



## RESEARCH ARTICLE

### ASSESSMENT OF KNOWLEDGE AND ATTITUDE OF PATIENTS ON HEMODIALYSIS TOWARD PREVENTION OF CENTRAL VENOUS CATHETERS ASSOCIATED BLOOD STREAM INFECTIONS, DURING ONGOING SUDAN WAR: A CROSS SECTIONAL STUDY.

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#### ABSTRACT

**Background:** Central venous Catheter (CVC) associated bloodstream infections remain a significant cause of morbidity and mortality among hemodialysis patients. Improving patient knowledge and attitudes is crucial for prevention. **Objectives:** To assess the knowledge and attitudes of patients receiving hemodialysis toward prevention of central venous catheter associated blood stream infections during the ongoing war in Sudan. **Methodology:** A descriptive cross-sectional hospital-based study, conducted at Ad Doueim Dialysis Centre, White Nile State, Sudan, from January to April 2026, during the ongoing war period. Data were collected from patients using a pre-tested structured questionnaire covering demographics, knowledge of signs/symptoms of catheter infection, and attitudes toward catheter care. **Results:** The study included a total of 70 patients undergoing hemodialysis. 37.1% (n=26) were aged above 50 years, males constituted 65.7% (n=46). 74.3% (n=52) from rural areas. 65.7% (n=46) of low educational level. 64.3% (n=45) had a previous history of a central venous catheter (CVC) related bloodstream infection. 64.3% (n=45) were using temporary catheters. 35.7% (n=25) were using long term tunneled catheters. 81.4% (n=57) demonstrated awareness of the importance of hand hygiene. 20% (n=14) were able to correctly identify local signs of infection such as redness, pain, or purulent discharge. Statistically significant associations were identified between knowledge level and infection rate (P value = 0.01), educational level and level of awareness (p value=0.03), as well as duration of hemodialysis and occurrence of infection (p value = 0.02). **Conclusion:** The study highlights substantial gaps in patient knowledge and preventive practices regarding central venous line associated blood stream infections. Low educational level, inadequate health education, and prolonged catheter use were associated with increased infection risk. Structured educational interventions and continuous patient awareness programs are strongly recommended to improve catheter care and reduce infections among hemodialysis patients. Strict infection control measures and proper catheter care practices should be reinforced by healthcare providers. Early reporting of infection symptoms should be encouraged, and adequate educational and infection prevention resources should be ensured in dialysis centres.

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## INTRODUCTION

End-stage kidney disease (ESKD), which is an advanced stage of chronic kidney disease (CKD), is a common global health challenge that is rapidly increasing the burden and need for renal replacement therapy [1, 2]. In 2016, there were 6500 patients on dialysis in Sudan, and more than 95% of these patients were dependent on hemodialysis [3]. The commonest form of renal replacement therapy (RRT) used to avert the complications of CKD such as uremia is renal hemodialysis [4]. Efficient haemodialysis requires a

well-functioning intravascular access which includes a native arteriovenous fistula, an arteriovenous graft, or a central line [5]. The most important risk factor for bacteremia in patients on dialysis according to studies is central venous catheter (CVC) [6]. A short-term central Venous catheter is a widely used alternative for hemodialysis, especially in emergency situations when there is no permanent and viable venous access for treatment. It is estimated that, among 91.2% of the hemodialysis patients in Brazil, 16.6% use the CVCs as the access route and, of these CVCs, 9.2% are of short-term [7]. There are a lot of advantages to the CVCs; however, when compared to other types of accesses, it is a major risk factor for

primary bloodstream infection (BSI). It is also associated with an increase in the risk of mortality and/or in the risk of other complications, such as endocarditis, epidural abscess, and arthritis [8, 9]. Central-line associated bloodstream infections (CLABSIs), exit-site infections, and tunnel infections are common complications related to hemodialysis central line use. Central Line associated bloodstream infections (CLABSIs) alone have a reported incidence of 1.1 to 5.5 episodes per 1000 catheter days and are associated with increased morbidity, hospitalization, and death [10, 11]. The risk of CLABSIs in patients on hemodialysis increases with the length of central line access dependence [12, 13]. Their increased risk is because of impaired immunity, the presence of comorbidity, undernourishment, and the repeated introduction of catheters during hemodialysis which breaks down the natural protective barriers [14].

