

Device-Associated Healthcare-Associated Infections (DA-HAIs) in Kuwait adult ICUs: A Multi-Center Study

Wafaa Hamza¹, Esam Hamed², Kafya Akroof³, Sabry Al Raghi⁴

¹Infection Control Directorate, Ministry of Health, Kuwait
Department of Public Health and Community Medicine, Faculty of Medicine, Assiut University, Egypt

²Department of Anesthesia and ICU, Faculty of Medicine, Assiut University, Egypt

^{3,4}Infection Control Directorate, Ministry of Health, Kuwait

Abstract: ***Background:** Device-associated (DA) health care– associated infection (HAI) surveillance in the intensive care unit (ICU) has an important role in hospital infection control and quality assurance. **Methods:** A retrospective study for analysis of ICU surveillance data collected from the monthly surveillance records of the year 2012 from three adult medical surgical ICUs in 3 general hospitals affiliated with Kuwait Ministry of Health. DA-HAIs were identified using the Centers for Disease Control and Prevention National Health surveillance definitions (CDC NHS). **Results:** Overall incidence rate of DA-HAIs was 19.8 per 1,000 ICU-days. The rates of ventilator associated pneumonia (VAP), central line associated blood stream infection (CLABSI), and catheter associated urinary tract infection (CAUTI) were 12.2, 4.3 and 3.9 per 1,000 device-days, respectively. The device utilization ratio (DURs) for mechanical ventilation, central line catheter, and urinary catheter was 0.61, 0.76, and 0.92, respectively. The overall average length of stay (ALOS) 9.1 days in the studied ICUs. *Acinetobacter spp* (26.1%), *pseudomonas aeruginosa* (16.0 %), *Candida spp* (15.1%), and *Klebsiella spp* (11.7%) were the common isolated pathogens. 42% of the bacterial isolate associated with DA-HAIs were found to have multidrug-resistant. **Conclusion:** Device-associated infections in ICUs represent a significant risk to patient health. Infection control surveillance and implementation of evidence based bundled guidelines for prevention can improve patient outcome.*

Keywords: Central line– associated bloodstream infection; Ventilator-associated pneumonia; Catheter-associated urinary tract infection, Device utilization ratio and Average length of stay

1. Introduction

Healthcare-associated infection (HAI) is one of the common adverse events affecting patients in intensive care units (ICUs). Rates of HAIs in the ICU are 3 to 5 times higher than those in other healthcare areas in the hospital [1], [2]. Although patients in the ICU represent only 10% of all hospital admissions, they account for nearly 50% of all HAIs in US hospitals [3], [4], [5].

In the high income countries, device-associated (DA) health care-associated infection (HAI) surveillance in ICU plays an important role in hospital infection control [6]. Similarly, surveillance was reported by the Centers for Disease Control and prevention's (CDC) study of the efficiency of nosocomial infection control as an well-organized tool to reduce DA-HAIs [7]. In literature, DA-HAIs are considered the major threat to patient safety in the ICU and are among the main causes of patient morbidity and mortality [8], [9], [10].

The CDC's National Nosocomial Infection Surveillance System and National Healthcare Safety Network (NHSN) have promulgated standardized criteria for DA-HAI surveillance [11]. This standardized surveillance method allows for the determination of DA-HAI rates per 1,000 device-days, equivalent among healthcare centers, and provides infection control practitioners (ICPs) with a detailed picture of the institutional problems that they face, allowing them to invent an effective strategy to improve

them. The device utilization (DU) ratio establishes an extrinsic risk factor for DA-HAIs [12]. The DU ratio also comprises a scale for the severity of illness in patients in relation to patient predisposition to DA-HAI. In the context of an expanded framework for DA-HAI control, it is in high-income countries that most of the relevant studies of ICU-acquired infections have been conducted [13].

The study aimed to analyse the incidence of DAIs, measure device utilization ratio (DU) and length of stay (LOS), and evaluate microbiological profiles, bacterial resistance, in 3 adult ICUs of 3 general hospitals in Kuwait.

2. Patients and Methods

2.1 Study Design

An epidemiological retrospective study for analysis of ICU surveillance data collected from the monthly surveillance of the year 2012.

