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Environmental Infection Control in Intensive Care Units at Gaza Governorates: Interventional Study

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Abstract

Background*:** Worldwide, many lives are lost because of the spread of infections in health facilities. Microbial organisms spreading in everything around us (air, water, food and inanimate surfaces). Most of these infections can be prevented by well-established processes for decontamination and cleaning of soiled instruments. High-risk areas such as intensive care units (ICUs) require special ventilation systems that designed to provide clean air with high efficiency, which need to be considered in the hospitals construction. It is also imperative for health care administrators to ensure implementation of the infection control program in health care facilities. This study aimed to evaluate the environmental infection control (EIC) measures in the general ICUs in Gaza. ***Methodology*:** A three-months descriptive cross sectional study was done to evaluate the two main general ICUs in Gaza "Shifa Complex and European Gaza Hospital (EGH)". A total of 196 microbiological samples for air, water, and inanimate surfaces were surveyed. Both ambient air and inspiratory air from mechanical ventilator machines (MV) were sampled and cultured for bacterial and fungal count. Also, 20 water specimens were tested for bacterial presence. In addition, 120 swabbed cultures from surfaces and equipments were growing in a pre-enrichment media before incubation. Moreover, a total of 516 reading for climate temperature (T) and relative humidity (RH) were gathered as the most important factors assist in bacterial multiplication. ***Results: The study revealed that 62% of the infection prevention and control (IPC) measures in Shifa ICU were unfit, in comparison with EGH ICU (53%). Also, the total bacterial count within indoor air in both ICUs ranged from (1170 to 1470) cfu/m3 (standard is less than 50 cfu/m3). Moreover, results revealed the presence of bacterial count that ranged from 73 to 90 cfu/m3 in the inspired air from MVs. However, fungal count was 830 cfu/m3 at Shifa, while free at EGH MVs. The climate temperature average during day hours was significantly high than the standard in about 4^{o}C, thus 79.73% of HCPs (P=0.000) saw that their provided care was affected negatively by unsatisfactory T. RH average was 59% in both units, at a high limit of the international standard. On the other hand, count of total and fecal coliform in all water sources were negative. The study revealed that 96% of pre-enriched swabbed cultures in Shifa were positive, closely the same as EGH (93%). Bacterial findings in both units were: *Pseudomonas* 38.5% (*n*=24), *E-coli* 32% (*n*=20), and *Klebsilla* 16% (*n*=10). However, *Staph arues* was 16.1% (*n*=5) in EGH ICU and free at Shifa. ***Conclusions:*** Periodic monitoring of ventilation system efficiency is desired to ensure optimal indoor air quality, Palestinian IPC should to be updated to include standards about air and ventilation system, particularly bacterial and fungal count in indoor air. Also standards for climate T and RH average in ICUs is necessary. Urgent interventions are required to improve methods of disinfecting the hospital environmental surfaces and equipments especially MVs. Although, the study supported using of pre-enrichment media rather than dry method and direct culture for inanimate surfaces outbreak examinations. Vital system and implementations for healthcare waste disposal and laundry system essentially required to be more developed.

Key words: Infection control, Indoor air, inspired air from mechanical ventilators, Water, Inanimate Surfaces, Temperature, Relative Humidity.

1.Introduction

Critical care is the specialized medical care of patients with or at high risk for life-threatening, or “critical,” conditions requiring constant monitoring and comprehensive care consisting of complex therapies and interventions. Most hospitalized patients with critical conditions are cared for in ICUs, patient care areas designed to provide extraordinary treatment by specially trained healthcare professionals, often with the use of high-tech equipment. More than three-quarters of acute care hospitals in the United States provide critical care services, and the national number of ICU beds continues to increase each year (Halpern et al., 2004).

Nosocomial infection is a major cause of morbidity and mortality in the critical care units, ventilator-associated pneumonia represents the most prevalent and visible hospital-acquired infection (Zilberberg and Shorr, 2011). For more than a century, medicine has viewed the microbial world as an enemy that should be destroyed, by practical measures known as “infection control,” and they are designed to prevent the spread of microorganisms from one person to another, or from one site to another on the same person, some infection control practices are rational, and some are ritual, but all are an essential part of daily life in the ICU. It is therefore important for all health care workers, patients, their family members, friends and close contacts to adhere to the infection control guidelines strictly. It is also imperative for health care administrators to ensure implementation of the infection control program in health care facilities (WHO, 2004).

