Mansoura Nursing Journal (MNJ) Vol. 12. No. 2 – 2025
Print ISSN: 2735 – 4121 Online ISSN : 2735 – 413X

Original Article

The Effect of Using Disinfecting Cap on Central Line Associated Blood Stream Infection Among Critical Ill Patients in Egypt

Ahmed Soliman Mohamed 1, Aida Faried Abdelwanees 2, Asmaa Ibrahim Abosaeda 3, Mohamed Ahmed Sultan 4

1 Nursing specialist in Directorate of Health Affairs, Port Said, Egypt.

2,3 Assist. Professors of Critical Care and Emergency Nursing, Faculty of Nursing, Mansoura, Egypt.

4 Prof. of Anesthesia and Intensive Care, Faculty of Medicine, Mansoura, Egypt

ABSTRACT

Background: Central line-associated bloodstream infections are considered one of the most common types of healthcare-associated infections , it has a significant concern in critical care environments, Causing greater sickness, fatalities, and healthcare costs, many strategies Have been used to mitigate the risk of central line-associated bloodstream infection **Aim**: This study aimed to investigate the effect of using disinfecting cap on central line- associated blood stream infection among critically ill patients in Egypt. **Methods**: This research used a quasi-experimental design at Mansoura University Emergency Hospital's trauma intensive Care Units. Ninety-six adult patients requiring internal jugular Central venous catheter patients with insertions lasting over 48 hours were randomly assigned to an intervention group. (n=48, disinfecting cap applied) or a control group (n=48, routine care). For data collection, a central line disinfecting cap tool was used. **Results**: The intervention group had a significantly lower central line-associated bloodstream infection rate (6.1%) compared to the control group (20.8%) (p = 0.033). The groups did not differ significantly in demographic characteristics, health-related factors, or central venous catheter insertion variables, more than 90% of cases who developed central line-associated bloodstream infection in both groups had central venous catheter duration more than 7days. **Conclusion**: Disinfecting caps have been shown to decrease the risk of central line-associated bloodstream infections. This simple and cost-effective intervention should be considered as part of routine central line maintenance bundles to safeguard patients and minimize the impact of infections contracted in hospitals.

Keywords:*Central Line-Associated Bloodstream Infection, Critical Care, Disinfecting Caps, Infection Prevention, Intensive Care Unit.*

Introduction:

The burden of healthcare-associated infections (HCAIs) on public health is substantial. that affects Patients in a hospital or other healthcare facility may acquire infections that were not present at the time of admission. These also include infections contracted by patients while in the hospital **(Haque et al., 2018).** HCAIs, particularly Central Line-Associated Bloodstream Infections (CLABSIs), are a major concern in healthcare settings. These infections, which can lead to severe complications, increased morbidity, and mortality rates, prolonged hospital stays, and substantial financial burdens on the healthcare system, are prevalent in hospitals and intensive care units. **(Baier et al., 2020a; Mishra et al., 2017)**

Central venous catheters (CVCs), while crucial for delivering lifesaving interventions in critical care settings, serve as the primary route for CLASBSI development (**Selby et al., 2021)**. Recognized as a leading cause of preventable HAIs **(Madni & Eastman, 2018)**, CLABSI prevention is a top priority for healthcare institutions worldwide **(*Australian Guidelines for the Prevention and Control of Infection in Healthcare (2010)* | *NHMRC*, n.d.; Loveday et al., 2014; O'grady et al., 2011).**

The Centers for Disease Control and Prevention (CDC et al., 2022) defines CLABSI as a bloodstream infection occurring 48 hours or more after central line placement, unrelated to infection at other body sites. According to The Infectious Diseases Society of America (IDSA), "catheter-related bloodstream infection" (CRBSI) is the preferred term. and outlines specific diagnostic criteria **(Lissauer et al., 2012)**. Annually, CLABSIs result in an estimated 250,000 cases and 30,000 deaths in the United States, making them a significant public health concern.**(Dudeck et al., 2015; Richter & McAlearney, 2018; Toor et al., 2022)**.

Research from low- and middle-income countries indicates a wide range of CLABSI incidence rates (1.6 to 44.6 per 1,000 central line days), suggesting that differences in healthcare practices and resources play a significant role. **(Talaat et al., 2016)**. Risk Factors for CLABSI

Development Multiple factors contribute to CLABSI development, including patient-related Factors, factors associated with catheters, healthcare provider behaviors, and the healthcare system:

Factors associated with patients include prolonged catheterization, compromised immune systems, underlying health conditions, and receipt of total parenteral nutrition **(Greenberg et al., 2015; Keller et al., 2016; Savetamal, 2021)**. Concerning factors related to catheters, Catheter type number of lumens (e.g., triple lumen catheters), and duration of catheterization **(Baier et al., 2020; Bozaan et al., 2019; Parameswaran et al., 2011; Templeton et al., 2008)**

Regarding healthcare Provider Practices comprise inadequate hand hygiene, breaches in aseptic technique during catheter insertion and maintenance, and frequent catheter manipulation **(Barton et al., 2022; Ekwere et al., 2013; Maiguy-Foinard et al., n.d.)** while Healthcare System Factors include variation in infection control practices and adherence to guidelines among healthcare facilities **(Talbot et al., 2013)**.

Key strategies for preventing CLABSI before catheter insertion include Reducing the unnecessary use of CVCs and ensuring healthcare providers are well-trained and competent for CVC insertion and maintenance and administering daily chlorhexidine baths for high-risk patients **(Buetti et al., 2022; Reynolds et al., 2021)**. These proactive measures ensure that catheter placement is necessary, and that healthcare staff are well-prepared to manage CVCs effectively.

During and after catheter insertion, additional precautions are crucial for preventing CLABSI. This involves strictly following aseptic techniques with the use of checklists, employing ultrasound guidance for catheterization in the internal jugular and femoral veins, Ensuring rigorous sterile barrier precautions and using alcoholic chlorhexidine for skin disinfection **(Buetti et al., 2022)**.

After insertion, maintaining appropriate nurse-to-patient ratios, using chlorhexidine dressings, disinfecting catheter hubs and injection ports, removing unnecessary catheters, and performing continuous CLABSI surveillance are key to minimizing infection risks **(Buetti et al., 2022)**.

Disinfecting Caps are a promising intervention disinfecting caps, containing sponges impregnated with antiseptic solutions like 70% isopropyl alcohol, provide passive disinfection of needleless connectors and have gained attention as a potential strategy to reduce CLABSI rates. Studies report significant reductions in CLABSI incidence (ranging from 30% to 87%) associated with disinfecting cap use **(Jimenez et al., 2015; Merrill et al., 2014)** .

Incorporating disinfecting caps into central line maintenance bundles offers several benefits. These include improved compliance with infection control practices, sustained reductions in CLABSI rates, and potential cost savings. **(Beeler et al., 2019; Martino et al., 2017)**. While previous research has shown promising results, there is limited research exploring the relationship between disinfecting caps and CLABSI rates in Egypt.

This study aims to investigate the effect of using disinfecting caps on central line-associated bloodstream infections among critically ill patients in Mansoura university Emergency Hospital. This research seeks to provide valuable insights for Egyptian healthcare facilities considering the adoption of disinfecting caps as a standard preventative strategy to safeguard patients and minimize the impact of CLABSIs.

Materials and Methods

1. Technical Design.

Research design:A quasi-experimental research design was utilized for this study, as it is both practical and appropriate for exploring the cause-and-effect relationship under investigation. **(Rogers & Révész, 2019).**

Subjects: A convenience sample included 96 adult critically ill patients of either Gender who are fulfilling the following criteria:

- Adult patients aged 18 years or more.
- All patients admitted to the intensive care unit (ICU) need to have an internal jugular CVC.
- CVC remains indwelling for more than 48 hours

The study did not include patients with central lines inserted for less than 48 hours.

Setting: The study took place Mansoura University's emergency hospital in the Intensive Care Units. There are three ICUs, with a total bed capacity of 32 beds. Two of them have 10 beds each, and the third one has 12 beds. The ICUs are designed to handle multiple trauma patients and have advanced technology for patient care. Each nurse is responsible for approximately two patients.

Data collection tools:

An adapted instrument was employed to collect data related to this study following a review of the relevant literature **(Al-Khawaja et al., 2021; CDC et al., 2022; Mermel et al., 2009)**.

Central Line Disinfecting Cap Tool:

This tool was employed to gather data regarding the socio-demographic characteristics of the patients, health- relevant data, central line data and CLABSI diagnostic criteria.

Part One: Patients' Socio-Demographic and Health-Relevant Data.