**Objective:** Assessment of Knowledge and attitudes of patients on hemodialysis toward prevention of central venous catheters associated blood stream infections during the ongoing war in Sudan .

## Methodology

**Study Design:** A descriptive cross-sectional hospital-based study.

**Study Area:** Ad-Doueim is a town in Sudan, it lies on the western bank of the White Nile State, about 190 km south of the capital Khartoum [14 N, 32 E]. Cover approximately 9,183.5 km and the estimated population of the city is around 87,000 people. Ad-Doueim hemodialysis center equipped with 11 hemodialysis machines across two rooms, include 101 hemodialysis patients.

**Study Period:** The study was conducted from January to April 2026

**Study Population:** The study population included patients undergoing hemodialysis through central venous catheters.

**Inclusion Criteria:** Patients on hemodialysis via central venous line. Patients willing to participate and provide informed consent

**Exclusion Criteria:** Patients critically ill and unable to respond. Patients refused to participate.

**Sample Size and technique:** Total coverage sampling technique was used because the total number of patients using central venous catheters was less than 100. The final sample size consisted of (70) patients who fulfilled the inclusion criteria and agreed to participate in the study

## Study variable

### Dependent variable

Patients knowledge regarding prevention of central venous lines associated blood stream infections.

Patients attitudes toward prevention of central venous lines associated blood stream infections.

### Independent Variable

Age of patients .

Gender.

Educational level.

Type of catheter.

Duration on hemodialysis.

History of central line replacement or removal.

Previous experience with central line complications.

## Confounding variables

Duration of catheter use.

Presence of comorbidity.

Adherence to care instructions.

## The Data Collection Tool

**Structured interviewer-administered questionnaire, including three parts:**

- Socio-demographic and clinical characteristics.
- Knowledge questions on central line infection prevention.
- Attitude scale using Likert-type questions.

**The Ethical Considerations:** Ethical approval was obtained from Scientific Research Committee, Faculty of Medicine and Health Sciences, University of Bakht El-Ruda. Permission was obtained from the general manager of Ad-Doueim Dialysis center. Informed consent was obtained from patients before data collection. Confidentiality and privacy were maintained throughout the study.

**Data analyzed method:** Data were analyzed using SPSS version 21, Descriptive statistics such as frequency and percentage were used, inferential statistics were applied to test associations. A p value of less than 0.05 was considered statistically significant.

# RESULTS AND DATA ANALYSIS

**Demographic Distribution:** Statistical data indicate that the age group most susceptible to End-Stage Renal Disease (ESRD) in the sample is over 50 years of age, accounting for 37.1% (n=26), reflecting a strong correlation between aging and the deterioration of renal functions. Males dominate the sample at 65.7% (n=46). Sociologically, a sharp decline in educational levels is observed, as illiterate individuals and those with only primary education constitute 65.7% (n=46) of the sample, with a dense population concentration in rural areas 74.3% (n=52). These demographic indicators play a pivotal role in health literacy absorption and the application of sterilization protocols (Table 1)

**Table (1). Demographic Distribution of the Study Sample (N = 70)**

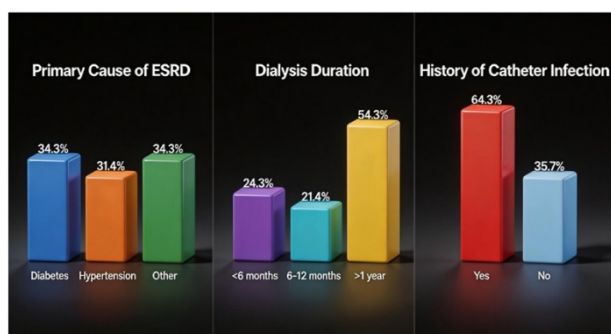
| Variable        | Category      | Frequency | Percentage (%) |
|-----------------|---------------|-----------|----------------|
| Age             | 18 – 30 years | 11        | 15.7%          |
|                 | 31 – 41 years | 16        | 22.9%          |
|                 | 41 – 50 years | 17        | 24.3%          |
|                 | Over 50 years | 26        | 37.1%          |
|                 | <b>Total</b>  | <b>70</b> | <b>100%</b>    |
| Gender          | Male          | 46        | 65.7%          |
|                 | Female        | 24        | 34.3%          |
|                 | <b>Total</b>  | <b>70</b> | <b>100%</b>    |
| Education Level | Illiterate    | 15        | 21.4%          |
|                 | Primary       | 31        | 44.3%          |
|                 | Secondary     | 14        | 20.0%          |
|                 | University    | 10        | 14.3%          |
|                 | <b>Total</b>  | <b>70</b> | <b>100%</b>    |
| Residence       | Rural         | 52        | 74.3%          |
|                 | Urban         | 18        | 25.7%          |
|                 | <b>Total</b>  | <b>70</b> | <b>100%</b>    |