Over 1.4 million people worldwide are suffering from infections acquired at hospitals. Between 5% and 10% of patients admitted to modern hospitals in the developed world acquire one or more infections. The risk in developing countries is 2 to 20 times higher (Pittet and Donaldson, 2006). Recent studies suggest that at least 20% of HAIs could be prevented through infection prevention and control strategies. IPC programs have been shown to be both clinically effective and cost-effective, providing important cost savings in terms of fewer HAIs reduced length of hospital stay, less antimicrobial resistance and decreased costs of treatment for infections (Ontario Ministry of Health and Long-Term Care, 2011).

Infection control activities must be integrated into the routine activities of the hospital. The management of these activities should be through a Hospital Infection Control Committee with a full time Infection Control Nurse who should coordinate various activities. The Committee should identify priorities, implement the plan and continuously monitor the situation for assuring quality and its continuous improvement (WHO, 2002a).

Most ICU patients are immune-compromised, whether from pathologies (e.g. hepatic failure, leukemia, AIDS) or treatments (immunosuppressive drugs), making them susceptible to opportunistic infection from organisms colonizing (but not necessarily infecting) healthier people. Each member of staff is a potential carrier of infection (Ling, 2011).

Hygiene is helped by adequate and appropriate facilities, including sufficient washbasins, aprons and unit guidelines and protocols. All multidisciplinary team members should be actively involved in making decisions, but nurses have an especially valuable role in coordinating and controlling each patient’s environment. Prevention can literally be ‘life-saving’. Problems from infection are likely to escalate; continuing vigilance and care can minimize infection risks and the spread of microorganisms. The importance of nursing to infection control is emphasized through its inclusion in the standards of care for critical care nursing (Vincent et al., 2002).

In addition, an international Study of the prevalence and outcomes of infection in intensive care units by (Vincent; et al., 2006) they believed that infection is a major cause of morbidity and mortality in intensive care units (ICUs) worldwide.

This study evaluated the characteristics and weekly variations in indoor air in a medical ICUs in northern Taiwan for 1 year. It also investigated the impact of patient visiting activities on the indoor climate in the medical ICU. A 4-bed room with patients in the medical ICU was selected for long-term air monitoring of air temperature and relative humidity. The result conclusion was, patient visiting activity impacts the indoor air quality of the ICU environment. Periodic monitoring of ventilation system efficiency is needed to ensure optimal indoor air quality., During the environmental sampling period, air temperature ranged from 21.28C to 25.88C, relative humidity ranged from 58% to 74% (Chin-Sheng et al., 2009).

Bioaerosols from numerous sources have been implicated in respiratory diseases, investigated the impact of patient visiting activities on the indoor climate in the medical ICU. A 4-bed room with patients in the medical ICU in northern Taiwan for 1 year, was selected for long-term air monitoring, bacteria, and fungi were measured. The measured bacteria and fungi concentrations varied among the surveyed weeks. The peak concentrations of indoor bacteria and fungi were found in June (7236 cfu/m^3 for bacteria and 7807 cfu/m3 for fungi), October (3869 cfu/m3 for bacteria and 5954 cfu/m3 for fungi), and December (2964 cfu/m^3 for bacteria and 11,654 cfu/$m^3$for fungi). Approximately 27% of the bacterial samples and 17% of the fungal concentrations exceeded 1000 cfu/m^3 (Chin-Sheng et al., 2009).

2. Methodology

2.1 Period and place of study

The study carried out in the two main locations in which Palestinian Ministry of Health (MOH) has general ICUs which provide intensive care for most specialties at Gaza hospitals, includes two health centers, Shifa Complex and EGH. On the other hand, data collected from October to December 2012**.**

2.2 Study tool

Fitness checklist, this tool has two uses, the first is to evaluate existing of environmental infection control measures by routine wake around checking, as an evaluation tool (wake around checklist).

