care units. Although this organism appears to have a predilection for the most vulnerable patients, community-acquired *A. baumannii* infection is an increasing cause for concern. The increase in *A. baumannii* infections has paralleled the alarming development of resistance it has demonstrated. The persistence of this organism in healthcare facilities, its inherent hardiness and its resistance to antibiotics results in it being a formidable emerging pathogen (Wybo *et al.*, 2007; Gootz & Marra, 2008).

Chapter Five

Conclusion and Recommendations

Chapter Five

Conclusion and Recommendations

5.1. Conclusion

5.1.1. Introduction:

This study was conducted to determine the prevalence of bacterial contamination in operating rooms at governmental and nongovernmental hospitals in Gaza Strip. Two major governmental hospitals were selected namely, Al Shifa hospital and European Gaza Hospital, and two major nongovernmental hospitals were selected namely, Al-Quds hospital and Dar Al-Salam hospital. The study findings might help in identifying the sources of bacterial contamination in operating rooms and taking necessary actions to maintain the operating rooms as a septic areas for the safety of patients and OR team members.

5.1.2. Prevalence of bacterial contamination in OR:

In general, 24.68% of the collected swabs found to be contaminated. When analyzing those contaminated swabs regarding the source of contamination, it was found that environment items had the highest contamination and were responsible for 48.31% of the total contaminated swabs followed by equipment items were responsible for 44.94% of the total contaminated swabs and person items were responsible for 6.62% of the total contaminated swabs.

5.1.3. Differences in prevalence of bacterial contamination between governmental and private hospitals:

There was no significant differences in the prevalence of bacterial contamination between governmental hospitals (m = 15.000) and nongovernmental hospitals (m = 14.500), ***t*** value = 0.153) and *P*-value was 0.894.

5.1.4. Differences in prevalence of bacterial contamination regarding the onset of swab collection:

There was no significant differences in the prevalence of bacterial contamination between swabs collected at pre-op stage (m = 14.000) and swabs collected at post-op stage (m = 16.000), where ***t*** value was – 0.312 and ***P***-value was 0.784.

5.1.5. Main bacterial species isolated from contaminated swabs:

Among the 60 contaminated swabs, bacteria frequency was 64 times distributed on 8 species. *S. aureus* found to be the highest (40.62%) followed by *Enterobacter* (23.43%), Coliform (7.81%), *Klebsiella* (7.81%) and *Acinitobacter* (7.812%). Total bacterial frequency at pre-op stage was (43.75%) and at post-op stage was (56.25%). At Al Shifa hospital, bacteria frequency was (21.87%), at EGH was (32.81%), at Al-Quds was (14.06%) and at Dar Al-Salam was (31.25%).

5.1.6. Antibiotic sensitivity profile for isolated bacteria:

S. aureus found to be resistant to most of antibiotics; it was sensitive only to Ampicilline, Amikacin, and Ofloxacin. *Enterobacter* spp. were sensitive to Trimethoprim, Ceftrixalone, ciprofloxacin, Amikacin, Doxyciline, and Ofloxacin. *Klebsiella* spp. were sensitive to Ceftazidime, ciprofloxacin, Amikacin, and Ofloxacin. *Acinetobacter* spp. were sensitive to Ceftazidime, ciprofloxacin, Amikacin, and Doxyciline.

5.2. Recommendations

In the light of the present study results, the researcher suggests the following recommendations:

- Evaluation of the cleaning and scrubbing procedures at operating rooms.
- Evaluation of the sterilizing procedures for surgical instruments.
- Establish and activate infection control teams at hospitals.

- Offer training and instruction programs for OR teams regarding nosocomial infections, mechanisms, and modes of transmission.
- Supply operating rooms with ultraviolet lights.
- Minimize the number of persons moving in and out operation theatre during surgeries.
- Periodic screening and swab collection from OR personnel, environment, and equipment.

5.3. Further research recommendations

According to the study results, the researcher suggests the following further studies:

- Further research is necessary regarding Knowledge, Attitudes, and Practice (KAP) of a septic techniques in OR.
- Studying the relationship between length of operation and surgical wound infection.
- Studying the impact of using disposable instruments during surgery on nosocomial infection.
- Studying in depth the incidence of surgical site infection post-operatively at wards.

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Appendix 1

Appendix 2

CDC RECOMMENDATIONS FOR PREVENTION OF SURGICAL SITE INFECTION

RATIONALE

The Guidelines for Prevention of Surgical Site Infection (1999) provides recommendations concerning reduction of surgical site infection (SSI) risk. Each recommendation is categorized on the basis of existing scientific data, theoretical rationale, and applicability.

Category I recommendations, including IA and IB, are those recommendations that are viewed as effective by HICPAC and experts in the fields of surgery, infectious diseases and infection control. Both Category IA and IB recommendations are applicable for, and should be adopted by, all healthcare facilities; IA and IB recommendations differ only in the strength of the supporting scientific evidence.

