

ORIGINAL ARTICLE

Assessment of Device-associated Infection and Compliance of Healthcare Workers to Infection Prevention and Control standards at Burn ICU Unit of Ain Shams University Hospital

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ABSTRACT

Key words:

Surveillance, Device associated-infection, CLABSI, VAP and CAUTI, Prevention bundles, Burn ICU

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Background: Burn victims are susceptible to infections due to altered immune response and loss of skin integrity. Burn ICU patients are particularly susceptible to device-associated infections such as catheter-associated urinary tract infections (CAUTI), central line-associated blood stream infections (CLABSI), and ventilator-associated pneumonia (VAP). The importance of prevention, and surveillance for these infections has been well established. **Objectives:** This study aimed to determine the incidence rates of device-associated infections in the Burn ICU of Ain Shams University Hospital together with assessment of compliance of healthcare workers to preventive bundles for VAP, CLABSI and CAUTI. **Methodology:** Prospective surveillance for device-associated infection was conducted in Burn ICU at Ain Shams University Hospitals between June 2022 to November 2022. The rates of VAP, CAUTI, and (CLABSI) were calculated following CDC definitions. Compliance to preventive bundles for VAP, CLABSI and CAUTI were measured using observation checklists. **Results:** CLABSI had the highest incidence (46.9/1,000 central line days) compared with VAP (44.4/1,000 ventilator days) and CAUTI (11.6/1,000 urinary catheter days). Compliance to VAP preventive bundle was the highest among healthcare workers; 96%. Compliance to CAUTI preventive bundle was 91.8% and 93% for insertion and maintenance bundles respectively. Compliance to insertion and maintenance bundles of central line preventive bundle were the least (51% and 54%, respectively). **Conclusion:** CLABSI was the most common infection among Burn ICU patients. This could be attributed to poor compliance to prevention bundles. Therefore, educational strategies should focus on prevention of this life-threatening infection.

INTRODUCTION

Healthcare-associated infections (HAIs) affect lots of burn patients all over the world leading to huge avoidable health costs and problems. The incidence of HAIs in intensive care unit (ICU) is two to three times greater in low- and middle-income countries compared to high-income countries. Also, the use of devices is much more¹. The most commonly reported device-associated infections include central line-associated bloodstream infection (CLABSI), ventilator-associated pneumonia (VAP) and catheter-associated urinary tract infection (CAUTI)². According to a meta-analysis study on the costs and financial impact of HAIs, it was estimated that the major HAIs (CLABSI, CAUTI, VAP, MRSA and *Clostridium difficile*) in adult care facilities were cost about \$8.3 - \$11.5 billion/ year³. Patients with burn injuries are more susceptible to infection due to several reasons such as the impaired function of the immune system, the loss of the skin

layer, which is a natural cutaneous barrier, and altered intravascular fluid dynamics and circulation⁴. Device-associated infections are important cause of avoidable morbidity, and mortality and extended ICU stays in burn units. If patients with a large burn injury survive the first 72 hours after injury, infections are the most prevalent leading cause of death. About 75% of burn injuries mortality is associated with infection⁵. Infection Prevention and Control programs in many countries, such as England, United States, Canada, Australia and Germany, have made HAI surveillance a mandatory part of health care. These countries primarily focus on device-associated infection surveillance, enabling them to evaluate the impact of particular risk factors and guide targeted interventions. Implementing and adhering to IPC practices is mandatory to provide safe and high-quality patient care in all healthcare settings³.

This study aimed to determine the incidence rates of device associated infections in the Burn ICU of Ain Shams University Hospital and baseline assessment of

compliance of healthcare workers to preventive bundles for device-associated infection.

METHODOLOGY

The present longitudinal prospective study was designed to determine the incidence rates of device-associated infections with baseline assessment of adherence of healthcare workers to VAP, CLABSI and CAUTI preventive bundles using observation checklists and hand hygiene compliance using the WHO hand hygiene compliance tool during the period between June 2022 to November 2022, at the Burn ICU of Ain Shams University Hospital, Cairo, Egypt.

Setting and subjects:

The ICU has eight separated Burn ICU rooms with an alcohol dispenser for each room, next to the door. Each room had a single bed, every four rooms open to a separate corridor with a common bathroom for all rooms. There is one sink in each corridor with three dispensers, the 1st containing plain liquid soap, the 2nd for betadine foam 7.5%, while the 3rd for paper towels.