The second one used to serve the research need, by investigative environmental sampling. Both microbiological sampling of (air, water, and inanimate surfaces) and two environmental measurements which were temperature and relative humidity as the most important physical environmental factors assist in bacterial multiplication.

The fitness checklist contains seven domains which were air and ventilation system quality, water quality, environmental surfaces, laundry, healthcare waste management, instruments and equipment cleaning, and cleaning aids "antiseptic disinfection and sterilization".

2.3 Microbiological samples description

Table 2.1: Samples size

No	ICU		Shifa	EGH	Total
1	Air samples	Indoor	16	16	32
		Ventilators	16	8	24
2	Water samples		12	8	20
3	Swabs cultures		89	31	120
	Total		133	63	196

2.4 Sampling methodology and processing

1. Air samples

An air sampler (Sampl'air- AES CHEMUNEX, France) was used to collect air samples. The apparatus is designed to pump 50 liters of air through the target media plate.

a. Indoor air

Samples collected from different sites. These sampling instruments were placed 1.2 to 1.5 m above the floor to simulate the human breathing zone from indoor air (Tang et al., 2009), as nursing station, between patients units and storage room (Tang and Wan, 2013).

b. Inspiration air from mechanical ventilator machines.

Although, different mechanical ventilator machines were selected to be tested, machines connected to patients were tested as the same as not connected (standby), Sterile test lung bag was used to collect inspired air from each MV of the selected sample. Selection was by testing all machines connected to patients and other machines which are standby to receive new patients. General total average were calculated for each unit for evaluation as needed by fitness checklist.

c. Culture media

Nutrient agar plates were used to collect samples for bacterial count, transferred to the laboratory in ice box, incubated for 48 hours at 37^{o}C then growing colony was counting.

Dichloran Rose Bengal Chloramphenicol (DRBC) agar was used to collect samples for fungal count, transferred to the laboratory in ice box and incubated for 5 days at 25^{o}C before counting the grown colonies.

d. Bacterial and Fungal count calculation

The number of growing colony was multiplied by 20 to get results per cubic meters in order to compare with the available stander of Hong Kong.

2. Water samples

Sterile wide mouth glasses bottles (250) ml to collect water sample were used. Thiosulfate Ringer was added to the bottles as policy in Public Health Laboratory in Gaza, this solution is used for neutralization of residual chlorine. Burning of the water tap opening was done to ensure results of pure water out of external contamination.

3. Environmental surfaces samples

Sterile swabs filled with 3 ml of Tryptic soy broth (TSB) were used to swab approximately 10 cm^2 of each environmental spot. Swabs were then incubated overnight at 37^{o}C and tested for turbidity. All samples were cultured on (Blood and MacConkey agars) and incubated overnight at 37^{o}C.

Positive cultures grown on both plates (Blood and MacConkey agars) were submitted to biochemical identification (API 20E), cultures grown only on Blood agar were gram stained. Gram positive cocci isolates were submitted to slide Catalase test (3% H_2O_2 solution). Catalase positive isolates were submitted to tube method Coagulase test.

On the other hand, after get the first result on October, that was significantly horrible. Coordination with infection control committee (ICC) in Shifa hospital was done, because of the strange wide of difference rather than the data they have. The story was in the different technique in which swabs were taken by the researcher and the other technique that regularly have been used by ICC and laboratory of Shifa hospital, and so at the second point of time in November, further samples at the same time and from the same site was swabbed side to side by the researcher and the members of ICC in Shifa. Thus, moistened with normal saline is the way in which ICC usually takes their cultures. And direct culture is the way in which the laboratory routinely cultured their swabs.

2.5 Environmental measurements description and processing

Auto ranging multimeter was used to measure atmospheric temperature and relative humidity in the two units. Readings were collected over a period of one month (October 2012).

Samples are summarized in table (2.2)

Table 2.2: Measurements reading from the two ICUs

No	ICU	Shifa	EGH	Total
1	Temperature measurements (T)	102	156	258
2	Relative humidity measurements(RH)	102	156	258
	Total	204	312	516

Auto ranging multimeter was used to measure atmospheric T & RH in the two units**.** Two to three days from each week along the month was selected to collect measurement readings. Many different point of time were selected to gathering readings as follow: 6 am, 7am, 8 am, 12 MD, 2 pm, 6 pm, 8 pm, 12 MN. Furthermore, many different sites were considered to get measurement from the two ICUs as nursing station, isolation rooms, north, south, west and east sides in both ICUs, also the storage room of each one. Once there was no significant difference in readings among all sites, overall total range for each unit and storage room were calculated.