This part was used to address the personal data of the patients and his health history which will include the following:

age, gender, date of admission, diagnosis, medical or surgical history, and length of stay.

Part Two: Central line related data

This part included the catheter insertion site, device insertion and removal date, and central line duration **(Al-Khawaja et al., 2021).**

Part Three: CLABSI Diagnostic criteria

This part included certain criteria as defined by the National Health Care Safety Network (NHSN) **(CDC et al., 2022;)** as following:

1. *Clinical signs of infection*

- Fever (>38.^{0} C)
- Chills
- Hypotension.

2. *Laboratory (Blood cultures will be required for patients who develop at least one of the previous signs or symptoms within 48 hours of central line insertion).*

- Identified pathogen(s) detected in one or more blood cultures.
- Common commensal organisms are found in two or more blood cultures.

2. Operational Design

The operational design included validity of the tools, and pilot study.

Validity of the study tool:

The study tool underwent a validation process involving three experts in critical care and emergency nursing. Their feedback led to necessary modifications, and the tool was subsequently ready for testing.

Pilot Study:

A pilot study was carried out on a total of 10% of the sample (5 patients in each group "control and intervention") Ten subjects were involved in the study, and its statistical validity was established. The pilot study participants were excluded from the main study sample.

3. Administrative Design

Preparation Phase

1. Authorization to conduct this study was granted by the relevant authorities.
2. Once permissions were granted to proceed in this proposed study, 96 patients who qualified based on the inclusion criteria were enrolled in the study by the investigator.
3. To maintain 24-hour follow-up, ICU nurses providing direct patient care were provided with the required education on the use of disinfecting caps.
4. Participants or their relatives (next of kin) provided written informed consent after informing them about the study's objectives, procedures, benefits, and potential risks.
5. They were informed that participation in the study is voluntary, and they have the right to either consent or decline the patient's involvement in the research.
6. They were assured that their personal information would remain confidential.
7. Participants were informed that they could withdraw the patient from the study at any time without any consequences.
8. The investigator conducted data collection over four months, beginning in May 2023 and concluding at the end of Aug 2023.
9. All data collection tools were coded to prevent the disclosure of any personal information about the sample.

Implementation Phase.

1. An initial assessment of all patients was carried out by the researcher in the day of central line insertion in the ICU to ensure that they meet the inclusion criteria and are not subject to any exclusion criteria.
2. The subjects were randomly assigned to either an intervention group (A) or a control group. Each group includes 48 patients.

For the intervention group

Disinfecting cap (70% Isopropyl Alcohol) was applied after completing a line access procedure, the disinfecting cap is for single use, it may remain on for up to seven (7) days.

For the control group

Central line ports were cleaned as routine care in the ICU.

- Patient's demographic and health relevant data and central line related data was collected using part One and Two data collection tool.

- **Ethical considerations:**

Research Ethics Committee in the Faculty of Nursing at Mansoura University granted ethical approval number (279). Additionally, official permission was secured from the Mansura university hospitals director based on a notification from the Faculty of Nursing that described the study's purposes Furthermore, all participants and healthcare providers were made aware about the study's goal and benefits, and the investigator's status as a master's student at the Faculty of Nursing, Mansoura University

Participants or their relatives were informed that the study posed no risks to their health and that participation was voluntary. They could withdraw at any time without affecting their care. Informed consent was obtained. To ensure confidentiality, data was collected and coded securely and stored separately from the hospital or university. Participants or their relatives were informed that data collection sheets would be coded without their names, and that the information would be used solely for research purposes.

4. Statistical

IBM SPSS Statistics version 27 was used to analyze the data. Descriptive statistics, including means, standard deviations, frequencies, and percentages, were calculated for all variables. For categorical variables, the Chi-Square test (χ^2) was used to compare the control and intervention groups or Fisher's Exact Test (FET) where appropriate. The primary outcome of interest, the occurrence of CLABSI, was compared between the groups using the Chi-Square test. Secondary analyses involved comparing specific clinical parameters, such as fever, chills, and hypotension, as well as organism identification in bloodstream infections, Statistical significance for all tests was set at a p-value of 0.05 or lower. This analysis strategy was designed to provide a comprehensive understanding of the effect of the disinfecting cap on CLABSI occurrence, ensuring the robustness of the findings.

Level significance:

A significance level of 5% (p-value) was used for all statistical tests. Results were considered: significant if the error probability was below 5% ($p < 0.05$), non-significant if the error probability was above 5% ($p > 0.05$), highly significant if the error probability was below 0.1% ($p < 0.001$). A lower p-value indicates a higher level of significance

Results

This study aimed to investigate the effect of the disinfecting cap on the occurrence of CLABSIs among critically ill patients in Egypt. We hypothesized that the use of a disinfecting cap would reduce the occurrence of CLABSI among critically ill patients with central line compared with the traditional disinfection.

Table 1 illustrates an interesting distribution across genders, age groups, and settings. Notably, there's a higher percentage of males compared to females in control and intervention group (64.6% & 79.6% respectively), with a similar trend observed across age groups, where 54.2% of individuals aged 40 to under 60 in the routine care group and 49% in the disinfecting cap group, followed by 39.6% and 38.8% in the 18 to under 40 age group, respectively, and 6.3% in the control group and 12.2% in the intervention group for the 60 and above category. Additionally, there was little difference in the average age between the control and intervention groups. (42.17 years & SD of +10.799) in and of 42.98 years & an SD of +14.664 respectively).

Despite these variations, the differences do not appear statistically significant based on the provided p-values. Furthermore, the distribution across different ICU settings seems relatively balanced, with 35.4%, 31.3%, and 33.3% in ICU 1, ICU 2, and ICU 3, respectively, for the control group, and 26.5%, 30.6%, and 42.9% in the same settings for the intervention group. These percentages offer a comprehensive view of the demographics within both groups, contributing to our understanding of the subjects.

Table 2 illustrates the health-relevant data of the Studied groups.

Table 2-A Reason for ICU Admission of the Studied groups reveals the breakdown of diagnoses that sheds light on the nature of injuries within the studied population. Interestingly, a variety of injuries are represented, with notable proportions in categories such as head injuries. Specifically,

29.2% and 20.8% of individuals in the control group were diagnosed with head injury and pelvic fracture, respectively, compared to 24.5% and 18.4% in the intervention group.

However, it's crucial to note that these differences do not appear statistically significant based on the provided p-values. Other diagnoses, such as spinal injury and brain contusion, also show variations between the control and intervention groups. For instance, 12.5% of individuals in the control group were diagnosed with spinal injury compared to 20.4% in the intervention group. Similarly, brain contusion was observed in 10.4% of the control group and 4.1% of the intervention group. These findings provide valuable insights into the spectrum of injuries encountered within the studied population, facilitating a better understanding of the clinical context.

Table 2-B illustrates the past surgical history of the Studied groups. The comparison of surgical history between the control and intervention groups revealed intriguing patterns. A greater proportion of individuals in the intervention group reported no prior surgical history (67.3%) relative to the control group (47.9%). Nevertheless, this difference did not appear statistically significant based on the provided p-value ($p = 0.133$). The control group had a higher rate of appendectomy (25.0%) compared to the intervention group (12.2%).

Table 2-C illustrates the past medical history of the Studied groups. Notably, compared to the control group, a larger proportion of individuals in the intervention group had no reported medical history (31.3% - 44.9% respectively). Hypertension (HTN) was more common in the control group (20.8%) than in the intervention group (8.2%). Similarly, coronary artery disease (CAD) was absent in the control group but present in 8.2% of individuals in the intervention group. Conditions such as diabetes mellitus (DM) and combinations of DM with HTN or CAD show comparable prevalence between the two groups. Chronic obstructive pulmonary disease (COPD) and end-stage renal disease (ESRD) were present in both groups but with minimal differences.

Overall, while there are variations in the prevalence of certain medical conditions between the control and intervention groups, statistical significance is not achieved. These findings contribute to a comprehensive understanding of the medical backgrounds of individuals within each group, aiding in the interpretation of outcomes and the development of tailored interventions.

Table 2-D Depicts the duration of ICU Stay of the Studied groups. It reveals several key insights. Notably, there was a balanced distribution of patients across different ICU stay durations, with no differences among the two groups. The extended stay in the ICU was observed more frequently in both the routine care and disinfecting cap groups, with 58.3% and 61.2% respectively falling into the 8-14 days category.