Seventy-one patients were chosen according to inclusion criteria: patients with Burns admitted to Ain Shams Hospital burn ICU with a relevant device (intubation, a central line, or an indwelling urinary catheter). The study did not include participants who were transferred from other hospitals. Patients were followed up for device-associated infections according to CDC definitions 2022⁶.

Surveillance for device-associated infection:

Data sources: for every Burn ICU patient with an inserted device, standardized data were collected, including demographic parameters (name, age, gender) and clinical criteria (total body surface area, cause of burn, diagnosis, date of ICU admission, date of device insertion and removal, signs of device-associated infections, as well as the outcome). In the Burn ICU, the number of patients, total number of patient days, central line (CL), mechanical ventilator, and urinary catheter days were all collected daily. We monitored patients using one or more devices to observe any infection related to using these devices. Data were collected from the patient's medical records and nurses as well as doctors' notes.

Surveillance definitions:

The definition of each device-associated with infection was used following the guidelines set by the CDC 2022⁶.

VAP is a pneumonia that occurs when the patient is kept on mechanical ventilator for more than two calendar days on the day of event; the 1st day being the day of ventilator placement, and ventilator was either placed on the date of the event itself or the day prior. When mechanical ventilator is reintubated or restarted, the ventilator day count for the ventilator association

begins anew if there is a pause in mechanical ventilator lasting at least one full calendar day⁶.

A laboratory-confirmed bloodstream infection (LCBI) that is not 2^{ry} to an infection in another site of the body is known as a primary bloodstream infection (BSI). A LCBI where an acceptable central line is present on the LCBI date of the event or the day prior and an acceptable BSI organism is detected is known as **CLABSI**⁶.

CAUTI is a UTI caused by the presence of an indwelling urinary catheter in an inpatient for more than two calendar days on the date of the event; the 1st is the day on which the catheter was placed; and indwelling urinary catheter was either placed on the date of the event itself or the day prior⁶.

$$\text{Device utilization ratio} = \frac{\text{Number of device days}}{\text{Number of patient days}}$$

The rates of DIAs were calculated as the number of infections for each device divided by the total number of device-days and expressed per 1000 device-days⁶.

Compliance to IPC measures:

Adherence of healthcare workers to hand hygiene using the WHO hand hygiene compliance tool and observation of VAP, CAUTI, and CLABSI preventing bundles was done by designing and using checklists once per week at least.

There were several elements included in the **VAP prevention bundle**: 30–45-degree elevation of patient's head, daily "sedation vacation" and evaluation of weaning readiness, daily oral care, peptic ulcer and deep vein thrombosis prophylaxis, change ventilator circuit when indicated such as visibly soiled or malfunctioned⁷.

Components of **CLABSI prevention bundle** for insertion included: hand hygiene compliance before catheter insertion, maximum sterile precaution barrier during insertion, chlorhexidine skin antisepsis, and optimal site of insertion, while the maintenance bundle included: hand hygiene, proper dressing change and daily assessment of the need for CVC⁷.

Components of **CAUTI prevention bundle** for insertion used were: avoiding the unnecessary usage of urinary catheters, using an aseptic technique for catheter insertion, and using a sterile closed drainage system, whereas maintenance components were: urinary catheter secured/ not obstructed, urinary bag above the floor and below the level of the bladder, empty the collecting bag regularly, daily assessment of the presence and need for indwelling urinary catheters⁸.

Hand hygiene compliance was measured using the WHO hand hygiene compliance tool. The healthcare workers were observed during 20 minutes sessions and opportunities and actions for hand hygiene were recorded. An observed opportunity for hand hygiene was documented as a "lost opportunity" if hand hygiene was not carried out, but it was recorded as an "action" if

it was, according to WHO observation form. Observed care sequences were defined as opportunities when an indication was observed. We recorded actions, according to the five moments of hand hygiene⁹.

RESULTS

Results according to patient clinical criteria:

During the period between June 2022 to November 2022 surveillance data were prospectively collected for 71 patients admitted to the Burn ICU for a total of 948 patient-days. These patients were on one or more of

invasive devices. The age of the patients ranged from 11 months to 81 years old, the mean age was 22.4 years old ± 19.7 SD; 32 were children, 28 were males and only 11 were females.