**Environmental Factor - Source of Water:** 41.4% (n=29) rely on tap water, while an alarming 58.6% (n=41) depend on untreated sources, wells at 35.7% (n=25) and rivers at 22.9% (n=16) (Table 2).

**Table 2. Distribution of Participants by Source of Water**

| Source    | Frequency | Percentage (%) |
|-----------|-----------|----------------|
| Tap water | 29        | 41.4%          |
| Well      | 25        | 35.7           |
| River     | 16        | 22.9%          |
| Total     | 70        | 100%           |

**Medical History and Infection Prevalence:** Clinical analysis reveals that Diabetes 34.3% (n=24) and Hypertension 31.4% (n=22) are the primary drivers of ESRD. Analytically, the presence of 54.3% (n=38) of patients undergoing dialysis for over a year, in parallel with a recorded prior catheter infection rate of 64.3% (n=45) confirms that infection is not an incidental event but a chronic clinical reality associated with prolonged exposure time within the center (Figure1).



**Figure 1. Clinical Distribution and Medical History of Patient**

**Type of Catheter Impact:** Data confirm that 64.3% (n=45) of patients use temporary catheters, compared to 35.7% (n=25) for long term tunneled catheters. From a scientific perspective, the tilt in favor of temporary catheters explains the observed high infection rates, as temporary catheters lack a protective cuff and are more prone to microbial migration through the insertion tract, in addition to often being inserted under emergency conditions where sterilization rigor may be less stringent (Table 4)

**Table 4. Distribution of Participants by Type of Central Venous Catheter (CVC)**

| Type of CVC        | Frequency | Percentage (%) |
|--------------------|-----------|----------------|
| Temporary          | 45        | 64.3%          |
| Tunneled Long Term | 25        | 35.7%          |
| Total              | 70        | 100%           |

**Clinical Mapping of Insertion Sites:** The temporary right internal jugular vein leads the insertion sites 41.4%(n=29), followed by the long term tunneled right internal jugular vein 35.7%(n=25). Despite relative adherence to lower-risk sites, the use of the femoral vein 10.0% (n=7) remains a concerning factor, as it is globally classified as the highest-risk site for enteric bacterial contamination, statistically contributing to the overall infection rates in the study (Table 5)

**Table 5. Distribution of Participants according to CVC\* Insertion Site**

| Site                                           | Frequency | Percentage (%) |
|------------------------------------------------|-----------|----------------|
| Temporary Right Internal Jugular Vein          | 29        | 41.4%          |
| Tunneled Long Term Right Internal Jugular Vein | 25        | 12.9%          |
| Temporary Left Internal Jugular Vein           | 9         | 10.0%          |
| Temporary Right Femoral Vein                   | 7         | 35.7%          |
| Total                                          | 70        | 100%           |

\*CVC=Central Venous Catheter.

**Dynamics of Catheter Replacement:** Results showed that 64.3% (n=45) of patients underwent previous catheter replacements. Upon further analysis, Infection is the leading cause at 62.2% (n=28), surpassing Obstruction 22.2% (n=10) and mechanical problems 15.6% (n=7). This hierarchy confirms that microbial control failure is the primary barrier to maintaining vascular access continuity among the center's patients (Table 6)

**Table 6. History and Reasons for Catheter Removal or Replacement**

| Variable                  | Category            | Frequency | Percentage (%) |
|---------------------------|---------------------|-----------|----------------|
| Prior Removal/Replacement | Yes                 | 45        | 64.3%          |
|                           | No                  | 25        | 35.7%          |
|                           | <b>Total</b>        | <b>70</b> | <b>100%</b>    |
| Reason for Removal        | Infection           | 28        | 62.2%          |
|                           | Obstruction         | 10        | 22.2%          |
|                           | Mechanical Problems | 7         | 15.6%          |
|                           | <b>Total</b>        | <b>45</b> | <b>100%</b>    |