3. Results and Discussion

The first tool (wake around checklist) is designed to calculate the compliance percentage at the end of the evaluation, simple calculation formula was considered for that aim.

3.1 Application of "Fitness checklist" on Shifa and EGH ICUs

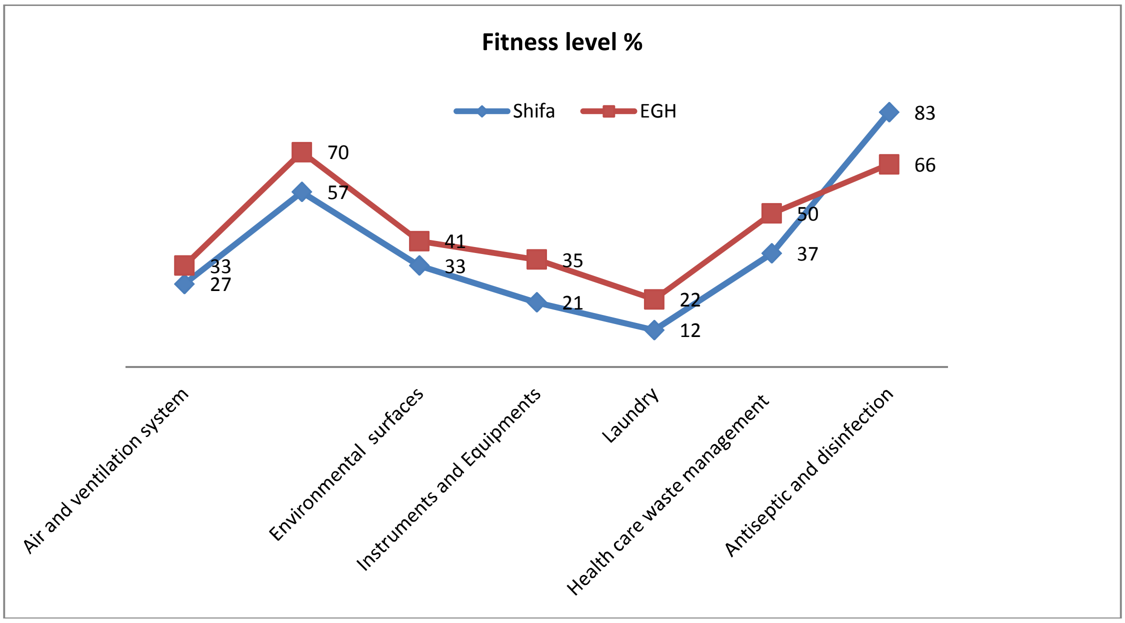

Figure 3.1: Evaluation of the EIC measures in Shifa and EGH

Figure 3.1: shows that in the total evaluation of the environmental safety measures in Shifa and EGH ICU a percentage of 62.3% of the measures in Shifa were unfit. However, a little down percentage in EGH around 53.4%. In detailed, around (72.5, 66.5)% respectively in Shifa and EGH of the domain of air and ventilation system fitness were unfit. Environmental surfaces cleaning (66.4,58.4)%, instruments and equipments cleaning (87.6, 64.3)% and laundry management (87.5, 77.5)% also have a high percentage of incompetent in Shifa and EGH respectively. In contrast, just (42.5, 30)% of the domain of water quality and hand washing facilities were unfit and about (16.6, 33.4)% of the domain of antiseptic and disinfection availability and using were inadequate in Shifa and EGH respectively. While healthcare waste management was in around (37, 50)% of unfitness degree. On the other hand, no significant difference is observed between the two units in all domains, so total average is representative to reflect the result of evaluation fitness. More detailed are clear in the following tables about each domain.