Among them 63 patients developed device-associated infections throughout the whole study. CLABSI had the highest incidence (46.9/1,000 central line days) compared with VAP (44.4/1,000 ventilator days) and CAUTI (11.6/1,000 urinary catheter days). Table 1 shows CLABSI, VAP and CAUTI rates, device and patient days during each month of the study period.

Table 1: Patient and device days, CLABSI, VAP and CAUTI rates through the whole study period:

Month	Patient days	Device days			Patients developing CLABSI (No)	Patients developing VAP (No)	Patients developing CAUTI (No)	CLABSI Rate *	VAP Rate *	CAUTI Rate *
		Urinary catheter	Ventilator	Central line						
June	135	135	8	132	3	3	0	22.7	375	0
July	203	203	63	203	12	3	3	59	47.6	14.7
August	183	183	40	183	9	1	3	49	25	16.3
September	171	166	53	171	8	1	2	46.7	18.8	12
October	194	194	10	186	9	0	3	48.3	0	15.4
November	62	60	6	62	3	0	0	48.3	0	0
Total	948	941	180	937	44	8	11	46.9	44.4	11.6

*Infection rates are expressed per 1000 device days

The device utilization ratio among burn ICU patients, was 0.71; the most frequently used device was urinary catheter (0.99) and central line (0.98), while ventilator was the least used one (0.19).

Results of compliance with device-associated infection preventive bundles:

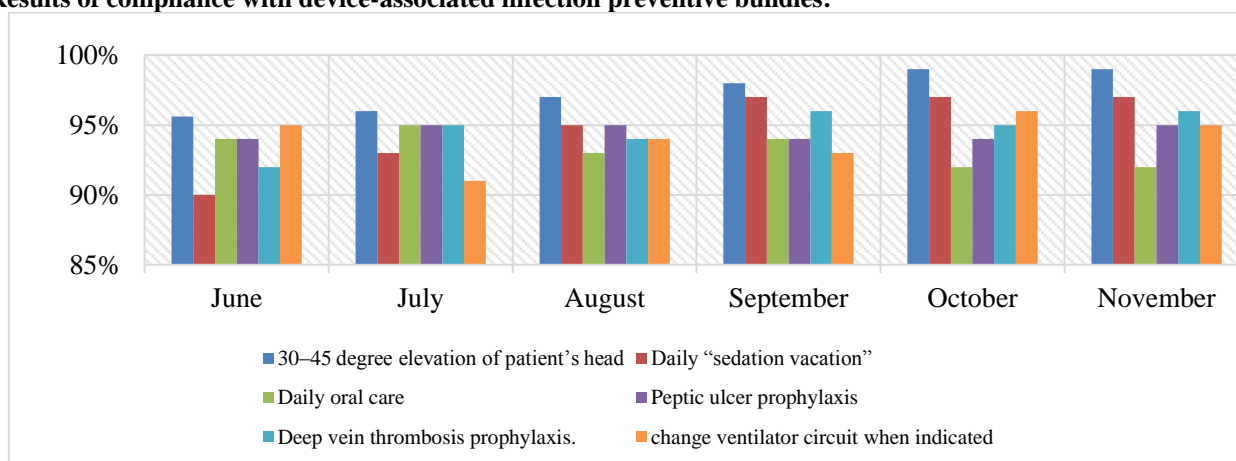


Fig. 1: Compliance of healthcare workers to the VAP prevention bundle

The compliance of healthcare workers throughout whole study period to the elements of VAP prevention bundle was 96%, while it was 51% to the central line

insertion bundle and 54% to the maintenance bundle for central line. Level of compliance for each component is shown in figures (1,2 and 3).