**Assessment of Knowledge:** Despite a general theoretical awareness of the importance of hand hygiene 81.4% (n=57), there is a 'qualitative ignorance' of clinical symptoms; only 20% (n=14) of participants could identify critical local symptoms such as redness and pus. This discrepancy indicates that patient knowledge is superficial and does not reach the level of 'preventive awareness' required for early intervention before an infection escalates into full-blown systemic sepsis. (Table 7)

**Table 7. Patient Perception of Infection, Symptoms, and Complications (n=70).**

| Knowledge Item                            | Response (Yes) | Frequency | Percentage (%) |
|-------------------------------------------|----------------|-----------|----------------|
| Catheter can cause bloodstream infection  | Yes            | 46        | 65.7%          |
| Knowledge of symptoms: Fever              | Yes            | 45        | 64.3%          |
| Knowledge of symptoms: Chills             | Yes            | 27        | 38.6%          |
| Knowledge of symptoms: Redness/Pain/Pus   | Yes            | 14        | 20%            |
| Knowledge of serious complications        | Yes            | 31        | 44.3%          |
| Importance of hand hygiene for prevention | Yes            | 57        | 81.4%          |

**Institutional Role:** 44.3% (n=31) of patients reported receiving no preventive instructions from the medical team. This figure represents a serious institutional gap; the failure of nearly half the sample to receive professional guidance directly explains the poor practices recorded and places responsibility for the spread of infection on the deficiency of health education programs within the dialysis unit (Table 8)

**Table (8): Healthcare Team Instructions Provided to Participants (n=70)**

| Question                                                                       | Response     | Frequency | Percentage (%) |
|--------------------------------------------------------------------------------|--------------|-----------|----------------|
| Did the healthcare team provide you with instructions on preventing infection? | Yes          | 39        | 55.7%          |
|                                                                                | No           | 31        | 44.3%          |
|                                                                                | <b>Total</b> | <b>70</b> | <b>100.0%</b>  |

**Attitude Toward Catheter Self-Care:** The study showed that the majority of participants had positive attitudes toward catheter self-care and infection prevention practices. Most participants (92.9%, n=65) believed that keeping the catheter covered and dry is important to prevent infection, while 77.1% (n=54) reported positive attitudes toward regular hand washing before touching the catheter. In addition, 78.6% (n=55) of participants expressed willingness to follow healthcare workers' instructions regarding catheter care and infection prevention. However, despite these positive attitudes, some participants still demonstrated inadequate practices toward catheter self-care. About 15.7% (n=11) of participants did not take appropriate action when catheter dressings became wet or contaminated, and (17.1%, n=12) changed dressings using non-sterile methods. These findings indicate a gap between patients' attitudes and their actual practices regarding catheter care (Table 9).

**Table (9). Attitudes Toward Catheter Self-Care (n=70)**

| Behavioral Attitude                                                         | Response (Yes) | Frequency | Percentage (%) |
|-----------------------------------------------------------------------------|----------------|-----------|----------------|
| Positive attitude toward hand washing                                       | Yes            | 54        | 77.1%          |
| Positive attitude toward keeping catheter covered                           | Yes            | 65        | 92.9%          |
| Commitment to follow medical instructions                                   | Yes            | 55        | 78.6%          |
| Follow the instructions given by the healthcare team regarding the catheter | Yes            | 37        | 52.9%          |

The results indicate that most patients 37.2% (n=26) prefer going to the nearest health center when the catheter dressing becomes wet, loose, or dirty, reflecting a moderate awareness of the seriousness of catheter-related complications and the need for professional medical care. Only 30% (n=21) perform a sterile dressing change, which is considered a relatively low percentage and suggests limited practical skills in proper catheter care. In addition, 17.1% (n=12) perform non sterile dressing changes and 15.7% (n=10) take no action at all, both of which are risky behaviors that may increase the likelihood of developing central venous catheter infection (Table 10).