3.1.1 Air and ventilation system

3.1.1.1 Airborne Infectious pathogens in ICUs

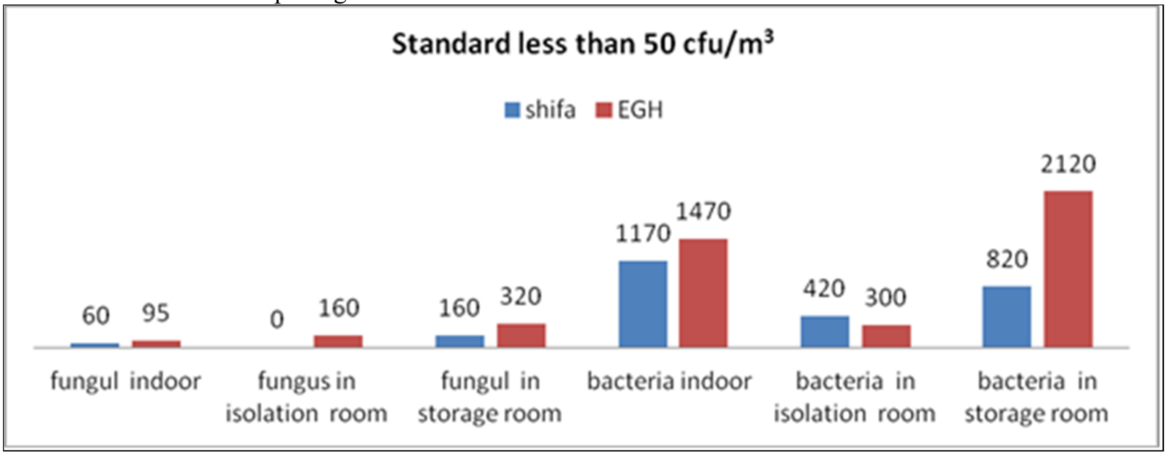

Figure 3.2: Airborne Infectious pathogens in ICUs

Figure 3.2 shows that total bacterial count in indoor air in ICU ranged from (1170 cfu/m^3 to 1470) cfu/m^3 in both ICU. According to Hong Kong indoor air quality management group, the only standard found. Thus the American Federal Standard adopted particulate count for evaluation purposes and didn't mention the microbial count (Charles et al., 2005). The total bacterial count and fungal count in indoor environment of offices and public places shouldn't exceed 500 cfu/m3. In healthcare facilities, the limits should be more restricted; In well ventilated operating theaters, bacterial count shouldn't exceed 50-150 cfu/m3. In comparison with the standard the study reflect a very high counts above standard. The fungal counts are not far from the standards (60-100 cfu/m3). Incompetent air ventilation system in both units could explain the reason for high microbial numbers.

This study inconsistent with a study conducted in a medical ICU in northern Taiwan for 1 year by Chin-Sheng et al., (2009), The peak concentrations of indoor bacteria and fungi were found in June (7236 cfu/m^3 for bacteria and 7807 cfu/m3 for fungi), October (3869 cfu/m3 for bacteria and 5954 cfu/m3 for fungi), and December (2964 cfu/m3 for bacteria and 11,654 cfu/m3for fungi). Approximately 27% of the bacterial samples and 17% of the fungal concentrations exceeded 1000 cfu/m^3 (Chin-Sheng et al., 2009).

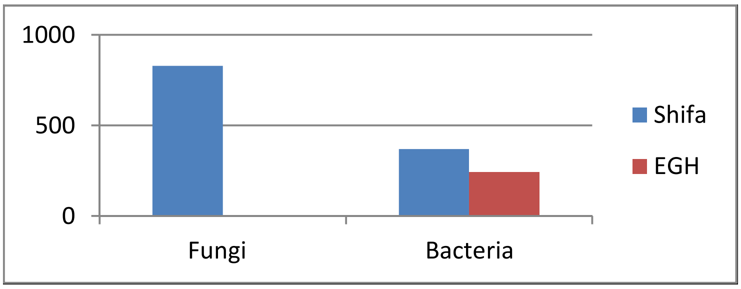

Figure 3.3: Fungal and bacterial count in MVs machines

Furthermore, the study reflect the presence of bacterial count which ranged from 73 to 90 in the inspired air from MVs machines, however, fungal count was 830 cfc/m^3 in Shifa ventilator. In contrast with EGH MVs machines which was free from fungal presence. Therefore, medical gases should be free from microbial load and provided as a sterile gases. This could be explained by the poor maintenance and disinfection system between patients, particularly, if know that there is not specialized person to take care of ventilators after being used for such patient.