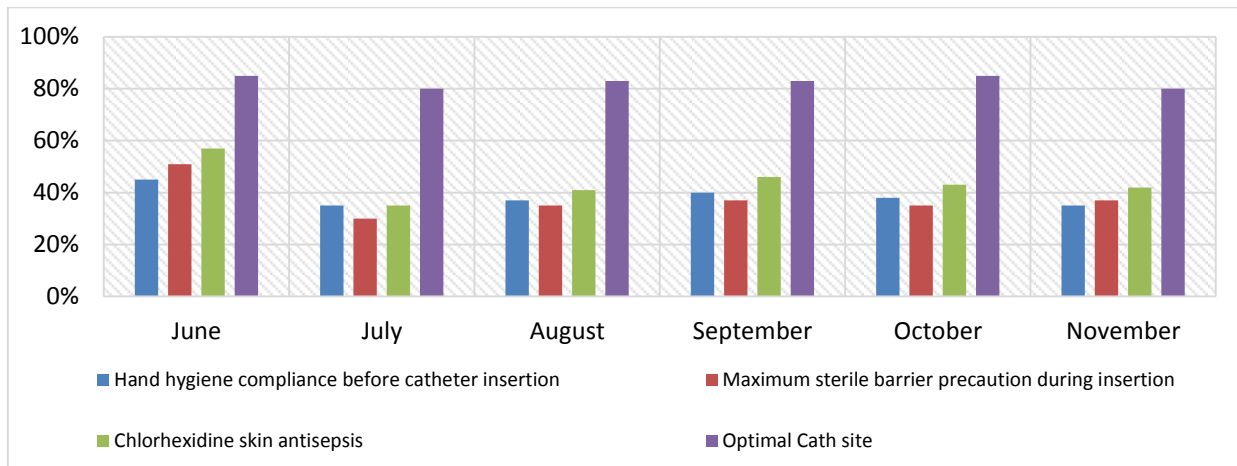


Fig. 2: Compliance of healthcare workers to the central line insertion bundle

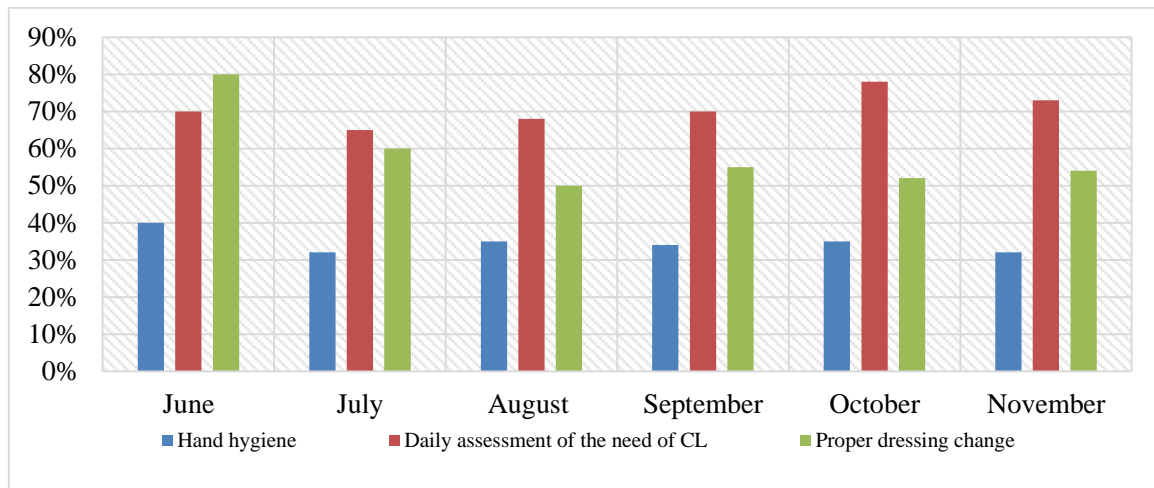


Fig. 3: Compliance of healthcare workers to the central line maintenance bundle

As regards the urinary catheter insertion bundle, the average compliance of healthcare workers was 91.8%. While, the average compliance to the maintenance bundle was (93%). Level of compliance for each component is shown in figures (4 and 5).