2.2 Settings

Three adult medical/ surgical ICUs “ICU A (15) beds, ICU B (15) beds and ICU C (11) beds” located in 3 general hospitals that are affiliated by Kuwait Ministry of Health ;Ameri, Farwania, and Jahra hospitals respectively. The ICU nurse to patient ratio was one to one most of the time. Each ICU has a minimum sink/bed ratio one to four. Infection control team provides support with daily rounds. All the

hospitals analyzed the samples in their own microbiology laboratories which provided in-vitro susceptibility testing of clinical isolates using standardized methods.

2.3 Data Collection

Data was collected by the infection control team in each hospital through their ongoing surveillance. Each hospital has one full-time infection control physician and several infection control nurses based on hospital's bed capacity. The infection control nurses are all professionals and work fulltime, they collected data on central line-associated bloodstream infections (CLABSIs), catheter-associated urinary tract infections (CAUTIs), and ventilator-associated pneumonias (VAPs) for all patients hospitalized in ICUs during the surveillance period. A standardized survey forms of Kuwait National Health Surveillance System (KNHSS) adopted from CDC/NHSN were used. Infection control team reviewed microbiology reports, X-ray, other diagnostic test reports, patient charts for signs and symptoms, as well as nurses and physician notes. Kuwait Ministry of Health Standing Committee for the Coordination of Health and Medical Research approved the study protocol, and confidentiality was protected.

2.4 Operational Definitions

All definitions of DA-HAIs were based on CDC/NHSN surveillance definition of healthcare-associated infection [11].

2.4.1 Ventilator-associated pneumonia is indicated in a mechanically ventilated patient with a chest radiograph that shows new or progressive infiltrates, consolidation, cavitation, or pneumatocele. At least one of the following ; fever $>38^{\circ}\text{C}$, leucocytosis >12000 or leucopenia <4000 or altered mental status with no other cause in patients >70 years old. The patient must also have at least 1 of the following criteria: new onset of purulent sputum or change in character of sputum; organism cultured from blood; or isolation of an etiologic agent from a specimen obtained by tracheal aspirate, bronchial brushing or broncho-alveolar lavage, or biopsy. Identifying of 2 of the the above mentioned criteria in addition to xray pneumonic finding was considered as clinically diagnosed pneumonia.

2.4.2 Central line-associated blood stream infection is laboratory confirmed when a patient with a central venous catheter (CVC) has a recognized pathogen that is isolated from 1 or more percutaneous blood cultures after 48 hours of central line insertion and is not related to an infection at another site. With skin commensals (for example, diphtheroids, *Bacillus* spp., *Propionibacterium* spp., coagulase-negative staphylococci, or micrococci), the organism is cultured from 2 or more blood cultures were collected within 2 days of each other. The patient also has at least 1 of the following signs or symptoms: fever (temperature 38°C), chills, or hypotension.

2.4.3 Catheter-associated urinary tract infection, the patient must meet 1 of 2 criteria. The first criterion is when a patient with a urinary catheter has 1 or more of the following symptoms with no other recognized cause: fever

(temperature 38°C), urgency, or suprapubic tenderness. The urine culture is positive for 10^5 colony forming units per mL or more, with no more than 2 microorganisms isolated. The second criterion is when a patient with a urinary catheter has at least 2 of the following criteria with no other recognized cause: positive dipstick analysis for leukocyte esterase or nitrate, pyuria (10 leukocytes per mL of urine), organisms seen on Gram stain, physician diagnosis of urinary tract infection, or the physician initiates therapy for urinary tract infection.

2.5 The measured outcomes included:

2.5.1 The rate of DA-HAIs :

- (a) Ventilator-associated pneumonia (VAP)
- (b) Central line-associated bloodstream infections (CLABSI)
- (c) Catheter-associated urinary tract infections (CAUTI) per 1,000 device-days.

The rates of VAP, CLABSI, and CAUTI per 1,000 device-days were calculated by dividing the total number of DA-HAIs by the total number of specific device-days and multiplying the result by 1,000 [14].

2.5.2 Device utilization (DU) ratios was calculated by dividing the total number of device-days by the total number of patient-days. Device-days are the total number of days of exposure to the device (ventilator, central line, or urinary catheter) for all of the patients in the selected population during the selected time period. Patient-days are the total number of days that patients are in an ICU during the selected time period [14].