Comparing the frequency distributions, it's evident that the proportions of patients staying in the ICU for 1-7 days, 8-14 days, and over 15 days were quite similar between the control and intervention groups. This similarity was further supported by the significancy test results, which indicate a non-significant difference ($X2 = 0.373$, $p = 0.956$) in ICU stay duration distribution between the two groups.

Moreover, the mean ICU stay durations for both groups were comparable, with the control group averaging 9.38 days and the intervention group averaging 9.82 days. Additionally, the standard deviations were close, suggesting similar variability in ICU stay durations between the groups.

The analysis of CVC insertion variables sheds light on procedural practices within both the control and intervention groups. Regarding insertion sites, the jugular vein was uniformly utilized in both groups, with a 100% adoption rate. In terms of lumens, the majority of CVCs in both groups were triple lumen, constituting 66.7% in the control group and 69.4% in the intervention group. Triple and double lumens did not significantly differ ($p = 0.774$).

Regarding the place of line insertion, it was indicated that a slightly higher percentage of CVC insertions in the ICU compared to the emergency room (ER) in both groups (66.7% and 73.5% respectively), although this disparity was not statistically significant ($p = 0.464$).

Considering CVC duration, no significant difference was observed between the groups across specified timeframes (3-5 days, 6-7 days, and >7 days). The distribution of CVC duration appeared consistent between the control and intervention groups.

Lastly CVC removal before ICU discharge, the majority in both groups had their CVCs removed, with 85.4% in the routine care group and 89.8% in the disinfecting cap group undergoing removal. Nevertheless, the difference in removal rates between the two groups wasn’t statistically significance ($p = 0.513$).

The comparison of confirmed CLABSI incidences between the control and intervention groups reveals a notable disparity. In the control group, 20.8% of individuals experienced CLABSI, whereas only 6.1% did in the intervention group. The CLABSI rates differed significantly between the two groups (p = 0.033).

These results imply that the use of disinfecting cap may have had a significant impact on reducing the occurrence of CLABSI within the studied population. It underscores the potential effectiveness of using the disinfecting cap in improving patient outcomes by mitigating the risk of bloodstream infections associated with central line placements.

Table 4-B illustrates The comparison of fever, chills, and hypotension occurrences between the control and intervention groups provides insights into clinical manifestations within both cohorts. For fever (>38°C), 37.5% of individuals in the control group experienced it, compared to 30.6% in the intervention group. However, this difference was not statistically significant (p = 0.474). Similarly, occurrences of chills were relatively low in both groups, with 6.2% in the control group and 2% in the intervention group, with no significant difference observed between the groups (p = 0.297).

Regarding hypotension, 45.8% of individuals in the control group experienced it, compared to 38.8% in the intervention group. However, like the other variables, the difference was not significant (p = 0.482).

Table 4-C comparison of organisms identified in bloodstream infections between the control and intervention groups offers valuable insights into microbial etiology within both cohorts. The majority of individuals in both groups did not exhibit any identified organism, with 79.2% in the routine care group and 93.9% in the disinfecting cap group. Despite a lower proportion of cases with no identified organism in the intervention group, this difference was not significant (p = 0.191).

Among the identified organisms, Enterobacter was the most commonly observed, with 10.4% of cases in the routine care group and 2.0% in the disinfecting cap group. Pseudomonas aeruginosa and Staphylococcus aureus were less frequently identified in the two groups, with minimal differences between them.

Table 1. Socio-demographic Characteristics of the Studied groups

Variables	**Control n=48**	**Intervention n=49**	**Significant Test**	
	No. (%)	**No. (%)**	**X^2**	**P Value**
Gender				
Male	31 (64.6%)	39 (79.6%)	2.719	0.117*
Female	17 (35.4%)	10 (20.4%)		
Age in years				
18 - 39	19 (39.6%)	24 (49%)	2.660	0.264
40 - 59	26 (54.2%)	19 (38.8%)		
60 and more	3 (6.3%)	6 (12.2%)		
Mean ±SD	42.17 ± 10.799	42.98 ± 14.664		
Setting				
ICU 1	17 (35.4%)	13 (26.5%)	1.199	0.549
ICU 2	15 (31.3%)	15 (30.6%)		
ICU 3	16 (33.3%)	21 (42.9%)		

Data are presented in terms of counts (n) and percentages (%), P value measures by Chi-Square test (X^2), *Fisher's exact test (FET), standard deviation (SD), and statistically significant at P≤ 0.05.

Table 2-A Reason for ICU Admission of the Studied groups

Variables	Control n=48	Intervention n=49	Significant Test	
	No. (%)	No. (%)	X^2	P Value
Diagnosis				
Combined orthopedic injury	4 (8.3)	5 (10.2%)	10.505	0.162
Spinal Injury	6 (12.5%)	10 (20.4%)		
Chest Trauma	5 (10.4%)	4 (8.2%)		
Pelvic Fracture	10 (20.8%)	9 (18.4%)		
SDH	4 (8.3%)	1 (2.0%)		
Lung Contusion	0 (0.0%)	6 (12.2%)		
Brain Contusion	5 (10.4%)	2 (4.1%)		
Head Injury	14 (29.2%)	12 (24.5%)		

SDH = Subdural hematoma. Data are presented in terms of counts (n) and percentages (%), P value measures by Chi-Square test (X^2), and statistically significant at P≤ 0.05.

Table 2-B Past Surgical History of the Studied groups

Variables	Control n=48	Intervention n=49	Significant Test	
	No. (%)	No. (%)	X^2	P Value
Surgical History				
None	23 (47.9%)	33 (67.3%)	7.049	0.133
Appendectomy	12 (25.0%)	6 (12.2%)		
Hernia repair	8 (16.7%)	3 (6.1%)		
Cholecystectomy	4 (8.3%)	4 (8.2%)		
Others*	1(2.1%)	3 (6.1%)		

Data are presented in terms of counts (n) and percentages (%), P value measures by Chi-Square test (X^2), standard deviation (SD), and statistically significant at P≤ 0.05.

*Note: the other was coronary artery bypass graft (CABG).

Table 2-C *Past Medical History of the Studied groups*

Variables	Control n=48	Intervention n=49	Significant Test	
	No. (%)	No. (%)	X2	P Value
Medical History				
None	15 (31.3%)	22 (44.9%)	9.086	0.429
Hypertension (HTN)	10 (20.8%)	4 (8.2%)		
Diabetes mellitus (DM)	5 (10.4%)	5(10.2%)		
Coronary artery disease (CAD)	0 (0.0%)	4 (8.2%)		
DM and HTN	5 (10.4%)	5 (10.2%)		
CAD, HTN, DM	3 (6.3%)	2 (4.1%)		
CAD, HTN	3 (6.3%)	3 (6.1%)		
COPD	2 (4.2%)	1(2.0%)		
ESRD	1(2.1%)	1 (2.0%)		
Others*	4 (8.3%)	2 (4.1%)		

Chronic Obstructive Pulmonary Disease (COPD), (ESRD)End Stage Renal Disease, Hypertension (HTN), Diabetes Mellitus (DM), coronary artery disease (CAD), Data are presented in terms of counts (n) and percentages (%), P value measures by Chi-Square test (X^2), and statistically significant at P≤ 0.05.

*Note: others included (Asthma, Epilepsy, Cancer, and Stroke).

Table 2-D Duration of ICU Stay of the Studied groups.

Variables	Control n=48	Intervention n=49	Significant Test	
	No. (%)	No. (%)	X^2	P Value
ICU Stay in Days				
1:7	16 (33.3%)	15 (30.6%)	0.373	0.956
8:14	28 (58.3%)	30 (61.2%)		
>15	4 (8.3%)	4(8.2%)		
Mean ±SD	9.38 ±4.03	9.82 ±4.44		

Data are presented in terms of counts (n) and percentages (%), P value measures by Chi-Square test (X^2), standard deviation (SD), and statistically significant at $P \leq 0.05$.

Table 3 Central Venous Catheter (CVC) Data of the Studied groups.

Variables	Control n=48	Intervention n=49	Significant Test	
	No. (%)	No. (%)	X^2	P Value
Central Venous Catheter insertion site				
Number of Lumens				
Triple	32 (66.7%)	34 (69.4%)	0.083	0.774**
double	16 (33.3%)	15 (30.6%)		
Place of Line Insertion				
Intensive Care Unit (ICU)	32 (66.7%)	36 (73.5%)	0.535	0.464**
Emergency Room (ER)	16 (33.3%)	13 (26.5%)		
CVC Duration in Days				
3:5	14 (29.2%)	14 (28.6%)	0.814	0.36
6:7	9 (18.8%)	15 (30.6%)		
>7	25 (52.1%)	20 (40.8%)		
CVC was removed before discharge from ICU				
Yes	41 (85.4%)	44 (89.8%)	0.429	0.513**
No	7 (14.6%)	5 (10.2%)		

Data are presented in terms of counts (n) and percentages (%), P value measures by Chi-Square test (X^2), *Fisher's exact test (FET), and statistically significant at $P \leq 0.05$.