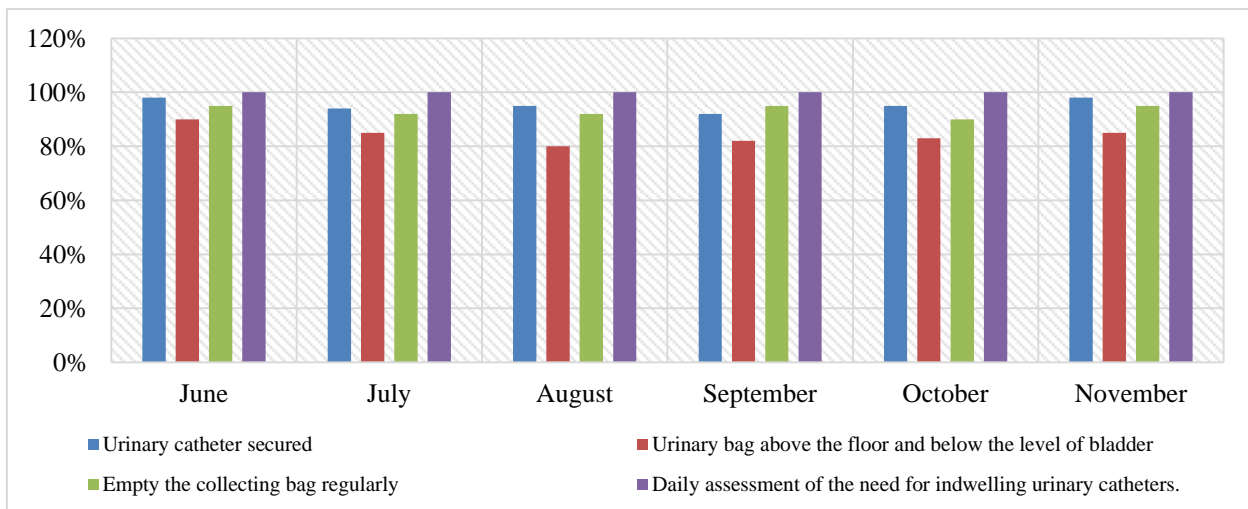


Fig. 4: Compliance of healthcare workers to the urinary catheter insertion bundle

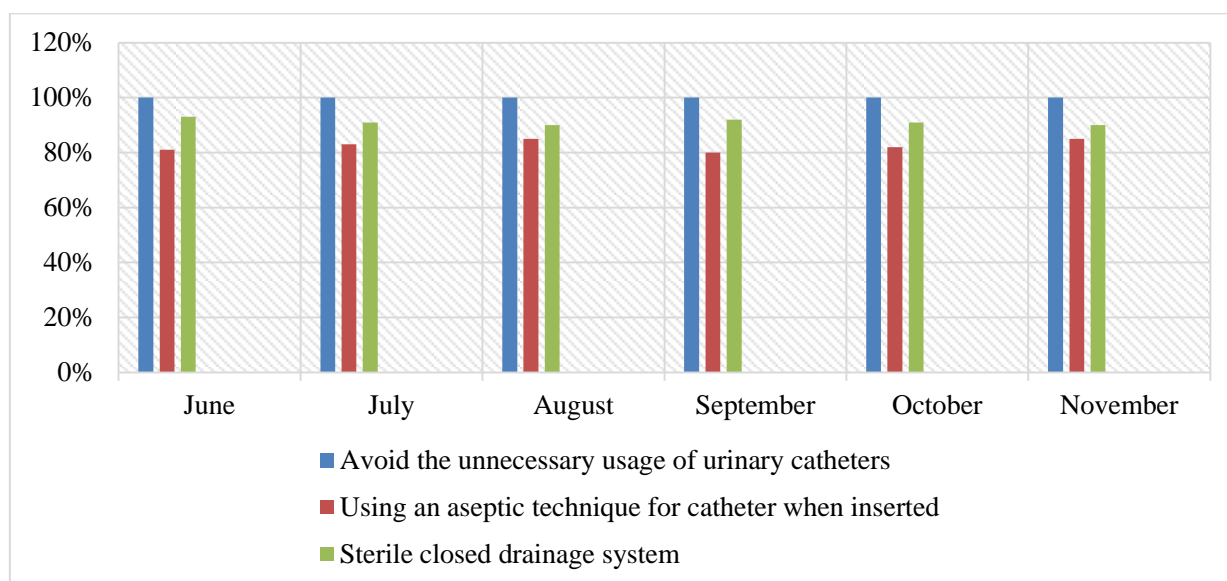


Fig. 5: Compliance of healthcare workers to the urinary catheter maintenance bundle

Results of hand hygiene compliance:

We recorded 350 hand-hygiene opportunities during observation sessions. figure (6) demonstrated compliance to hand hygiene 5 moments (Before touching a patient, before clean/aseptic procedure, after body fluid exposure risk, after touching patient surroundings, after touching patient

surroundings) across the burn ICU. Compliance for hand hygiene throughout study period was 30%. Highest compliance was recorded for moments 2 (before clean/aseptic procedure) and 3 (after body fluid exposure risk). In contrast, moment 5 had the lowest compliance (after touching patient surroundings).