Category II recommendations are supported by less scientific data than Category I recommendations; such recommendations may be appropriate for addressing specific nosocomial problems or specific patient populations. No recommendation is offered for some practices, either because there is a lack of consensus regarding their efficacy or because the available scientific evidence is insufficient to support their adoption. For such unresolved issues, practitioners should use judgment to determine a policy regarding these practices within their organization.

RANKING

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

Category IB. Strongly recommended for implementation and supported by some experimental, clinical or epidemiological studies and strong theoretical rationale.

Category II. Suggested for implementation and supported by suggestive clinical or epidemiological studies or theoretical rationale.

No recommendation (unresolved issue). Practices for which insufficient evidence or no consensus regarding efficacy exists.

RECOMMENDATIONS

1. PREOPERATIVE

a. Preparation of the patient

1. Whenever possible, identify and treat all infections remote to the surgical site before elective operation and postpone elective operations on patients with remote site infections until the infection has resolved. *Category IA*

2. Do not remove hair preoperatively unless the hair at or around the incision site will interfere with the operation. *Category IA*

3. If hair is removed, remove immediately before the operation, preferably with electric clippers. *Category IA*

4. Adequately control serum blood glucose levels in all diabetic patients and particularly avoid hyperglycemia perioperatively. *Category IB*

5. Encourage stopping use of tobacco products. At minimum, instruct patients to abstain for at least 30 days before elective operation from smoking cigarettes, cigars, pipes or any other form of tobacco consumption (e.g., chewing/dipping). *Category IB*

6. Do not withhold necessary blood products from surgical patients as a means to prevent SSI. *Category IB*

7. Require patients to shower or bathe with an antiseptic agent on at least the night before the operative day. *Category IB*

8. Thoroughly wash and clean at and around the incision site to remove gross contamination before performing antiseptic skin preparation. *Category IB*

9. Use an appropriate antiseptic agent for skin preparation (Table 6). *Category IB*

10. Apply preoperative antiseptic skin preparation in concentric circles moving toward the periphery. The prepared area must be large enough to extend the incision or create new incisions or drain sites, if necessary. *Category II*

11. Keep preoperative hospital stay as short as possible while allowing for adequate preoperative preparation of the patient. *Category II*

12. No recommendation to taper or discontinue systemic steroid use (when medically permissible) before elective operation. *Unresolved issue*

13. No recommendation to enhance nutritional support for surgical patients solely as a means to prevent SSI. *Unresolved issue*

14. No recommendation to preoperatively apply mupirocin to the nose (nares) to prevent SSI. *Unresolved issue*

b. Hand/forearm antisepsis for surgical team members

1. Keep nails short and do not wear artificial nails. *Category IB*

2. Perform a preoperative surgical scrub for at least 2 to 5 minutes using an appropriate antiseptic. Scrub the hands and forearms up to the elbows. *Category IB*

3. After performing the surgical scrub, keep hands up and away from the body (elbows in flexed position) so that water runs from the tips of the fingers toward the elbows. Dry hands with a sterile towel and put on a sterile gown and gloves. *Category IB*

4. Clean underneath each fingernail prior to performing the first surgical scrub of the day. *Category II*

5. Do not wear hand or arm jewelry. *Category II*

6. No recommendation on wearing nail polish. *Unresolved Issue*

c. Management of infected or colonized surgical personnel

1. Educate and encourage surgical personnel who have signs and symptoms of a transmissible infectious illness to report conditions promptly to their supervisory and occupational health service personnel. *Category IB*

2. Develop well-defined policies concerning patient care responsibilities when personnel have potentially transmissible infectious conditions. These policies should govern: (a) personnel responsibility in using the health service and reporting illness, (b) work restrictions, and (c) clearance to resume work after an illness that required work restriction. The policies also should identify persons who have the authority to remove personnel from duty. *Category IB*

3. Exclude from duty surgical personnel who have draining skin lesions until infection has been ruled out or personnel have received adequate therapy and infection has resolved. *Category IB*

4. Do not routinely exclude surgical personnel who are colonized with organisms such as *S. aureus* (nose, hands or other body site) or group A *Streptococcus*, unless such personnel have been linked epidemiologically to dissemination of the organism in the healthcare setting. *Category IB*

d. Antimicrobial prophylaxis

1. Administer a prophylactic antimicrobial agent only when indicated, and select it based on its efficacy against the most common pathogens causing SSI for a specific operation and published recommendations. *Category IA*

2. Administer by the intravenous route the initial dose of prophylactic antimicrobial agent, timed such that a bactericidal concentration of the drug is established in serum and tissues when the incision is made. Maintain therapeutic levels of the agent in serum and tissues throughout the operation and until, at most, a few hours after the incision is closed in the operating room. *Category IA*