**Table (10): Distribution of Participants by Action Toward Wet, Loose, or Dirty Dressing**

| Action                          | Frequency | Percentage (%) |
|---------------------------------|-----------|----------------|
| Sterile change                  | 21        | 30.0%          |
| Non-sterile change              | 12        | 17.1%          |
| Go to the nearest health center | 26        | 37.2%          |
| Do nothing                      | 11        | 15.7%          |
| <b>Total</b>                    | <b>70</b> | <b>100.0%</b>  |

**Correlation Analysis:** Chi-Square tests proved significant relationships; the correlation between knowledge deficit and high infection rates was highly statistically significant ( $P=0.01$ ). It was also proven that educational level directly influences awareness levels ( $P=0.03$ ), and that prolonging dialysis for more than a year increases the likelihood of infection ( $P=0.02$ ) (Table 11)

**Table (11): Correlations Between Study Variables (Chi-Square Test)**

| Association Tested                 | Chi-Square | *P-value | Significance       |
|------------------------------------|------------|----------|--------------------|
| Education Level x Knowledge        | 6.9        | 0.03     | Significant        |
| Knowledge Level x Infection Rate   | 8.2        | 0.01     | Highly Significant |
| Dialysis Duration x Infection Rate | 7.5        | 0.02     | Significant        |

\*P-Value <0.05 is significant.

## DISCUSSION

This is a descriptive cross-sectional analytical study was conducted to assess the level of knowledge, attitudes, and practices regarding the prevention of central venous line associated bloodstream infections among hemodialysis patients at Ad Doueim Dialysis Center, White Nile State, Sudan during the ongoing war. The study adopted a scientific analytical approach linking statistical findings with previous scientific evidence to explain the demographic, clinical, behavioral, and environmental factors influencing infection occurrence. The findings demonstrated that central venous line associated bloodstream infection is influenced by multiple interconnected factors including age, gender, educational level, environmental conditions, duration of dialysis, type of catheter, and patients' level of health awareness.

The study findings revealed that the age group above 50 years represented the highest proportion of participants, accounting for 37.1% (n=26), followed by participants aged 41–50 years who represented 24.3% (n=17). This finding reflects the well-established relationship between advanced age and the progression of chronic kidney disease (CKD) toward End-Stage Renal Disease (ESRD). Aging is associated with gradual nephron loss, vascular changes, chronic inflammation, and increased prevalence of chronic illnesses such as diabetes mellitus and hypertension, all of which contribute to renal impairment [1]. Furthermore, elderly patients are more susceptible to infections due to weakened immunity, delayed wound healing, and repeated invasive procedures. Similar findings were reported by Eriksen and Ingebreetsen (2006), who identified age as a major predictor of CKD progression [2]. Regarding gender distribution, males represented the majority of the study sample with 65.7% (n=46), whereas females accounted for 34.3% (n=24). This predominance may be attributed to the higher prevalence of hypertension, smoking, cardiovascular diseases, and unhealthy lifestyle behaviors among males. Gender disparities in healthcare accessibility and health-seeking behaviors may also contribute to this variation. These findings are consistent with Hallan *et al.* (2006), who reported that ESRD is more prevalent among males than females [4].

Concerning educational level, the proportion of illiterate participants reached 21.4% (n=15), while participants with only primary education represented 44.3% (n=31). Therefore, more than two-thirds of the participants had a low educational background. This finding represents one of the most significant explanatory indicators in the study because it is strongly associated with health literacy, which plays a crucial role in patients' adherence to preventive and therapeutic instructions. Patients with lower educational levels often experience difficulties understanding medical terminology, infection prevention instructions, sterile techniques, and early signs of catheter-related infection. Consequently, lower educational attainment contributes to poor preventive practices and increased susceptibility to infection. The study also demonstrated a statistically significant association between educational level and infection-related knowledge ( $P = 0.03$ ), indicating that reduced educational status negatively affects preventive awareness and behavior [5,6]. These findings agree with Ibrahim *et al.* (2018), who reported that lower educational levels were associated with poor adherence to catheter care recommendations among hemodialysis patients [23].

The majority of participants resided in rural areas, representing 74.3% (n=52), while only 25.7% (n=18) lived in urban settings. This finding highlights the significant environmental and socioeconomic challenges affecting healthcare outcomes in rural communities. Rural residence is commonly associated with limited access to specialized healthcare services, poor health infrastructure, inadequate health education programs, and lower socioeconomic conditions, all of which contribute to increased vulnerability to healthcare-associated infections. Patients from rural areas often travel long distances to dialysis centers, leading to physical exhaustion and reduced ability to maintain proper catheter hygiene and self-care. Similar findings were documented by Ahmed *et al.* (2022), who reported higher infection rates among Sudanese hemodialysis patients living in rural areas due to inadequate healthcare resources and environmental limitations<sup>[24]</sup>.