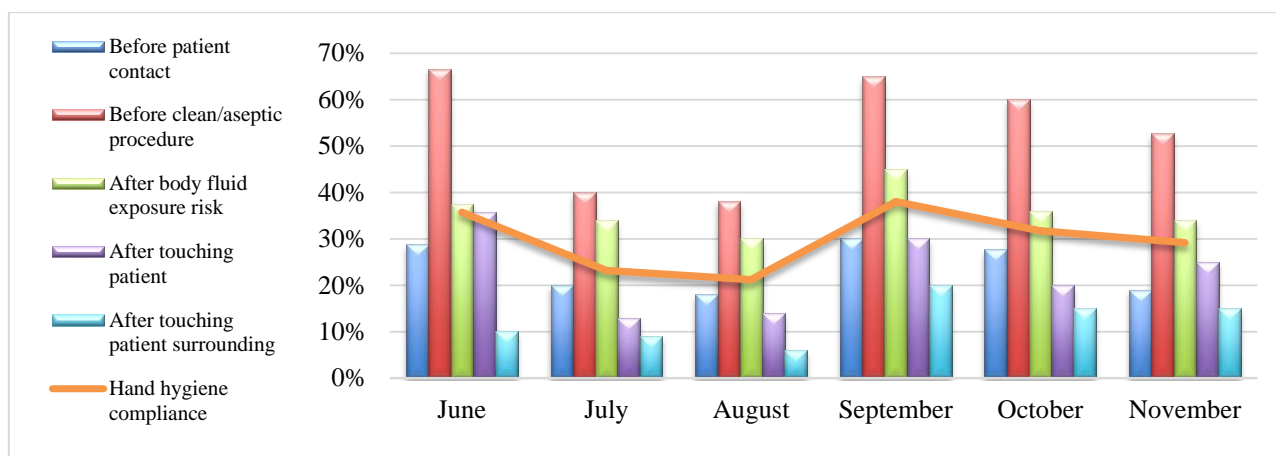


Fig. 6: Hand hygiene compliance rate among Burn ICU healthcare workers according to the five moments

DISCUSSION

HAI's are a major cause of morbidity and mortality globally, with a greater burden in low- and middle-income countries. They prolong hospital stays, increase healthcare costs, and cause a threat to the safety of healthcare workers and patients. Burn patients are more vulnerable to HAI's, due to the disruption of the skin barrier and the severe systemic immunocompromising effects of the burn¹⁰.

This study was designed to determine the incidence rates of device-associated infections with assessment of compliance of healthcare workers to VAP, CLABSI and CAUTI preventive bundles using observation checklists and to hand hygiene using the WHO hand hygiene compliance tool and for during the period between June 2022 to November 2022, at the Burn ICU of Ain Shams University Hospital, Cairo, Egypt.

The present study demonstrated that the most encountered type of device-associated infection in the burn ICU was CLABSI which had the highest incidence

(46.9/1,000 central line) compared with VAP (44.4/1,000 ventilator days) and CAUTI (11.6/1,000 urinary catheter days).

Our results come in agreement with those reported by Santucci et al.¹¹, who conducted a prospective study at the burn ICU of Hospital das Clônicas, São Paulo, Brazil, and found that CLABSI had the highest incidence rate (34 per 1000 central line), followed by VAP (26 per 1000 ventilator days). Similarly, Hultman et al.¹², performed an observational, retrospective analysis of data, from 2002–2012, that included 3,181 patients at the burn ICU, and showed that CLABSI had the highest incidence (11/1000 device days).

Data collected and analyzed in the national surveillance, by Talaat et al.¹³ from April 2012–September 2014, showed the following findings in three burn ICUs in different hospitals in Cairo: VAP had the highest incidence rate of device-associated infection (4/1,000 ventilator days) followed by CLABSI (2.6/1,000 central line) and CAUTI (1.3/1,000 urinary catheter days).

As regards device utilization ratio in this study, the most frequently used devices were urinary catheter and central line. The average device utilization ratio for urinary catheter and central line was (0.99) and (0.98), respectively, while it was (0.19) for the mechanical ventilation. According to results of the national surveillance by Talaat et al.¹³ in 3 different burn ICUs in Cairo, the device utilization ratio was highest for urinary catheter (0.8), followed by central line (0.7) and finally, the mechanical ventilator (0.1).