3. Before elective colorectal operations in addition to d2 above, mechanically prepare the colon by use of enemas and cathartic agents. Administer nonabsorbable oral antimicrobial agents in divided doses on the day before the operation. *Category IA*

4. For high-risk cesarean section, administer the prophylactic antimicrobial agent immediately after the umbilical cord is clamped. *Category IA*

5. Do not routinely use vancomycin for antimicrobial prophylaxis. *Category IB*

2. INTRAOPERATIVE

a. Ventilation

1. Maintain positive-pressure ventilation in the operating room with respect to the corridors and adjacent areas. *Category IB*

2. Maintain a minimum of 15 air changes per hour, of which at least 3 should be fresh air. *Category IB*

3. Filter all air, recirculated and fresh, through the appropriate filters per the American Institute of Architects' recommendations. *Category IB*

4. Introduce all air at the ceiling, and exhaust near the floor. *Category IB*

5. Do not use UV radiation in the operating room to prevent SSI. *Category IB*

6. Keep operating room doors closed except as needed for passage of equipment, personnel and the patient. *Category IB*

7. Consider performing orthopedic implant operations in operating rooms supplied with ultraclean air. *Category II*

8. Limit the number of personnel entering the operating room to necessary personnel. *Category II*

b. Cleaning and disinfection of environmental surfaces

1. When visible soiling or contamination with blood or other body fluids of surfaces or equipment occurs during an operation, use disinfectant to clean the affected areas before the next operation. *Category IB*

2. Do not perform special cleaning or closing of operating rooms after contaminated or dirty operations. *Category IB*

3. Do not use tacky mats at the entrance to the operating room suite or individual operating rooms for infection control. *Category IB*

4. Wet vacuum the operating room floor after the last operation of the day or night with disinfectant. *Category II*

5. No recommendation on disinfecting environmental surfaces or equipment used in operating rooms between operations in the absence of visible soiling. *Unresolved issue*

c. Microbiologic sampling

1. Do not perform routine environmental sampling of the operating room. Perform microbiologic sampling of operating room environmental surfaces or air only as part of an epidemiologic investigation. *Category IB*

d. Sterilization of surgical instruments

1. Sterilize all surgical instruments according to published guidelines. *Category IB*

2. Perform flash sterilization only for patient care items that will be used immediately (e.g., to reprocess an inadvertently dropped instrument). Do not use flash sterilization for reasons of convenience, as an alternative to purchasing additional instrument sets, or to save time. *Category IB*

e. Surgical attire and drapes

1. Wear a surgical mask that fully covers the mouth and nose when entering the operating room if an operation is about to begin or already under way or if sterile instruments are exposed. Wear the mask throughout the operation. *Category IB*

2. Wear a cap or hood to fully cover hair on the head and face when entering the operating room. *Category IB*

3. Do not wear shoe covers for the prevention of SSI. *Category IB*

4. Wear sterile gloves if a scrubbed surgical team member. Put on gloves after putting on a sterile gown. *Category IB*

5. Use surgical gowns and drapes that are effective barriers when wet (i.e., materials that resist liquid penetration). *Category IB*

6. Change scrub suits that are visibly soiled, contaminated and/or penetrated by blood or other potentially infectious materials. *Category IB*

7. No recommendations on how or where to launder scrub suits, on restricting use of scrub suits to the operating suite or for covering scrub suits when out of the operating suite. *Unresolved issue*

f. Asepsis and surgical technique

1. Adhere to principles of asepsis when placing intravascular devices (e.g., central venous catheters), spinal or epidural anesthesia catheters, or when dispensing and administering intravenous drugs. *Category IA*

2. Assemble sterile equipment and solutions immediately prior to use. *Category II*

3. Handle tissue gently, maintain effective hemostasis, minimize devitalized tissue and foreign bodies (i.e., sutures, charred tissues, necrotic debris) and eradicate dead space at the surgical site. *Category IB*

4. Use delayed primary skin closure or leave an incision open to heal by second intention if the surgeon considers the surgical site to be heavily contaminated (e.g., Class III and Class IV). *Category IB*

5. If drainage is necessary, use a closed suction drain. Place a drain through a separate incision distant from the operative incision. Remove the drain as soon as possible. *Category IB*

3. POSTOPERATIVE INCISION CARE

a. Protect with a sterile dressing for 24 to 48 hours postoperatively an incision that has been closed primarily. *Category IB*

b. Wash hands before and after dressing changes and any contact with the surgical site. *Category IB*

c. When an incision dressing must be changed, use sterile technique. *Category II*

d. Educate the patient and family regarding proper incision care, symptoms of SSI, and the need to report such symptoms. *Category II*

e. No recommendation to cover an incision closed primarily beyond 48 hours, nor on the appropriate time to shower or bathe with an uncovered incision. *Unresolved issue*