From an environmental perspective, the findings showed that 35.7% (n=25) relied on well water, 22.9% (n=16) depended on river water, whereas only 41.4% (n=29) used tap water. This finding is particularly alarming because water quality is considered a fundamental determinant in infection prevention and control. Repeated exposure to contaminated water during hand washing or dressing changes may facilitate the transmission of Gram-positive and Gram-negative bacteria to the catheter insertion site, thereby increasing the risk of bacteremia and bloodstream infections. Inadequate water supply and sanitation systems have been strongly associated with increased healthcare-associated infections in low-resource countries<sup>[9,10]</sup>.

Regarding the causes of CKD, diabetes mellitus represented the leading cause of ESRD among participants with 34.3% (n=24), followed by hypertension with 31.4% (n=22). These findings are consistent with global epidemiological data indicating that diabetes mellitus and hypertension are the primary causes of CKD and ESRD worldwide. Chronic hyperglycemia contributes to glomerular damage and microvascular complications, while uncontrolled hypertension damages renal blood vessels and accelerates renal dysfunction. Additionally, diabetic patients often exhibit impaired immunity and delayed wound healing, increasing their susceptibility to infection [11].

The results further demonstrated that 54.3% (n=38) of patients had been undergoing hemodialysis for more than one year. Analytically, the presence of 54.3% (n=38) of patients undergoing dialysis for over a year, in parallel with a recorded prior catheter infection rate of 64.3% (n=45) confirms that infection is not an incidental event but a chronic clinical reality associated with prolonged exposure time within the center. Prolonged duration of dialysis is considered a significant risk factor for infection because patients are repeatedly exposed to invasive procedures, catheter manipulation, and healthcare environments. Long-term dialysis may also lead to psychological exhaustion and reduced compliance with preventive measures. The study revealed a statistically significant association between duration of dialysis and occurrence of infection ( $P = 0.02$ ), confirming that prolonged hemodialysis exposure increases infection risk<sup>[12]</sup>. Moreover, 64.3% (n=45) of patients reported previous catheter-related infections, indicating that it represents a major healthcare problem within the dialysis center. This high prevalence reflects deficiencies in infection prevention programs, inadequate patient education, and poor catheter care practices.

The high infection rate may also be associated with the extensive use of temporary catheters, poor environmental conditions, and inadequate health literacy. Regarding catheter type, 64.3% (n=45) of patients used temporary catheters, whereas 35.7% (n=25) used long-term catheters. Temporary catheters are more susceptible to infection because they lack protective mechanisms such as subcutaneous tunneling and antimicrobial barriers present in permanent vascular access devices. In addition, temporary catheters are often inserted under emergency conditions, which may compromise strict aseptic techniques. Similar findings were reported by Maki *et al.* (2006), who concluded that temporary catheters are associated with higher infection rates compared with long term catheters and arteriovenous fistulas<sup>[16]</sup>.

Concerning catheter insertion sites, the right internal jugular vein (temporary one) was the most commonly used insertion site with 41.4% (n=29), followed by the right internal jugular vein (long term tunneled one) 35.7% (n=25). Although the right internal jugular vein is globally recommended due to its lower risk of thrombosis and infection, the continued use of femoral catheters among some patients remains concerning because femoral sites are more vulnerable to bacterial contamination owing to their proximity to moist and contaminated body regions<sup>[15]</sup>. The study also showed that 64.3% (n=45) of patients had undergone previous catheter removal or replacement, with infection representing the leading cause in 62.2% (n=28). This finding illustrates the substantial impact of infection on vascular access sustainability. Catheter-related infections often lead to catheter loss, repeated invasive procedures, increased healthcare costs, prolonged hospitalization, and higher morbidity rates.