The device utilization ratio is an extrinsic risk factor for device-associated infections and may indicate the severity of the patient's condition or the patient's intrinsic susceptibility to infection¹⁴.

The high rates of device-associated infections in this study can be attributed to high device utilization ratios, excessive use of antibiotics, poor adherence to application of infection control practices with the use of each device, poor hand hygiene compliance, low nurse-to-patient ratio, and the environment in the burn ICU which might be contaminated due to presence of a common bath room for all the patients.

According to our findings, compliance with the four components of the central line preventive bundle was the lowest for maximal sterile precautions during catheter insertion and hand hygiene before catheter insertion (38%) for each, followed by alcohol-based chlorhexidine skin antiseptics (44%). This relatively agrees with the result of El-Sadek et al.¹⁵ who found that the compliance to use alcohol-based chlorhexidine skin antiseptics was 44%, and 35% for optimal catheter insertion site.

Yaseen et al.¹⁶ revealed in a study in adult ICUs at King Abdulaziz Medical City, Saudi Arabia, throughout 2008–2015, that compliance with the optimal site of central line insertion was the lowest (37%).

Similarly, *Lai et al.*¹⁷ reported in their national study in 27 ICUs in Taiwan, optimal site of central line insertion was the most deficient bundle component at the beginning of the study followed by hand hygiene with a compliance rate of 57.6% and 86.2% respectively.

The high incidence rate of CLABSI in our study could be attributed to the poor compliance with central line insertion and maintenance bundles (51% & 54% respectively). In addition, the subclavian vein could not be accessed in many cases despite adhering to the site selection component due to the anatomic location of the burn injury in this area. Femoral vein was used in a number of cases due to burn injuries in the upper part of the body. Femoral and jugular sites have been shown to have higher colonization rates than subclavian sites, as well as higher rates of CLABSIs in some studies¹⁸.

Regarding compliance with the five components of VAP preventive bundle in our study, we found that the highest compliance was for daily oral care (97.6%) followed by head elevation 30–45 degrees (97.4%), daily sedation (94.8%), while, deep vein thrombosis and peptic ulcer prophylaxis had the least compliance rate (94.6% and 94.5%) respectively. This is relatively consistent with average values of compliance reported by Hoang et al.¹⁹ in their one-year study at Bach Mai hospital ICU, Japan.

Concerning compliance with the three components of urinary catheter insertion preventive bundle in our study we found that the least compliance was to use of an aseptic technique for the catheter during insertion (92%). Similarly, Duszynska et al.²⁰ reported that adherence to the maximal barriers precautions when inserting urinary catheter had the least compliance (83%) in their study.

As regards the hand hygiene compliance during the study period, the overall compliance with the 5 moments of hand hygiene, was 30%, the 2nd moment of hand hygiene (before clean/ aseptic procedure) had the highest rate of compliance (53.7%). While the lowest rate was for the 5th moment (after touching the patient's surroundings) (13%). Similar findings were reported by Khalifa et al.²¹ in Cairo, and Kamanga et al.²² in Malawi. According to the WHO²³, the average hand hygiene compliance rate in critical care is about 60%, considerable differences between high- and low-income countries (64% vs. 9%).

The poor hand hygiene compliance among healthcare workers in our study can be attributed to work overload, understaffing, skin irritation, miss understanding about wearing gloves, lack of knowledge about importance of hand hygiene.

CONCLUSION

In conclusion, our surveillance revealed high rates of device-associated infections in our Burn ICU especially CLABSI rates. In addition, poor compliance to some

preventive bundles as central line insertion and VAP bundles could be the cause for this high rates. High compliance level to the preventative bundles is necessary to the is critical to minimize device-associated infections thus reducing morbidity and mortality among burn patients.

A multifaceted cooperative approach and resource support are imperative to maintain reduced device-associated infection incidence rates.

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Ethical Considerations

The protocol of this study was approved by Ethics Committee of Faculty of Medicine, Ain Shams University, Egypt.

Declarations:

Consent for publication: Not applicable

Availability of data and material: Data are available upon request.

Competing interests: The author(s) declare no potential conflicts of interest with respect to the research, authorship and/or publication of this article. This manuscript has not been previously published and is not under consideration in another journal.

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