3.1.1.2 Heating, Ventilation, and Air Conditioning Systems in ICU

Table 3.1 : Temperature (21- 24)ºC and RH(30-60)% measures

Item	**Finding**							
	Shifa			EGH			Both Total av.	
	Dh	Nh	Av.	Dh	Nh	Av.	Dh	Nh
Temperature average	29.5	25.2	27.3	28.1	24	26.06	28.8	24.6
Temperature average in SR	30	25.7	27.8	28	24	26	29	24.85
Relative Humidity average.	59.5	58	58.7	59.4	57.6	58.54	59.45	57.8
Relative Humidity average in SR	61	59.6	60.3	60.2	60	60.1	60.4	59.8

Dh: Day hours, Nh: Night hours, Av: Average.

Regarding climate temperature table 3.1 shows that temperature average in Shifa ICU was more than (27^{o}C) in both of unite and storage room, measurements was greater than it was in EGH by 1^{o}C. However, both ICUs were far than the upper limit of the standard (21-24)^{o}C in about 2-3^{o}C. Therefore, the temperature level average during day hours was significantly greater far than the standers in about 4.8^{0}C, thus, temperature range was 28.8^{o}C during day hours and around 24.6^{o}C during night hours.
On the other hand, relative humidity level was clearly above the standard in Shifa ICU storage room, otherwise, the condition in both units were at the high limit of the standards nearly 60%.
The result of this study was better than the study conducted in a medical ICU in northern Taiwan for 1 year by Chin-Sheng et al., (2009) in term of relative humidity, but worse in term of air temperature. It was investigated the impact of patient visiting activities on the indoor climate in the medical ICU. A 4-bed room with patients in the medical ICU was selected for long-term air monitoring of air temperature and relative humidity. The result concluded as, air temperature ranged from 21.28^{o}C to 25.88^{o}C, relative humidity ranged from 58% to 74% (Chin-Sheng et al., 2009).
Temperature should be maintained between 20°C and 24°C and humidity between 30% and 60% to inhibit bacterial multiplication (WHO, 2003) and American Institute of Architect (AIA), 2001. Heating, ventilation, and air conditioning systems in health-care facilities are designed to maintain the indoor air temperature and humidity at comfortable levels for staff, patients, and visitors; control odors; remove contaminated air; facilitate air-handling requirements to protect susceptible staff and patients from airborne health-care–associated pathogens; and minimize the risk for transmission of airborne pathogens from infected patients. Decreased performance of healthcare facility systems, filter inefficiencies, improper installation, and poor maintenance can contribute to the spread of health-care–associated airborne infections (WHO, 2004).

3.1.1.3 Ventilation, Filtration and Pressurization

HEPA (High efficiency particulate air) filters are available in both ICUs. However, its high efficiency and number of air changed per hour seems to be incompetent, because of the microbial results of air sampling as shown in figure (3.2). In addition, there is two isolation room in the in EGH ICU in opposition with Shifa ICU which has just one isolation room.

3.1.2 Water quality and Hand washing

Count of total and fecal coliform in tap water, drinking water in both ICUs were negative after twice culturing from the two units. Although, water in ventilator heated humidifier was positive culture for presence of pathogenic bacteria in both ICUs. However, sterile water was used in EGH ICU in opposition with Shifa ICU which use tap water "against the standard". Therefore, the water source is not the cause of infection in the ventilator heated humidifier, most likely the cause is improper disinfection for the humidifiers between patients.

3.1.2.1 Hand washing facilities

Elbow operated mixer tap were available in the sinks in Shifa ICU, but not in EGH ICU. However, Hand rub was not available in area wherein hand washing sink is not accessible in both ICUs according to WHO recommendations.