2.5.3 Average Length of stay (ALOS) was also calculated by adding number of previous days in ICU for these patients in the first day of each month plus number of patients every month plus number of previous days for these patients in the first day of next month divided by number of patients in ICU in the first day of each month plus number of new arrivals of patients.

2.6 Laboratory Testing and Culture techniques

2.6.1 VAP In most cases, a deep tracheal aspirate from the endotracheal tube was cultured aerobically and Gram stained.

2.6.2 CLABSI blood cultures were drawn percutaneously from all patients and cultured using a standardized semiquantitative method [15].

2.6.3 CAUTI a urine sample was aseptically collected from the the urinary catheter port and cultured quantitatively. For all samples standard laboratory methods for identification and susceptibility test was performed [16].

In all the cases, standard laboratory methods were used to identify microorganisms. Antimicrobial susceptibilities were determined by disk diffusion method and an automated method (bioMerieux, Vitek II).

2.7 Data analysis

Data was coded, entered and analyzed using the SPSS version 18 for Windows (SPSS Inc, Chicago, IL). Simple descriptive measures were used (mean ± standard deviation for quantitative variables and frequency with percentage distribution for qualitative variables).

3. Results

During the 12 months period of the study, surveillance data was collected from 1791 patients hospitalized in the 3 adult medical/ surgical ICUs and acquired 229 HAIs for a total of 11562 ICU-days, 413 patients hospitalized in ICU (A) for 2288 days, and 602 patients hospitalized in ICU (B) for 5187 days and 776 patients hospitalized for 4087 days in ICU (C). The overall healthcare associated infection rate was 19.8 per 1,000 ICU-days (Table 1).

3.1 Healthcare associated –Device associated infections in the studied ICUs

Healthcare associated infections were distributed by means of; VAP represented 37.6 % , CAUTI represented 18.3%, CLABSI represented 16.6% and 27.5 % were SSI and other infections combined from all ICUs. Rates of ventilator-associated pneumonia varied among the studied ICUs from 5.8 - 23.2 per 1000 ventilator days, with pooled mean rate of 12.2 per 1,000 mechanical ventilation-days (95% CI, 5.8–18.6),. CLABSI rates ranged from 2.8- 4.8 with pooled mean rate of 4.3/ per 1,000 central line days (95% CI, 3.0–5.6), , all cases were laboratory-confirmed blood stream infections. CAUTI rates ranged from 1.5- 8.8 with pooled mean rate of 3.9 per 1,000 urinary catheter days (95% CI, 1.6–6.1) (Table 1).

Table 1: Distribution of Device Associated Infections In The 3 Studied ICUs

Device Associated infections 2012	Pt N	ICU days	CL Days	CLA BSI Rate	VAP	MV days	VAP Rate	CA UT I	UC days	CA UTI Rate	SSI	OTH	TOTAL	
				95% CI			95% CI			95% CI				
ICU-A	413	2288	10	2083	4.8	15	949	15.8	19	2183	8.8	3	24	71
ICU-B	602	5187	22	4583	4.8	13	3611	3.6	7	4666	1.5	1	7	50
ICU-C	776	4087	6	2142	2.8	58	2500	23.2	16	3902	4.1	11	17	108
Overall	1791	11562	38	8808	4.3 (3.0-5.6)	86	7060	12.2 (5.8-18.6)	42	10751	3.9 (1.6-6.1)	15	48	229

3.2 Demographic characteristics of the cases

Among the studied patients of DA-HAIs; males represent 43.4 % , females were 56.4% , mean age ± SD was 51.6± 2.02 years , the cause of ICU admission was medical conditions in 74.7% and surgical conditions in 25.3% (Table 2).

3.3 Variation in device use and ALOS:

It was varied; for mechanical ventilation utilization ranged from 0.42- 0.7 (overall, 0.61) ; for central lines use ranged from 0.55- 0.92 (overall, 0.76),and urinary catheter utilization ranged from 0.90- 0.95 (overall, 0.92) (Table 2 and figure 1). Average Length Of Stay (ALOS): ranged from 7.5- 11.8 days (pooled mean of 9.1 days). Trend of monthly devices utilization ratio in the studied ICUs (Table 2).