Note: *Jagular CVC was an inclusion criterion in the recruited patients **= Fisher Exact test, X^2, Chi-Square test

Table 4 -A Comparing Total CLABSI Occurrence in the Studied groups

Variables	Control n=48	Intervention n=49	Significant Test	
	No. (%)	No. (%)	X^2	P Value
Confirmed CLABSI				
CLABSI	10 (20.8%)	3 (6.1%)	4.521	0.033*
Not CLABSI	38 (79.2%)	46 (93.9%)		

Data are presented in terms of counts (n) and percentages (%), P value measures by Chi-Square test (X^2), *Fisher's exact test (FET), and statistically significant at P≤ 0.05.

Table 4-B clinical signs of infection

Variables	Control n=48	Intervention n=49	Significant Test	
	No. (%)	No. (%)	X^2	P Value
Fever > 38° C				
Yes	18 (37.5%)	15 (30.60%)	0.512	0.474*
No	30 (62.50%)	34 (69.40%)		
Chills				
Yes	3 (6.2%)	1(2%)	1.087	0.297*
No	45 (93.8%)	48 (98%)		
Hypotension				
Yes	22 (45.8%)	19 (38.80%)	0.495	0.482*
No	26 (54.20%)	30 (61.20%)		

Data are presented in terms of counts (n) and percentages (%), P value measures by Chi-Square test (X^2), *Fisher's exact test (FET), and statistically significant at P≤ 0.05.

Table 4 –C *Organisms Identified in Bloodstream Infections between Control and Intervention Groups*

Variables	Control n=48	Intervention n=49	Significant Test	
	No. (%)	No. (%)	X^2	P Value
Organism				
None	38 (79.2%)	46 (93.9%)	4.752	0.191
Enterobacter	5 (10.4%)	1 (2.0%)		
Staphylococcus aureus	2 (4.2%)	1 (2.0%)		
Pseudomonas aeruginosa	3 (6.3%)	1 (2.0%)		

Data are presented in terms of counts (n) and percentages (%), P value measures by Chi-Square test (X^2), *Fisher's exact test (FET), and statistically significant at P≤ 0.05.

Discussion.

This study aimed to investigate the effect of using disinfecting cap on central line associated blood stream infection among critical ill patients in Egypt. We hypothesized that the use of a disinfecting cap would reduce the occurrence of CLABSI among critically ill patients with central line compared with the traditional disinfection.

The socio-demographic characteristics of the studied groups yield valuable insights into the composition and context of the participant population. The findings reveal a higher proportion of male participants compared to females in routine care and disinfecting cap groups, which is consistent with previous research indicating a

higher prevalence of critical illness among males **(Eid et al., 2023; Xie et al., 2020)**.

Moreover, the study by **Atia (2020)** echoes these findings; this gender distribution aligns with the demographic patterns often observed in ICU admissions, where males tend to be overrepresented due to specific factors such as higher rates of traumatic injuries and cardiovascular diseases**(Atia, 2020; Eid et al., 2023)**.

Additionally, recent research by **(Maqbool et al., 2023)** sheds light on differences between genders in the bloodstream infection probability. They found that compared to men, women had a significantly lower risk of community-associated bloodstream infections, healthcare-associated bloodstream infections, and surgical site infections, even when accounting for patient characteristics at admission and events during hospitalization.

Interestingly, Gender differences were most evident in teenagers and young adults, becoming less apparent in younger children and older adults.

(Maqbool et al., 2023). This finding underscores the importance of considering demographic variables, including gender, in epidemiological analysis.

Regarding age distribution, the mean age of participants in both groups falls within the middle-aged range, with no significant difference observed between the control and intervention groups. This demographic profile is characteristic of ICU populations, where middle-aged adults constitute a significant proportion of admissions, this must be due to conditions such as sepsis, respiratory failure, and trauma, The similarity in age distribution between the control and intervention groups suggests that the studied population is representative of typical ICU cohorts.

In a Chinese multicenter retrospective study conducted by **(Ma et al., 2021)**, ICU patients who are both male and older have a significantly higher risk of death. This finding highlights the critical importance of factoring in both gender and age when predicting the likelihood of survival for patients in the ICU who need mechanical ventilation.

The distribution across different ICU settings indicates a relatively balanced representation, with no significant discrepancies between the routine care and disinfecting cap groups.

The breakdown of diagnoses leading to ICU admission in the studied groups offers valuable insights into the spectrum of injuries encountered within the population under investigation. Notably, Head injuries were prevalent among both the control and intervention groups, this observed pattern might be explained by the study was conducted in trauma ICUs, which specializes in treating patients with complex conditions. This suggests that the patients may have had a higher risk of mortality due to the severity of their injuries, potentially influencing the observed gender and age differences.

Worldwide, emergency room visits constitute 10% of Neurological complications **(WHO, 2016).** In Egypt, neurological disorders are a leading cause of death, representing a substantial 14.9% of all fatalities. **(Institute for Health Metrics and Evaluation, 2019).**

The past surgical history of the studied groups.

It revealed interesting relations between the routine care and disinfecting cap groups. While Over 50% of individuals in the intervention group reported no prior surgeries compared to the control group, this difference fell short of statistical significance,

This lack of significance may be attributed to several factors, including a relatively limited sample size or chance distribution within the groups.

The past medical history of the studied groups.

It revealed several notable findings that offer insights into the health profiles of participants in both the routine care and disinfecting cap groups. Understanding these differences and similarities is crucial for interpreting outcomes and designing effective interventions tailored to the needs of each group.

Firstly, the intervention group had a lower proportion of individuals with no medical history compared to the control group, this observation suggests that individuals randomized to the intervention group may have been generally had fewer pre-existing health conditions compared to those in the control group.

Regarding past medical history, the current findings revealed that hypertension and diabetes mellitus were the most prevalent past medical conditions in both study groups. According to the national diabetes statistics report released by the CDC, Diabetes is a health concern for more than 34 million Americans that representing nearly 11% of the U.S. population **(CDC, 2020).**

In Egypt, the prevalence of diabetes in adults in 2021 reached 20.9% **(International Diabetes Federation, 2021).** Furthermore, it has been approximate that 1.28 billion human beings globally suffered from hypertension, with a significant majority (two-thirds) living in low- and middle-income countries. (WHO, 2023). Estimated 29.2% of Egyptian adults meet the criteria for hypertension **(Khalfallah et al., 2023)**

The observation that extended ICU stays were similarly prevalent in both the routine care and disinfecting cap groups, with approximately half and more than half respectively falling into the 8-14 days category, underscores the severity of illness and complexity of care required for a significant proportion of patients in both cohorts. This finding implies that factors beyond the intervention, such as underlying health conditions or severity of illness, may have a more substantial impact on ICU length of stay**(Böhmer et al., 2014)**.

Comparison of the frequency distributions of ICU stay durations between the control and intervention groups revealed consistency across all categories (1-7 days, 8-14 days, and over 15 days). The non-significant difference in ICU stay duration distribution between the two groups is supported by the Chi-square test results, further indicates that the use of disinfecting caps did not result in significant changes in ICU length of stay compared to routine care**(Hou et al., 2023)**

Moreover, the comparable ICU stay durations for both groups suggest no significant difference in the average length of ICU stay between the two cohorts. The similarity in standard deviations further supports this conclusion, indicating similar variability in ICU stay durations between the control and intervention groups.

The analysis of CVC insertion variables in this study provides valuable insights into procedural practices related to CLABSIs within the context of the control and intervention groups. The study revealed a consistent preference for the jugular vein as the insertion site for central venous catheters both groups, with a 100% adoption rate.

This standardization in insertion practices may contribute to reducing variability and potential complications associated with differing insertion sites. In a study investigating the elements linked to a rise in catheter-related bloodstream infections the percentage of internal jugular vein utilized for central line insertion between femoral and subclavian was more than three-fourths**(Moriyama et al., 2022)**

Moreover, the majority of CVCs in both groups were triple-lumen catheters, The non-significant difference between triple and double-lumen catheters suggests that the number of lumens may not significantly impact CLABSI rates in this study. This aligns with a comparable finding by **(Pronovost et al., 2006)**. that there is no significant difference in infection rates between double and triple-lumen catheters.