In terms of infection-prevention knowledge, 81.4% (n=57) of patients recognized the importance of hand hygiene, which reflects a generally positive awareness toward preventive practices. However, detailed clinical knowledge remained insufficient; only 20% (n=14) were able to identify local signs of infection such as redness, pain, and discharge, while only 44.3% (n=31) understood the serious complications associated with catheter-related infections. These findings indicate a clear gap between general awareness and comprehensive clinical understanding. Furthermore, 44.3% (n=31) of participants reported receiving no educational instructions from healthcare providers regarding infection prevention. This finding reflects deficiencies in patient education programs within the dialysis center and highlights the urgent need for structured educational interventions. Regarding attitudes and practices, 77.1% (n=54) reported commitment to regular hand washing, 92.9% (n=65) emphasized the importance of keeping the catheter covered, and 78.6% (n=55) expressed positive attitudes toward following medical instructions. Nevertheless, actual preventive practices were less satisfactory, as only 52.9% (n=37) consistently adhered to catheter care instructions. This discrepancy suggests that positive attitudes alone are insufficient to ensure effective preventive behavior without continuous education, supervision, and supportive healthcare environments. Additionally, only 30% (n=21) performed sterile dressing changes appropriately, whereas 17.1% (n=12) changed dressings using non-sterile methods and 15.7% (n=11) took no action when dressings became wet or contaminated. These unsafe practices significantly increase the probability of bacterial transmission and bloodstream infection<sup>[17]</sup>. The statistical analyses strongly supported the objectives of the study by demonstrating significant associations between

several independent variables and infection rates. The findings confirmed that catheter-related infections are multi-factorial conditions influenced by educational status, dialysis duration, catheter type, environmental conditions, and health literacy. A statistically significant association was identified between poor knowledge and increased infection rates ( $P = 0.01$ )<sup>[5,13,17]</sup>, emphasizing that inadequate knowledge constitutes a direct risk factor for central venous catheter infection.

The findings of the current study are also consistent with the Health Belief Model, which explains preventive health behaviors according to patients' perceptions of disease susceptibility, severity, benefits of preventive actions, and barriers to implementation. Patients with higher awareness levels demonstrated better adherence to preventive measures such as hand hygiene and catheter care, whereas poor health perception and environmental barriers negatively affected compliance and increased infection risk<sup>[18]</sup>. Overall, the study demonstrates that prevention of central venous catheter infection among hemodialysis patients is influenced by interconnected demographic, clinical, environmental, and behavioral factors. The findings emphasize the urgent need for comprehensive educational programs, stronger infection control policies, improved environmental health conditions, and continuous patient support to reduce infection rates and improve patients' quality of life.

## CONCLUSION

The study concluded that hemodialysis patients at Ad-Doueim Dialysis Center during the ongoing war, possessed a moderate level of general knowledge regarding infection prevention; however, considerable deficiencies were identified in detailed clinical knowledge related to early recognition of infection symptoms and proper catheter care practices. The study further demonstrated that higher infection rates were significantly associated with lower educational levels, rural residence, poor environmental conditions, prolonged duration of hemodialysis, use of temporary catheters, and inadequate patient education provided by healthcare professionals. The findings confirmed that improving patients' knowledge and practical skills could substantially reduce infection rates, minimize catheter-related complications, and improve the quality of life among hemodialysis patients.

### Recommendations

- **Simplified Educational Programs:** Design visual-based awareness programs (images and videos) tailored for illiterate patients to translate positive attitudes into correct behaviors.
- **Focus on Early Detection:** Train patients to perform daily catheter site inspections to identify redness and swelling immediately.
- **Teach-Back Method:** Require patients to practically demonstrate care steps to nursing staff to ensure the quality of attitude execution.
- **Community and Environmental Support:** Provide subsidized "Catheter Care Kits" (including sterile water, sanitizers, and gauze) for rural patients to overcome the risks of contaminated water.
- **Continuous Audit and Catheter Evaluation:** Medically assess the need to transition from temporary to long-term catheters or AV fistulas to minimize risks, and implement

periodic re-evaluations of self-care competence for long-term patients to combat treatment fatigue.

**Limitations of the Study:** This study had several limitations that should be considered when interpreting the findings. The study was conducted in only one hemodialysis center in, which may limit the generalizability of the findings to other settings in Sudan. Some. The study relied mainly on a structured questionnaire without direct observation of actual practices, which may have limited the assessment of true preventive behaviors regarding central line infection prevention.

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**Author Contributions**

**Conception/design:** MY, MA, MA, MM, WH, NA, HA

**Provision of study material/patients: Collection and/or assembly of data:** MA, MA, MM, WH, NA, HA

**Data analysis and interpretation:** MA, MA, MM, WH, NA, HA, MY

**Manuscript writing:** MY.

**Final approval of manuscript:** All authors.

**Data Availability Statement:** The data underlying this article will be shared on reasonable request to the corresponding author.

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