Table 2: Patients Characteristics , Device Utilization and Average Length Of Stay In The Studied ICUs

Variables	ICU-A	ICU-B	ICU-C	Overall
Male	31.8 %	33.7%	55%	43.4
Female	68.2%	66.3%	45%	56.4
Mean age	51 ±2.1 Y	51.9 ±1.9 Y	51.2±2.1 Y	51.6± 2.02 Y
Admission was Medical	75%	77.3%	73.8%	74.7%
Admission was Surgical	25%	22.7%	26.2%	25.3%
MV utilization	0.42	0.70	0.64	0.61
CL utilization	0.92	0.89	0.55	0.76
UC utilization	0.95	0.90	0.93	0.92
ALOS	8 days	11.8 days	7.5 days	9.1 days

MV Mechanical Ventilation, CL Central Line, UC Urinary Catheter, ALOS Average Length Of Stay

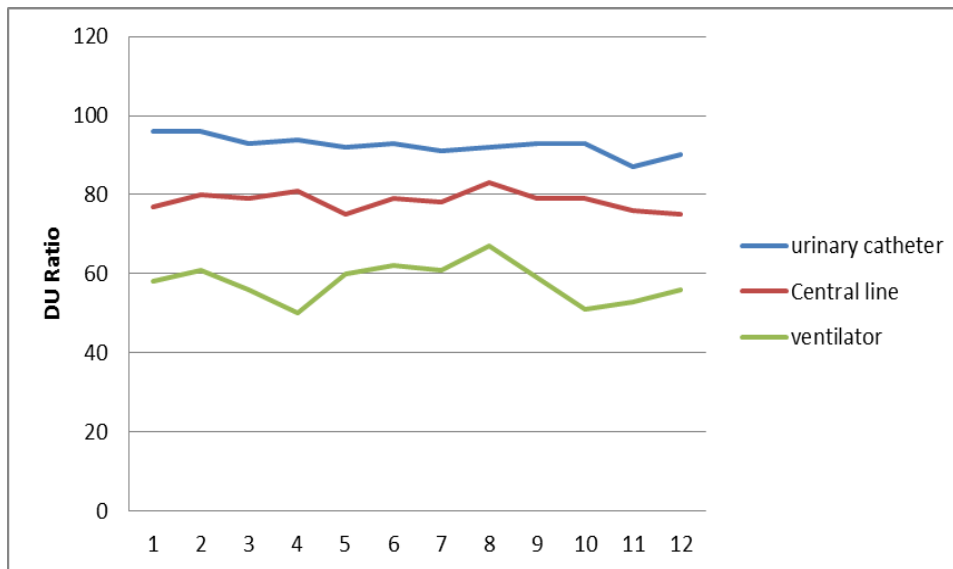


Figure 1: Trend of Monthly Devices utilization ratio in the studied ICUs

3.4 Microorganism profile and bacterial resistance

181 pathogen isolated from 166 DA- HAIs , 22 (13.3%) of the DA-HAIs were polymicrobial, 26.1 % of all DA-HAIs were caused by *Acinetobacter* spp, 83.7% of which were multidrug resistant (MDRO), 16.0 % were caused by *Pseudomonas* spp, 41.6% of which were (MDRO); 13.3% caused by *Candida* spp, 11.7% caused by *Klebsiella* spp; 63.6 % of which were extended spectrum β -lactamase

producers (ESBL), 5.9% by *Staphylococcus Aureus*; 63.6 % of which were methicilin-resistant *Staphylococcus Aureus* (MRSA), 5.9% by *Enterococcus* spp; 9% of which were VRE, 4.8% by *Stenotrophomonas* spp; 44.4 % were MDRO, 3.7 % (7 cases) culture not done as they were clinically diagnosed VAP, 2.7 % of infections caused by *Escherichia coli*; 40 % were (ESBL), 2.7% by *Enterobacter cloacae*; 40% MDRO, 2.7 % by *Serratia marcescens*, and 2.1% by *coagulase-negative staphylococci* (Table 3).