3.1.3 Environmental surfaces

Many previous studies confirm the importance of pre-enrichment for recovery of environmental contaminants (Landers et al., 2010). Using of moistened swab with a broth media as pre-enrichment media, will find out truthfully pathogenic bacteria in environmental inanimate surfaces. Therefore, pre-enrichment of swabs in tryptic soy broth (TSB) were done by the researcher for 24 hours then cultured on Blood and MacConkey agars according to literature recommendations, as it is one of the alternative of enrichment media listed by the CDC (2005).
Environmental surfaces cleaning have a high percentage of incompetent (62%), with no significant difference was observed between the two units. There is an increasing body of evidence that cleaning or disinfection of the environment can reduce transmission of healthcare-associated pathogens (Boyce, 2007). On the other hand, standard cleaning procedures have been proved to be not enough for full eradication of HAI pathogens (French et al., 2004). Improved methods of disinfecting the hospital environment are needed (Byers et al., 1998). Moreover, cleanliness is not enough to assure effective removal of pathogens and visual assessment is not a reliable indicator of surface cleanliness or of cleaning efficacy (Cooper et al., 2007). Nursing counter, telephone, the walls, ceiling (condition vent), water tap, sinks, toilet (water tap), toilet (siphon hand), clean linens, mattresses, pillows, bed frames and HCP uniform all of these surfaces were swabbed for culture.

3.1.4 Instruments and Equipments cleaning

Blood gas analyzers, dressing sets, central line sets, monitors keyboard and cables, resuscitation equipments

(Ambu bag, Ambu mask, heated humidifier, laryngoscope, patient unit, infusion pumps, syringe pumps, oxygen humidifier, ventilator, irrigation bottle after suctioning all of these subjects were swabbed for culture.

3.1.4.1 Swab culture results

Table 3.2 : Bacterial finding results in ICUs by use of TSB

	Shifa hospital		EGH	
Bacteria	Frequency	Percentage	Frequency	Percentage
Pseudomonas	15	48.4	9	29
E-coli	11	35.4	9	29
klebsilla	4	12.9	6	19.3
Staph arues	0	0.00	5	16.1
Total of positive	**30**	**96.6**	**29**	**93.7**
Negative culture + *Staph*	3	9.7	3	9.7
Total	**33**	**106.3**	**32**	**103.4**

Table 3.2 shows that *Pseudomonas* nearly 48.4% at Shifa ICU is the highest percentage of bacterial finding in the environmental surfaces and" Instruments and Equipments" followed by *E-coli* about 35.4% and then *Klebsilla* around 12.9%. however, *Staph arues* was significantly observed in EGH ICU around 16% with complete absents in Shifa ICU during the study. On the other hand, both *Pseudomonas and E-coli* were the highest percentage of bacterial finding in the environmental surfaces and "instruments and equipments" in EGH ICU in percentage of 29% of all studded cultures, followed by *Klebsilla* about 19.3% and then *Staph arues*. Another note in the table that the total percentage is mor than 100%, mostly because some of the swabs represent more than one type of bacteria.

In summary, 96.6%, 93.7% of all the swabbed cultures in Shifa ICU and EGH ICU respectively were positive. Therefore, improved methods of disinfecting the hospital environment are needed.

Moreover, the same swabs were taken at the same time and from the same site by the researcher and the members of ICC in Shifa hospital. However, the results were significantly different, thus just 27% of the samples were positive as shown in table 3.2. As a result of this experiment, using of moistened swab with a broth media as pre-enrichment media, will find out truthfully pathogenic bacteria.

Figure 3.4 : *Pseudomonas* on Blood and Makconcy agar media

Figure 3.5 : Fungus on DRBC agar from indoor air

Therefore, when pre-enrichment of swabs in tryptic soy broth (TSB) were done by the researcher for 24 hours then cultured on Blood and MacConkey agars mostly all of environmental inanimate surfaces swabs were positive (96%).