Additionally, **(Varabyeva et al., 2023)** investigated the relationship between the number of lumens in central-line catheters and the incidence of CLABSIs in adult leukemia patients. Their findings indicated no statistically significant difference in CLABSI rates between patients using catheters with three lumens versus those with two lumens **(Varabyeva et al., 2023)** Bottom of Form,

In contrast a pilot study by **(Bozaan et al., 2019)** provides significant evidence that reducing the number of CVC lumens, especially in the case of PICCs, can effectively reduce the risk of complications and improve patient safety.

Regarding the place of line insertion, a slightly higher percentage of CVC placements occurred in the Intensive Care Unit (ICU) compared to the Emergency Room (ER) in both groups. While this direction may reflect the critical care nature of CVC placement. The non-significant difference between ICU and ER insertions is consistent with the findings of a study by **(Maki et al., 2006)**. that also did not observe a significant association between place of insertion site and CLABSI risk.

Our research demonstrates a correlation between the CVC use duration and the incidence of CLABSIs, More than 90% of cases who developed CLABSI in both groups have CVC duration more than 7days, our findings are in line with research conducted in a Japanese ICU revealed that longer durations of CVC insertion were correlated with an elevated risk of CLABSI, along with prolonged ICU stays and greater illness severity**(Moriyama et al., 2022)**.

Additionally, other studies indicate that the CVC placement duration continues to be a major a factor contributing to CLABSIs in hospital setting, despite the use of prevention measures **(Pitiriga et al., 2022)**

Most patients in both groups of the present study had their CVCs removed before leaving the ICU, the study found no significant difference in outcomes between the routine care and disinfecting cap groups, regardless of the duration of CVC placement (3-5 days, 6-7 days, or over 7 days).

interestingly It was advised by Ilan et al to remove the CVC prior ICU discharge (Ilan et al., 2012)

Comparing Total CLABSI Occurrence in the Studied groups

The observed significant reduction in CLABSI rates was linked with the utilization of disinfecting caps in the disinfecting cap group compared to the routine care group. This result highlights the Promise benefits of this intervention in preventing healthcare-associated infections.

The present study findings indicated a substantial difference in CLABSI incidence, only few numbers of patients in the disinfecting cap group experiencing infections compared to its triple in the routine care group. This statistically significant result ($p = .033$) underscores the importance of implementing preventive strategies such as disinfecting caps to mitigate the risk of CLABSI in clinical settings. This outcome aligns with accumulating evidence demonstrating the favorable impact of disinfecting caps on CLABSI prevention.

Several studies have echoed similar results, underscoring the effectiveness of disinfecting caps. For instance, Wright et al. (2013) reported 50% less infection rate with the use of disinfecting caps, while research focusing on a coronary ICU indicated a significantly lower infection risk associated with cap utilization, a decrease of nearly fourteen times**(Taşdelen Öğülmen & Ateş, 2021)**.

Furthermore, a meta-analysis by (Voor in ‘t holt et al., 2017) concluded that disinfecting caps substantially lower CLABSI rates and recommended their integration into central line maintenance bundles. This conclusion finds support in real-world evidence from (Hou et al., 2023) who demonstrated a significant decrease of over seventy percent in CLABSI rates linked with disinfecting cap adoption, leading to reductions in hospital duration of hospitalization and cost reduction.

The ease of use of disinfecting caps has been shown to simplify daily tasks, leading to high compliance rates (82%) and significant reductions in CLABSI rates (68% to 85.2%) (Martino et al., 2017)

Moreover, a comprehensive review of the literature revealed a reduction in CLABSI rates ranging from 30% to 87% with the utilization of disinfecting caps **(Jimenez et al., 2015; Merrill et al., 2014).**This wide range of reduction in CLABSI rates underscores the significant impact of disinfecting caps on infection prevention.

The high prevalence of Staphylococcus aureus-associated bloodstream infections and multidrug-resistant organisms (MDROs), as reported by **(Hamam et al., 2021)** underscores the pressing need for effective infection control measures. Our findings suggest that disinfecting caps could serve as a valuable tool in addressing this public health challenge.

Regarding the comparison of fever, chills, and hypotension occurrences between the control and intervention groups. It offers valuable insights into the clinical manifestations experienced by individuals in both cohorts following the implementation of disinfecting cap. While the results did not reveal statistically significant differences in the incidence of these symptoms between the two groups, the findings contribute to a comprehensive understanding of patient outcomes associated with central line placements and infection prevention strategies.

The analysis of fever, chills, and hypotension occurrences following central line placement revealed interesting observations, despite the lack of significant differences between the routine care and disinfecting cap groups. While the use of disinfecting caps did not appear to significantly impact the incidence of these specific symptoms, several important considerations emerge.

Firstly, the observation that over one-third of patients in both groups experienced fever highlights the inherent risk of infection associated with central line placements. Although the difference between the groups was not statistically significant, the relatively high fever rate emphasizes the need for rigorous infection prevention strategies, regardless of the specific intervention employed.

These findings align with previous research, such as that conducted by **(Elauoty et al., 2020.)** who found that Many critically ill patients with central lines experienced concerning symptoms. In their study, they reported that roughly one in six patients experienced fever,

Secondly, the low incidence of chills in both groups, which is echoed by **(Elauoty et al., 2020.)** coupled with the absence of a significant difference, suggests that chills might not be a reliable indicator of CLABSI in this context.

This finding aligns with **(Hyernard et al., 2019)** highlighting the variability of infection presentation, particularly in specific patient populations. Similar observations for hypotension further reinforce the need for a nuanced understanding of infection presentation.

While hypotension is often considered a hallmark of severe infection, its lack of association with the intervention in this study warrants further investigation. It is plausible that the disinfecting caps effectively prevented more severe infections that would typically manifest as hypotension, or that hypotension was driven by factors unrelated to CLABSI.

Furthermore, it is important to realize that relying only on classical signs like fever, chills, and hypotension to diagnose CLABSI might not be sufficient, especially in certain patient populations. Research has shown that older adults, for instance, frequently exhibit atypical presentations of bacteremia, and lacking these typical signs **(Hyernard et al., 2019)**. This underscores the need to consider patient characteristics for atypical presentation when interpreting these results.

Organisms Identified in CLABSI between routine care and disinfecting cap Groups

Among the identified organisms, Enterobacter was the most observed, with 10.4% of cases in the routine care group and 2.0% in the disinfecting cap group. Both groups showed lower rates of Staphylococcus aureus and Pseudomonas aeruginosa infections, with minimal variation between them.

Significantly, our findings align with those from diverse geographical locations and healthcare settings, providing a broader perspective on microbial patterns associated with bloodstream infections. For instance, the study conducted in the Kingdom of Bahrain showed gram-negative bacteria to be the most frequent pathogens causing CLABSI in ICU), accounting for 59% of cases. Among these, Enterobacter, Acinetobacter, and Staphylococcus epidermidis were the predominant organisms, with each accounting for 15% of cases**(Al-Khawaja et al., 2021)**

Similarly, in an academic medical center study spanning from 2015 to 2020, Coagulase-negative staphylococci were the most common Gram-positive culprit, closely followed by Staphylococcus aureus for CLABSI. paraphrase Enterobacteriaceae spp., Acinetobacter spp., and Pseudomonas spp. were the most frequently identified, causative agents of CLABSI among Gram-negative organisms, **(Alwazzeh et al., 2023).**

Moreover, in another study, the Acinetobacter species was the most prevalent organism isolated in cases of CLABSI, followed by Klebsiella pneumoniae and Enterobacter aerogenes. Intriguingly, a sensitivity analysis revealed significant differences in antimicrobial susceptibility patterns among both Gram-negative and Gram-positive bacteria **(Malek et al., 2019)** .

The microbiological analysis of the current study, while not yielding statistically significant differences, offer valuable insights into the potential benefits of disinfecting caps in preventing CLABSI. The high proportion of individuals in both groups without an identified organism (79.2% in the control and 93.9% in the intervention) speaks to the effectiveness of existing infection control protocols, aligning with observations from other studies that have documented substantial CLABSI reductions through quality improvement projects **(Ramirez et al., 2012)**.

However, the direction toward a higher proportion of cases with no identified organism in the intervention group suggests that disinfecting caps may provide an additional layer of protection. This observation is further strengthened by the finding that Enterobacter, a common nosocomial pathogen frequently implicated in CLABSI was more prevalent in the routine care group compared to the disinfecting cap group **(Al-Khawaja et al., 2021; Malek et al., 2019)**.