Table 3: Microorganism profile and bacterial resistance of DA-HAI In The Studied ICUs

Microorganism related to DA-HAI	MDRO (n =) %		CLABSI related (n =)	VAP related (n =)	CAUTI Related (n =)	Overall (n =) %	
	Acinetobacter Baumannii	41				83.7	11
Stenotrophomonus	4	44.4	4	4	1	9	4.8
Staphylococcus aureus	7	63.6	6	3	2	11	5.9
Coagulase-negative Staphylococcus	0	-	2	1	1	4	2.1
Klebseilla spp	14	63.6	7	9	6	22	11.7
Pseudomonas spp	8	26.7	6	19	5	30	16.0
Serratia marcescens	0	-	3	1	1	5	2.7
Enterococcus faecalis	1	9	4	3	4	11	5.9
Enterobacter cloacae	0	-	1	0	4	5	2.7
Candida spp	0	-	4	7	14	25	13.3
Escherichia coli	2	40	2	1	2	5	2.7
Strept cocci	0	-	0	2	0	2	1.1
Aspergrilus	0	-	0	1	0	1	.5
Berkholderia	0	-	0	1	0	1	.5
Proteus mirabilis	0	-	0	1	0	1	.5
Culture not done Clinically diagnosed -VAP	-	-	-	8	-	7	3.7

4. Discussion

The risk of infection among hospitalized ICU patients represents a substantial health problem in this group of patients who are already significantly ill. We believe that the influence of this problem can be reduced though the application of a targeted surveillance for DA-HAI. It gives a valuable disclose to the features of the burden of DA-HAIs that can be highly beneficial in adapting a plan to approach the resolution of the problem. The current study measured the baseline DA- HAIs in 3 adult medical surgical ICUs

before implementing the evidence based bundles of care in these ICUs.

We reported an overall rate of 19.8 per 1,000 device days and the most common DA-HAI was VAP 12.2 per 1000 ventilator days, while CLABSI rate was 4.3 per 1000 central line days. These findings are equivalent to the results of a study conducted on 3 adult ICUs in Malaysia [17]. CLABSI and CAUTI rates in the current study were lower than the international Nosocomial infection control consortium (INICC) rate in medical-surgical ICUs of 7.6 and 6.3 per 1,000 device days respectively[18] A similar findings were

reported in a study of DA-HAI in 3 Greek ICUs as well as in a study of 3 adult ICUs in Egypt [19], [20].

In the current study VAP represented 37.6 %, CAUTI represented 18.3, CLABSI represented 16.6% while 27.5 % of ICU recorded infections were attributable to Surgical site infection (SSI) and other infections. These findings might be justified in part by the variability exemplified in the level of practices during utilization of these devices in terms of abiding to the sterilization roles during initial use and subsequent care, on the other hand the level of immunity jeopardy of the patient might have a role as well but this is not in the spectrum of this work.

Rosenthal et al., 2006 in their study of device-associated nosocomial infections conducted in 55 ICUs in 8 developing countries reported an overall rate of 22.5 infections per 1000 ICU days. Ventilator-associated pneumonia (VAP) recorded as the highest rate (41% of all device-associated infections or 24.1 cases, followed by central venous catheter (CVC) related bloodstream infections (30% of all device-associated infections or 12.5 cases and catheter-associated urinary tract infections (CAUTI) (29% of all device-associated infections or 8.9 cases [21]. In a another study conducted in multiple ICUs in Philippines they reported lower overall rate (12.2) DA-HAIs per 1,000 ICU-days; VAP represented 67.2% followed by CAUTI 22.4% then CLABSI 10.4% [22].

A 10-years study in 40 Indian hospitals showed VAP, CLABSI, and CAUTI rates are comparable to the present study findings (9.4, 5.1, and 2.1 respectively) and this report was similar to the one revealed by an Iranian study and a multicentre Turkish study [23], [24], [25]. In a Brazilian hospital, device associated infection; rates were comparable to the current study and to a multicentre study in Mongolian hospitals [26], [27].

DA-HAI rates recorded in this study could partially be attributed to the lack of adherence to the infection control guidelines on specific related practices, despite the availability and implementation of a national infection prevention and control program in place. This findings could also be explained by the fact that the majority of patients included in the study were experiencing available levels of severity and compromise in their immunity due to their illness.

Device utilization ratio (DUR) poses an indicator for the risk of DA-HAI and can serve as an alarming sign for the severity of illness the patients are experiencing in addition to their basic hypothetical susceptibility to develop infection. The recorded DURs were classified as; mechanical ventilation (overall, 0.61), central lines (overall, 0.76), and urinary catheters (overall, 0.92). Although of the lower mean DUR of mechanical ventilation by about 30% compared to DUR of urinary catheterization in the study; the estimated VAP rate was about three times the recorded CAUTI rate which mean that there are other risk factors different from DURs to justify these DA-HAI rates.