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Available at: http://www.cdc.gov/ncidod/hip/SSI/SSI_guideline.htm

الخلاصة:

هذه الدراسة هدفت إلى معرفة معدل وجود وانتشار التلوث الميكروبي في غرف العمليات الجراحية و ذلك بأخذ مسحات من الأدوات و المعدات والأشخاص قبل وبعد إجراء العمليات الجراحية في مجموعه من مستشفياتنا الحكومية وغير الحكومية بقطاع غزه. كذلك هدفت الدراسة إلى معرفة أنواع هذه الميكروبات و مدى استجابتها ومقاومتها للمضادات الحيوية الشائعة الاستخدام.

قام الباحث بجمع ٢٤٣ مسحه من ٢١ هدف داخل غرف العمليات شملت مسحات من المعدات المستخدمة، مسحات من بيئة غرف العمليات، و مسحات من الطاقم الطبي وكان حجم المسحات التي تم جمعها و تحليلها من المستشفيات الحكومية (٥٨,٤%) اكبر من التي جمعت وحللت من المستشفيات الخاصة (٤١,٦%).

أظهرت النتائج أن النسبة العامة لمعدل التلوث الميكروبي بلغت (٢٤,٧%) من المجموع العام للمسحات، حيث كان ما نسبته ٤٤,٩% من مسحات المعدات و ٤٨,٣١% من مسحات بيئة غرف العمليات و فقط ٦,٦٢% من مسحات جمعت من الطاقم الطبي.

سجلت النسبة المئوية للتلوث الميكروبي بالمسحات المأخوذة من قبل إجراء العمليات الجراحية معدلا (٢٢,٥٨%) اقل من النسبة التي سجلت بعد إجراء العمليات الجراحية (٢٦,٨٩%) و لكن هذا الفارق لم يرقى إلى فرق ذا دلاله احصائيه جوهريه. أيضا و في نفس المضمار، أوضحت النتائج انه لم يكن هناك فروق ذات دلالات احصائيه جوهريه بين نسبة التلوث الميكروبي في المستشفيات الحكومية عند مقارنتها مع مثيلاتها من المستشفيات الخاصة، مع ملاحظة انه وجد ارتفاع طفيف في معدل التلوث الميكروبي بالمستشفيات الحكومية (١٢,٧٦%) مقارنه مع مثيلاتها من المستشفيات الخاصة (١١,٩٣%).

بالنسبة لأنواع الميكروبات التي تم عزلها من المسحات الايجابية، فقد أظهرت الدراسة وجود ثماني أنواع مختلفة من البكتيريا والتي شملت: *Staphylococci, Enterobacter, Klebsiella, Escherichia, Pseudomonas, Acinetobacter, and Streptococci.* ، حيث كانت المكورات العنقودية الذهبية *S. aureus,* موجودة بأعلى نسبه (٤٠,٦%) تتبعها الانتيروباكتر *Enterobacter* بنسبة ٢٣,٤% واللتان تمثلان معا أكثر من ثلثي الأنواع التي تم عزلها. أما فيما يتعلق باختبارات الحساسية للمضادات الحيوية لهذه الأجناس فقد أظهرت النتائج وجود مقاومه

عاليه للعديد من المضادات الحيوية الـشائعة الاسـتخدام مثـل: Ampicilline, amoxicillin, Trimethoprim, Cefalexine, cefruoxime, and Nalidixic acid, والذي يمكن أن يصعب ويقلل من إمكانية معالجة الإصـابات الناتجة عن مثل هذه البكتيريا و إيجاد بدائل لمقاومتها.

في الختام فان هذه النتائج لهذه الدراسة تظهر أن كلا من المستشفيات سواء الحكومية أو الخاصة على حـد سـواء بقطاع غزه تعاني من نسبه عاليه من التلوث الميكروبي بغرف العمليات خصوصا من المسحات المأخوذة من بيئـة الغرف مثل الأرضيات والجدران و هذا بطبيعة الحال ممكن أن يشكل معضلة ليست بالهينـة، خـصوصا إذا كـان الحديث يدور عن مكان يجب أن يكون خالي تماما أو بأعلى قدر ممكن من التلوث الميكروبي في كل وقت لتجنـب حدوث إصابات ميكروبيه قد تكون خطيرة على حياة المريض بصوره أساسيه وكذلك أيضا علـى الطـاقم الطبـي العامل بغرف العمليات.

إن هذه النتائج يجب أن تعيد تقييم الطرق والاستراتيجيات المستخدمة في تطهير غرف العمليات وتعقـيم الأدوات و ممارسات الطاقم الطبي، ليس فقط في المستشفيات التي أجريت فيها الدراسة بل أيضا بجميع مستشفيات قطاع غزه.