Figure 3.6 : Fungus in addition to Bacteria on Nutrient media from MVs inspiratory air

Table 3.3 : Bacterial finding results in ICU by use of Normal Saline and direct culture

Bacteria	Shifa hospital	
	Frequency	Percentages%
Acintobacter	2	6.1
Enterobacter	1	3.05
Bacillus	2	6.1
Dephteroids	2	6.1
***Staph* spp**	2	6.1
Total of positive	**9**	**27.45**
Negative culture + *Staph*	25	75.75
Total	**33**	**103.2**

Table 3.3 shows that, just 27% of the samples were positive by the routinely used technique in which Shifa ICC usually takes their cultures. And direct culture is the way in which the laboratory routinely cultured their swabs. It is important to mention that the routinely used technique in Shifa is the same in all Gaza hospitals related to the Palestinian Ministry of Health (MOH).
This finding support the pre-enrichment method over the direct culture on solid agars to avoid overlooking potential pathogens which exist in low numbers but still impose risk. Using of pre-enrichment media was mentioned by other studies (Landers et al., 2010) and (CDC, 2003).

3.1.5 Laundry handling facilities
Laundry management in total have a high percentage of incompetent around 82%. Nearly 87% in Shifa ICU and 77% in EGH ICU. Special bags were available for dirty linen in EGH ICU, but not in Shifa ICU. Bed mattress and pillows were not covered with moisture-resistant cover.
Regarding HCPs uniform, Ideally clean uniforms should be worn each shift, and not worn outside the unit. ICUs need adequate supplies to ensure everyone have clean uniforms each shift. However, swab cultures results of two different nurses and doctors in each ICUs in different point of time were contaminated with pathogenic bacteria. In addition, it is tormentor if knowing that all HCPs have to wash their own suit at their homes, because no laundry facilities available for them.
3.1.6 Healthcare waste
Health care waste management was in around 55% of unfitness degree. Nearly 60% in Shifa ICU and 50% in EGH ICU. Correct segregation of waste: domestic, infectious, and cytotoxic were not done neither in Shifa nor EGH ICU. The three colored or labeled bags for segregation of waste were not available also. Waste bag were not disposed of at 2/3 full in both units, but complete full, "against standards", that the risk of infection spreading is consider because of improper tight closing of the bags. On the other hand, persons handling wastes did not wear heavy gloves & closed shoes in both units. However, sharp containers were not properly sealed prior to disposal, and sharp boxes were not less than 3/4 full before disposing in Shifa ICU. In contrast, all items of sharp disposal in EGH ICU were positive.

Figure 3.8: HCW handling wastes in ICU

Figure 3.9: full Sharp box not less than 3/4 full

3.1.**7** Antiseptic and disinfection

However, most of the nurses instruct the cleaner to clean and disinfect soiled bottle of suctioning procedures before reuse under their supervision, all of the swabs cultures post disinfectant were positive. The proved reason was time factor, as bottles were soaked in the available chlorine disinfectant for just moments, against the CDC, 2008 recommendations for disinfectant use.

So simple trial was done by the researcher compared by swab culture results, between the previous act and the correct soaking time in the same usually available chlorine disinfectant and the same concentration. In fact, 10 minutes soaking as CDC, 2008 recommendations for disinfectant use, was enough to have negative bacterial culture results.

4. Conclusions and Recommendations

4.1 Conclusions

The study revealed that there is a percentage of 62% of the measures in Shifa were unfit. However, a little down percentage in EGH around 53%. In some details, the total bacteria count in indoor air in ICU ranged from (1170 cfu/m^3 to 1470) cfu/m^3 in both ICUs, however bacterial count shouldn't exceed 50-150 cfu/m3 According to Hong Kong indoor air quality management group. Moreover, the study reflect the presence of bacterial count which ranged from 73 to 90 in the inspired air from MVs machines, however, fungal count was 830 cfu/m^3 in Shifa ventilator, in contrast with EGH MVs which was free from fungal presence. Regarding climate temperature, the level average during day hours was significantly greater far than the standers in about 4.8^{o}C.

4.2 Recommendations

Regular maintenance of HEPA filters is required, in order to evaluate the efficiency of the filters against pathogenic microbes and to detect the exactly number of total air change. Urgent coordination with medical equipment engineering department to solve the problem in MVs machines. Palestinian IPC should to be updated to include standards about air and ventilation system, particularly bacterial and fungal count in indoor air. Also standards for climate T and RH average in ICUs is necessary. The study finding support the pre-enrichment method over the dry direct culture on solid agars to avoid overlooking potential pathogens.

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