Although in the current study the difference was not statistically significant, it aligns with research demonstrating the efficacy of disinfecting caps in reducing bacterial colonization and CLABSI rates, particularly for Staphylococcus aureus (**Casey et al., 2018; Wright et al., 2013)**. This raises the possibility that disinfecting caps may create an environment less favorable to the growth of certain organisms, including Enterobacter.

(Casey et al., 2018) suggested that the disinfecting cap's effectiveness against CLABSIs could be due to its direct antimicrobial properties or its ability to act as a physical barrier against microbial entry into the catheter hub. Notably, they observed a lower incidence of Enterobacter infections in the intervention group, which is promising.

Conclusion

This study investigated the effect of using disinfecting cap on CLABSIs among critical ill patients. The results suggest that using disinfecting caps significantly reduces CLABSI incidence compared to traditional disinfection methods. This finding supports mounting evidence indicating effectiveness of disinfecting caps in mitigating CLABSI risk. The study also revealed important insights into the patient population and CLABSI characteristics in this setting.

The predominance of male patients and middle-aged adults aligns with typical ICU demographics. The high prevalence of Head injuries and pelvic fractures reflects the trauma-focused nature of the ICU where data was collected. While the study did not find significant differences in most CLABSI characteristics such as number of lumens, and place of line insertion, and CVC duration in days between the two groups, the significant reduction in overall CLABSI incidence in the intervention group underscores the potential benefit of disinfecting caps as a preventive measure.

The study's limitations include its relatively small sample size, particularly the limited number of CLABSI-confirmed cases, which may have impacted the study's power to detect statistically significant differences for some variables. Furthermore, the study was conducted at a single trauma ICU in Egypt, restricting the generalizability of the findings to other healthcare settings and patient populations.

Recommendations for Future Research.

Future research should address Conducting larger multicenter studies to enhance statistical power and generalizability, also including a wider range of infection indicators, including inflammatory markers, to capture potential atypical presentations, and developing and implementing targeted educational programs about CLABSI prevention through disinfecting cap use in different ICU settings could enhance healthcare professionals' knowledge and improve compliance with best practices.

Acknowledgements

We express our gratitude to the ICU nurses who took part in the research.

Conflict of interest authors have no competing interests to declare.

References

Al-Khawaja, S., Saeed, N. K., Al-khawaja, S., Azzam, N., & Al-Biltagi, M. (2021). Trends of central line-associated bloodstream infections in the intensive care unit in the Kingdom of Bahrain: Four years' experience. *World Journal of Critical Care Medicine*, *10*(5), 220–231. https://doi.org/10.5492/wjccm.v10.i5.220

Alwazzeh, M. J., Alnimr, A., Al Nassri, S. A., Alwarthan, S. M., Alhajri, M., AlShehail, B. M., Almubarak, M., Alghamdi, N. S., & Wali, H. A. (2023). Microbiological trends and mortality risk factors of central line-associated bloodstream infections in an academic medical center 2015–2020. *Antimicrobial Resistance and Infection Control*, *12*(1). https://doi.org/10.1186/s13756-023-01338-5

Atia, G. A. F. (2020). Effect of Central Venous Catheter Care Bundle Implementation on Outcomes of Critically Ill Patients. *Evidence-Based Nursing Research*, *2*(1), 12. https://doi.org/10.47104/ebnrojs3.v2i1.93

Australian Guidelines for the Prevention and Control of Infection in Healthcare (2010) | NHMRC. (n.d.). Retrieved June 12, 2022, from https://www.nhmrc.gov.au/about-us/publications/australian-guidelines-prevention-and-control-infection-healthcare-2010

Baier, C., Linke, L., Eder, M., Schwab, F., Chaberny, I. F., Vonberg, R. P., & Ebadi, E. (2020a). Incidence, risk factors and healthcare costs of central line-associated nosocomial bloodstream infections in hematologic and oncologic patients. *PLoS ONE*, *15*(1). https://doi.org/10.1371/JOURNAL.PONE.0227772

Baier, C., Linke, L., Eder, M., Schwab, F., Chaberny, I. F., Vonberg, R. P., & Ebadi, E. (2020b). Incidence, risk factors and healthcare costs of central line-associated nosocomial bloodstream infections in hematologic and oncologic patients. *PLoS ONE*, *15*(1). https://doi.org/10.1371/JOURNAL.PONE.0227772

Barton, A., Bitmead, J., Clare, S., Daniels, R., Gregory, B., Lee, P., Leitch, A., & McDonald, C. (2022). How to improve aseptic technique to reduce bloodstream infection during vascular access procedures. *British Journal of Nursing*, *31*(17), 880–885. https://doi.org/10.12968/BJON.2022.31.17.880

Beeler, C., Kerley, D., Davis, C., Hazen, D., Snyderman, W., Lyons, K., Sadowski, J., Sweeney, J., Dbeibo, L., Kelley, K., & Webb, D. H. (2019). Strategies for the successful implementation of disinfecting port protectors to reduce CLABSI in a large tertiary care teaching hospital. *American Journal of Infection Control*, *47*(12), 1505–1507. https://doi.org/10.1016/j.ajic.2019.05.016

Böhmer, A. B., Just, K. S., Lefering, R., Paffrath, T., Bouillon, B., Joppich, R., Wappler, F., & Gerbershagen, M. U. (2014). *Factors influencing lengths of stay in the intensive care unit for surviving trauma patients: a retrospective analysis of 30,157 cases*. https://doi.org/10.1186/cc13976

Bozaan, D., Skicki, D., Brancaccio, A., Snyder, A., Friebe, S., Tupps, M., Paje, D., & Chopra, V. (2019a). Less Lumens-Less Risk: A Pilot Intervention to Increase the Use of Single-Lumen Peripherally Inserted Central Catheters. *Journal of Hospital Medicine*, *14*(1), 42–46. https://doi.org/10.12788/JHM.3097

Bozaan, D., Skicki, D., Brancaccio, A., Snyder, A., Friebe, S., Tupps, M., Paje, D., & Chopra, V. (2019b). Less Lumens-Less Risk: A Pilot Intervention to Increase the Use of Single-Lumen Peripherally Inserted Central Catheters. *Journal of Hospital Medicine*, *14*(1), 42–46. https://doi.org/10.12788/JHM.3097

Buetti, N., Marschall, J., Drees, M., Fakih, M. G., Hadaway, L., Maragakis, L. L., Monsees, E., Novosad, S., O'Grady, N. P., Rupp, M. E., Wolf, J., Yokoe, D., & Mermel, L. A. (2022). Strategies to prevent central line-associated bloodstream infections in acute-care hospitals: 2022 Update. *Infection Control & Hospital Epidemiology*, *43*(5), 553–569. https://doi.org/10.1017/ICE.2022.87

Casey, A. L., Karpanen, T. J., Nightingale, P., & Elliott, T. S. J. (2018). An in vitro comparison of standard cleaning to a continuous passive disinfection cap for the decontamination of needle-free connectors. *Antimicrobial Resistance and Infection Control*, *7*(1). https://doi.org/10.1186/s13756-018-0342-0

Centers for Disease Control and Prevention. (2020). National diabetes statistics report Retrieved from: https://www.cdc.gov/diabetes/library/features/diabetes-statreport.html [Accessed: May 2024].

CDC, Ncezid, & DHQP. (2022). *Bloodstream Infection Event (Central Line-Associated Bloodstream Infection and Non-central Line Associated Bloodstream Infection)*.