The records regarding DURs reported in this study were higher than those of the study conducted by Rosenthal, et al, 2006 as they revealed figures for mechanical ventilation;

(overall, 0.38), CVCs; (overall, 0.54), and urinary catheters; (overall, 0.73) [21]. A comparable finding were reported in a study took place in a respiratory ICU [28]. On the other hand the DUR was described from adult medical / surgical ICUs in 3 university affiliated hospitals in Greece as 0.95 for mechanical ventilation, 0.94 for central venous catheters, and 0.95 for urinary catheters [19].

The high DURs recorded in the current study compared with the rates reported by the CDC's NHSN may represent the liability of HAIs in high-income countries. Device utilization was the risk factor for acquiring VAP, CLABSI, and CAUTI. The extent of DUR in our ICUs may require further analysis. The use of non invasive methods of ventilation and earlier elimination of invasive devices should be encouraged. Reducing device utilization and implementing the care bundles, will probably lead to the reduction in the burden of DA-HAIs and improvement in the quality of care and patient safety in ICUs.

Average Length Of Stay in ICU (ALOS) in the current study ranged from 7.5 to 11.8 days (average value of 9.1 days), this figure is less than what was reported by Eleni et al., 2013 who estimated a median ICU length of stay as 14 days. Another study related to DA-HAIs in ICU in Morocco measured ALOS for patients with DA-HAIs; it ranged from 9.0 to 13.7 days (average 11.1 days) which is comparable to the present study and to other similar study took place in Cuban university hospitals. DA-HAI and consequent prolonged hospital stay reflect an extra burden on the ICUs as well as the healthcare services [29], [30].

In this study *Acinetobacter baumannii* was the most common isolated causative microorganism (26.1%) for DA-HAI followed by *Pseudomonas aeruginosa* (16%), candida spp (13.3%), then *Klebsiella* spp (11.7%), while polymicrobial organisms represented 13.3%. The rate of MDRO among the above mentioned common isolated bacteria was 83.7%, 41.6 % 63.6 % respectively. These finding are in agreement with the results of the studies conducted in Greek and in Egypt [19], [20], [21]. This findings illustrate that Gram-negative bacteria was recorded the most. Control of antibiotic resistance requires application of more strict antimicrobial stewardship in the treatment of DA-HAIs.

Acinetobacter baumannii exhibited the highest level of bacterial resistance among the bacteria when tested for specific antimicrobial sensitivity. Similar finding was recorded in a Brazilian study [31]. As this bacterium was isolated frequently in mixed type of infections, this increased level of resistance could be furtherly clarified by the attainment of resistance genes from other bacteria.

The most frequent pathogen we isolated from VAP and CABSI was *Acinetobacter baumannii* while Candida spp was the commonest isolated pathogen in CAUTI. These findings are consistent with results of previous studies in Egypt, Turkey, and Greek [20], [32], [19].

This study disclosed high rate of drug resistance among gram negative and gram positive organisms is in agreement with other studies [33] , [22] , [34]. This high antibiotic

resistance rates could indicate excessive and irrational use of antimicrobial agents. This finding might also be attributed to the deficiency of an appropriate policy and guideline to control antibiotic use, nevertheless highlights the importance of strict implementation of the antimicrobial stewardship.

5. Conclusion

Device-associated infections in ICUs represent a significant risk to patient health. Infection control surveillance and implementation of evidence based bundled guidelines for prevention can improve patient outcome.

6. Recommendation

Provide healthcare experts with simple, inexpensive, nevertheless efficient, preventive approaches are important to improve the adherence to the infection prevention and control practices and to address DA-HAIs burden successfully by accomplishing a reduction in infection rates and their adverse effects.

7. Study Limitation

With data collected from a comprehensive surveillance in 3 ICUs for one year, we do not consider our data to be adequate in representing the entire country.

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Author Profile

Dr. Wafaa S. Hamza, received MBBCh degree of medicine and surgery from Assiut University, Faculty of Medicine, Assiut , Egypt, 1992 and Master degree in Public Health from same university in 2000. Worked as volunteer researcher in Carolina Population Center in 2001. Received PhD in Public Health and Community Medicine from faculty of Medicine Assiut university 2009. Worked as lecturer of public health in teaching and research. Joined Kuwait Ministry of Health , Infection Control Directorate and work as infection control senior specialist.