Dudeck, M. A., Edwards, J. R., Allen-Bridson, K., Gross, C., Malpiedi, P. J., Peterson, K. D., Pollock, D. A., Weiner, L. M., & Sievert, D. M. (2015). National healthcare safety network report, data summary for 2013, device-associated module. *American Journal of Infection Control*, *43*(3), 206–221. https://doi.org/10.1016/j.ajic.2014.11.014

Eid, M. H., Ţânţu, M. –. M., Latour, J. M., Sultan, M. A., & Kandeel, N. A. (2023). Suction circuit flushing with chlorhexidine decreases ventilator-associated pneumonia: a quasi-experimental study. *Frontiers in Medicine*, *10*. https://doi.org/10.3389/fmed.2023.1295277

Ekwere, T., Control, I. O.-I. J. of I., & 2013, undefined. (2013). Hand hygiene knowledge and practices among healthcare providers in a tertiary hospital, south west, Nigeria. *Ijic.InfoTA Ekwere, IP OkaforInternational Journal of Infection Control, 2013•ijic.Info*, *9*, 4. https://doi.org/10.3396/IJIC.v9i4.032.13

Greenberg, R. G., Cochran, K. M., Smith, P. B., Edson, B. S., Schulman, J., Lee, H. C., Govindaswami, B., Pantoja, A., Hardy, D., Curran, J., Lin, D., Kuo, S., Noguchi, A., Ittmann, P., Duncan, S., Gupta, M., Picarillo, A., Karna, P., Cohen, M., … McCaffrey, M. J. (2015). Effect of Catheter Dwell Time on Risk of Central Line–Associated Bloodstream Infection in Infants. *Pediatrics*, *136*(6), 1080–1086. https://doi.org/10.1542/PEDS.2015-0573

Hamam, S., Sakr, A., Zahran, W., El Kholy, R., Kasemy, Z., Ibrahem, R., Sakr, M., & Younis, F. (2021). Health care-associated infections at an Egyptian tertiary care hospital: a 2-year prospective study. *Menoufia Medical Journal*, *34*(2), 514. https://doi.org/10.4103/mmj.mmj_455_20

Haque, M., Sartelli, M., Mckimm, J., Muhamad, &, Bakar, A., & Abu Bakar, M. (2018). Health care-associated infections–an overview. *Taylor & FrancisM Haque, M Sartelli, J McKimm, MA BakarInfection and Drug Resistance, 2018•Taylor & Francis*, *11*, 2321–2333. https://doi.org/10.2147/IDR.S177247

Hou, Y., Griffin, L. P., Ertmer, K., Bernatchez, S. F., Kärpänen, T. J., & Palka-Santini, M. (2023). Effectiveness of Disinfecting Caps for Intravenous Access Points in Reducing Central Line-Associated Bloodstream Infections, Clinical Utilization, and Cost of Care During COVID-19. *ClinicoEconomics and Outcomes Research*, *15*, 477–486. https://doi.org/10.2147/CEOR.S404823

Hyernard, C., Breining, A., Duc, S., Kobeh, D., Dubos, M., Prevel, R., Cazanave, C., Lambert, M., Bonnet, F., Mercie, P., Contis, A., Duffau, P., Camou, F., Guerville, F., Rainfray, M., & Roubaud-Baudron, C. (2019). Atypical Presentation of Bacteremia in Older Patients Is a Risk Factor for Death. *The American Journal of Medicine*, *132*(11), 1344-1352.e1. https://doi.org/10.1016/J.AMJMED.2019.04.049

Ilan, R., Doan, J., Cload, B., Squires, M., & Day, A. (2012). Removing nonessential central venous catheters: Evaluation of a quality improvement intervention. *Canadian Journal of Anesthesia*, *59*(12), 1102–1110. https://doi.org/10.1007/s12630-012-9794-5

Institute for Health Metrics and Evaluation. (2019). What causes the most deaths? Retrieved from: http://www.healthdata.org/egypt[Accessed: May 2024]

International Diabetes Federation. (2020). Egypt. Retrieved from: https://idf.org/ournetwork/regions-members/middle-east-and-north-africa/members/34-egypt.html[Accessed: May 2024]

Jimenez, A., Barrera, A., & Madhivanan, P. (2015). Systematic Review on Impact of Use of Disinfectant Caps Protectors for Intravenous Access Ports on Central Line-Associated Bloodstream Infections (CLABSI). *Open Forum Infectious Diseases*, *2*(suppl_1). https://doi.org/10.1093/ofid/ofv133.157

Keller, S. C., Williams, D., Gavgani, M., Hirsch, D., Adamovich, J., Hohl, D., Krosche, A., Cosgrove, S., & Perl, T. M. (2016). Environmental exposures and the risk of central venous catheter complications and readmissions in home infusion therapy patients. *Cambridge.OrgSC Keller, D Williams, M Gavgani, D Hirsch, J Adamovich, D Hohl, A Krosche, S Cosgroveinfection Control & Hospital Epidemiology, 2017•cambridge.Org*. https://doi.org/10.1017/ice.2016.223

Khalfallah, M., Elsheikh, A., Eissa, A., & Elnagar, B. (2023). Prevalence, Predictors, and Outcomes of Resistant Hypertension in Egyptian Population. *Global Heart*, *18*(1). https://doi.org/10.5334/gh.1211

Lissauer, M. E., Leekha, S., Preas, M. A., Thom, K. A., & Johnson, S. B. (2012). Risk factors for central line-associated bloodstream infections in the era of best practice. *Journal of Trauma and Acute Care Surgery*, *72*(5), 1174–1180. https://doi.org/10.1097/TA.0B013E31824D1085

Loveday, H. P., Wilson, J. A., Pratt, R. J., Golsorkhi, M., Tingle, A., Bak, A., Browne, J., Prieto, J., & Wilcox, M. (2014). Epic3: National evidence-based guidelines for preventing healthcare-associated infections in nhs hospitals in england. *Journal of Hospital Infection*, *86*(S1). https://doi.org/10.1016/S0195-6701(13)60012-2

Ma, J.-G., Zhu, B., Jiang, L., Jiang, Q., & Xi, M. (2021). *Gender-and age-based differences in outcomes of mechanically ventilated ICU patients: a Chinese multicentre retrospective study*. https://doi.org/10.1186/s12871-021-01555-8

Madni, T., & Eastman, A. L. (2018). CLABSI. *Surgical Critical Care Therapy: A Clinically Oriented Practical Approach*, 399–402. https://doi.org/10.1007/978-3-319-71712-8_38/COVER/

Maiguy-Foinard, A., Décaudin, B., … P. T.-, & 2019, undefined. (n.d.). Effect of multi-lumen perfusion line on catheter-related bacteremia in premature infants: study protocol for a cluster-randomized crossover trial. *Trialsjournal.Biomedcentral.Com*. Retrieved October 26, 2023, from https://trialsjournal.biomedcentral.com/articles/10.1186/s13063-019-3218-6

Maki, D., Kluger, D., Proceedings, C. C.-M. C., & 2006, undefined. (2006). The risk of bloodstream infection in adults with different intravascular devices: a systematic review of 200 published prospective studies. *ElsevierDG Maki, DM Kluger, CJ CrnichMayo Clinic Proceedings, 2006•Elsevier*, *81*(9), 1159–1171. https://www.sciencedirect.com/science/article/pii/S0025619611612275

Malek, A. M., Abouseif, H. A., Abd Elaziz, K. M., Allam, M. F., & Fahim, H. I. (2019). Incidence Of Central Line-associated Bloodstream Infections In Intensive Care Units In A Private Hospital (Cairo, Egypt). *The Open Public Health Journal*, *11*(1), 562–571.

https://doi.org/10.2174/1874944501811010562

Maqbool, S., Sharma, R., Cureus, S. M.-, & 2023, undefined. (2023). Incidence of Central Line-Associated Bloodstream Infection in a Tertiary Care Hospital in Northern India: A Prospective Study. *Cureus.ComS Maqbool, R Sharma, S MAQBOOLCureus, 2023•cureus.Com*. https://doi.org/10.7759/cureus.44501

Martino, A., Thompson, L., Mitchell, C., Trichel, R., Chappell, W., Miller, J., Allen, D., & Mann-Salinas, E. (2017). Efforts of a Unit Practice Council to implement practice change utilizing alcohol impregnated port protectors in a burn ICU. *Burns*, *43*(5), 956–964. https://doi.org/10.1016/j.burns.2017.01.010

Mermel, L. A., Allon, M., Bouza, E., Craven, D. E., Flynn, P., O'Grady, N. P., Raad, I. I., Rijnders, B. J. A., Sherertz, R. J., & Warren, D. K. (2009). Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 update by the infectious diseases society of America. In *Clinical Infectious Diseases* (Vol. 49, Issue 1, pp. 1–45). https://doi.org/10.1086/599376

Merrill, K. C., Sumner, S., Linford, L., Taylor, C., & Macintosh, C. (2014). Impact of universal disinfectant cap implementation on central lineeassociated bloodstream infections. *American Journal of Infection Control*, *42*(12), 1274–1277. https://doi.org/10.1016/j.ajic.2014.09.008

Mishra, S. B., Misra, R., Azim, A., Baronia, A. K., Prasad, K. N., Dhole, T. N., Gurjar, M., Singh, R. K., & Poddar, B. (2017). Incidence, risk factors and associated mortality of central line-associated bloodstream infections at an intensive care unit in Northern India. *International Journal for Quality in Health Care*, *29*(1), 63–67. https://doi.org/10.1093/intqhc/mzw144

Mohamed Elsayed Ali Elauoty, R., Hussein Ali, Z., Ali Bader, G., & Elsayed Abo Ghabsha, M. (n.d.-a). Assessment of Central Line Associated Blood Stream Infection among Critical Ill Patients. In *International Journal of Novel Research in Healthcare and Nursing* (Vol. 7). www.noveltyjournals.com

Mohamed Elsayed Ali Elauoty, R., Hussein Ali, Z., Ali Bader, G., & Elsayed Abo Ghabsha, M. (n.d.-b). Assessment of Central Line Associated Blood Stream Infection among Critical Ill Patients. *International Journal of Novel Research in Healthcare and Nursing*, *7*, 235–246. Retrieved July 16, 2024, from www.noveltyjournals.com

Moriyama, K., Ando, T., Kotani, M., Tokumine, J., Nakazawa, H., Motoyasu, A., & Yorozu, T. (2022). *Medicine ® Risk factors associated with increased incidences of catheter-related bloodstream infection*. https://doi.org/10.1097/MD.0000000000031160

O'grady, N. P., Alexander, M., Burns, L. A., Dellinger, E. P., Garland, J., Heard, S. O., Lipsett, P. A., Masur, H., & Mermel, L. A. (2011). Guidelines for the Prevention of Intravascular Catheter-related Infections. *Clinical Infectious Diseases*, *52*(9), 162–193. https://doi.org/10.1093/cid/cir257

Parameswaran, R., Sherchan, J. B., Varma, M., Mukhopadhyay, C., & Vidyasagar, S. (2011). Intravascular catheter-related infections in an Indian tertiary care hospital. *Jidc.OrgR Parameswaran, JB Sherchan, C Mukhopadhyay, S VidyasagarThe Journal of Infection in Developing Countries, 2011•jidc.Org*. http://jidc.org/index.php/journal/article/view/1261

Pitiriga, V., Bakalis, J., Kampos, E., Kanellopoulos, P., Saroglou, G., & Tsakris, A. (2022). Duration of central venous catheter placement and central line-associated bloodstream infections after the adoption of prevention bundles: a two-year retrospective study. *Antimicrobial Resistance and Infection Control*, *11*(1). https://doi.org/10.1186/s13756-022-01131-w

Pronovost, P., Needham, D., Berenholtz, S., Sinopoli, D., Chu, H., Cosgrove, S., Sexton, B., Hyzy, R., Welsh, R., Roth, G., Bander, J., Kepros, J., & Goeschel, C. (2006). An Intervention to Decrease Catheter-Related Bloodstream Infections in the ICU. *New England Journal of Medicine*, *355*(26), 2725–2732. https://doi.org/10.1056/NEJMOA061115

Ramirez, C., Lee, A. M., & Welch, K. (2012). Central Venous Catheter Protective Connector Caps Reduce Intraluminal Catheter-Related Infection. *Journal of the Association for Vascular Access*, *17*(4), 210–213. https://doi.org/10.1016/J.JAVA.2012.10.002

Reynolds, S. S., Woltz, P., Keating, E., Neff, J., Elliott, J., Hatch, D., Yang, Q., & Granger, B. B. (2021). Results of the CHlorhexidine Gluconate Bathing implementation intervention to improve evidence-based nursing practices for prevention of central line associated bloodstream infections Study (CHanGing BathS): a stepped wedge cluster randomized trial. *Implementation Science*, *16*(1). https://doi.org/10.1186/S13012-021-01112-4

Richter, J. P., & McAlearney, A. S. (2018). Targeted implementation of the Comprehensive Unit-Based Safety Program through an assessment of safety culture to minimize central line-associated bloodstream infections. *Health Care Management Review*, *43*(1), 42–49. https://doi.org/10.1097/HMR.0000000000000119

Rogers, J., & Révész, A. (2019). Experimental and quasi-experimental designs. *The Routledge Handbook of Research Methods in Applied Linguistics*, 133–143. https://doi.org/10.4324/9780367824471-12/EXPERIMENTAL-QUASI-EXPERIMENTAL-DESIGNS-JOHN-ROGERS-ANDREA-R

Savetamal, A. (2021). Infection in Elderly Burn Patients: What Do We Know? *Surgical Infections*, *22*(1), 65–68. https://doi.org/10.1089/SUR.2020.322

Selby, L. M., Rupp, M. E., & Cawcutt, K. A. (2021). Prevention of Central-Line Associated Bloodstream Infections: 2021 Update. *Infectious Disease Clinics of North America*, *35*(4), 841–856. https://doi.org/10.1016/J.IDC.2021.07.004

Sweet, M. A., Cumpston, A., Briggs, F., Craig, M., & Hamadani, M. (2012). Impact of alcohol-impregnated port protectors and needleless neutral pressure connectors on central line-associated bloodstream infections and contamination of blood cultures in an inpatient oncology unit. *American Journal of Infection Control*, *40*(10), 931–934. https://doi.org/10.1016/j.ajic.2012.01.025

Talaat, M., El-Shokry, M., El-Kholy, J., Ismail, G., Kotb, S., Hafez, S., Attia, E., & Lessa, F. C. (2016). National surveillance of health care–associated infections in Egypt: Developing a sustainable program in a resource-limited country. *American Journal of Infection Control*, *44*(11), 1296–1301. https://doi.org/10.1016/J.AJIC.2016.04.212

Talbot, T., Bratzler, D., … R. C.-A. of internal, & 2013, undefined. (2013). Public reporting of health care–associated surveillance data: recommendations from the Healthcare Infection Control Practices Advisory Committee. *Acpjournals.OrgTR Talbot, DW Bratzler, RM Carrico, DJ Diekema, MK Hayden, SS Huang, DS YokoeAnnals of Internal Medicine, 2013•acpjournals.Org*, *159*(9), 631–635. https://doi.org/10.7326/0003-4819-159-9-201311050-00011

Taşdelen Öğülmen, D., & Ateş, S. (2021). Use of alcohol containing caps for preventing bloodstream infections: A randomized controlled trial. *Journal of Vascular Access*, *22*(6), 920–925. https://doi.org/10.1177/1129729820952961

Templeton, A., Schlegel, M., Fleisch, F., Rettenmund, G., Schöbi, B., Henz, S., & Eich, G. (2008). Multilumen central venous catheters increase risk for catheter-related bloodstream infection: Prospective surveillance study. *Infection*, *36*(4), 322–327. https://doi.org/10.1007/S15010-008-7314-X/METRICS

Toor, H., Farr, S., Savla, P., Kashyap, S., Wang, S., Cureus, D. M.-, & 2022, undefined. (2022). Prevalence of central line-associated bloodstream infections (CLABSI) in intensive care and medical-surgical units. *Cureus.ComH Toor, S Farr, P Savla, S Kashyap, S Wang, DE MiulliCureus, 2022•cureus.Com*. https://doi.org/10.7759/cureus.22809

Varabyeva, A., Lo, C. P. S., Brancaccio, A., Perissinotti, A. J., Patel, T., Sandison, K., Benitez, L. L., Pettit, K., Burke, P. W., Bixby, D. L., & Marini, B. L. (2023). Impact of number of lumens in central-venous catheters on central-line bloodstream infection (CLABSI) and venous thromboembolism (VTE) risk in patients with acute leukemia. *Infection Control & Hospital Epidemiology*, *44*(1), 125–127. https://doi.org/10.1017/ICE.2021.423

Voor in ‘t holt, A. F., Helder, O. K., Vos, M. C., Schafthuizen, L., Sülz, S., van den Hoogen, A., & Ista, E. (2017). Antiseptic barrier cap effective in reducing central line-associated bloodstream infections: A systematic review and meta-analysis. *International Journal of*

Nursing Studies, *69*, 34–40. https://doi.org/10.1016/J.IJNURSTU.2017.01.007

World Health Organization. (2016). What are neurological disorders? Retrieved from: https://www.who.int/news/item/27-02-2007-neurological-disorders-affectmillions-globally-who-report [Accessed: May 2024]

Wright, M. O., Tropp, J., Schora, D. M., Dillon-Grant, M., Peterson, K., Boehm, S., Robicsek, A., & Peterson, L. R. (2013). Continuous passive disinfection of catheter hubs prevents contamination and bloodstream infection. *American Journal of Infection Control*, *41*(1), 33–38. https://doi.org/10.1016/J.AJIC.2012.05.030

Xie, J., Tong, Z., Guan, X., Du, B., Qiu, H., & Slutsky, A. S. (2020). Critical care crisis and some recommendations during the COVID-19 epidemic in China. *Intensive Care Medicine*, *46*, 837–840. https://doi.org/10.1007/s00134-020-05979-7