

## Assessment of hemodialysis nurses' performance toward infection prevention and control in Gaza hospitals

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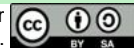
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### ABSTRACT

Hemodialysis (HD) units are high-risk areas for healthcare-associated infections (HAIs). Nurses play a vital role in infection prevention and control (IPC), yet their adherence to IPC standards can be inconsistent, especially in resource-limited areas like the Gaza Strip (GS). This study aimed to assess the performance of HD nurses in implementing IPC practices at governmental hospitals in the GS. A descriptive cross-sectional study was conducted in six governmental hospitals, involving 112 registered nurses working in HD units. Data were collected using a structured, self-administered questionnaire covering demographic characteristics, IPC-related knowledge, and self-reported performance. SPSS version 26 was used for both descriptive and inferential analysis. Nurses showed moderate IPC knowledge (mean = 78.4%, SD = 8.5) and performance (mean = 62.3%, SD = 12.1). Performance varied across domains, with the highest scores in injectable medication preparation (mean = 11.92, SD = 3.59) and the lowest in dialysis station disinfection (mean = 5.44, SD = 2.94). Significant differences in IPC performance were associated with gender, hospital location, and type of HD service ( $p < 0.001$ ), with pediatric HD nurses demonstrating the highest compliance. HD nurses' performance is moderate, with gaps in environmental hygiene. These results highlight the need for training and monitoring targeted to enhance infection control and promote patient safety.

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## INTRODUCTION

Healthcare-associated infections (HAIs) represent a critical global public health challenge, contributing significantly to patient morbidity, prolonged hospitalization, long-term disability, increased mortality, and escalating healthcare expenditures (Abban et al., 2023). Despite advances in clinical protocols and antimicrobial stewardship, HAIs remain prevalent across diverse healthcare settings, particularly in resource-constrained environments where systemic barriers impede consistent implementation of evidence-based prevention strategies (Abbas, 2024). The burden of these infections extends beyond individual patients, straining already fragile health systems and undermining progress toward universal health coverage (Falodun et al., 2025; Al-Tawfiq, 2025). In low-resource and conflict-affected regions, the convergence of infrastructural deficits, supply chain disruptions, and workforce challenges exacerbates vulnerability to HAIs, necessitating context-specific assessments of frontline clinical practices to identify actionable improvement pathways (Sandu et al., 2025).

Patients undergoing hemodialysis (HD) constitute one of the most vulnerable populations for HAIs due to recurrent vascular access procedures, prolonged exposure to clinical environments, and immunocompromised states associated with end-stage renal disease (Alfano et al., 2025). Within dialysis units, central line-associated bloodstream infections (CLABSIs), catheter-related bloodstream infections, and vascular access site infections predominate, often leading to sepsis, hospitalization, permanent vascular access loss, and diminished quality of life (Sikka et al., 2024; Elangovan et al., 2024). The invasive nature of HD therapy, requiring frequent manipulation of catheters, fistulas, or grafts, creates repeated opportunities for pathogen introduction, making stringent adherence to infection prevention and control (IPC) protocols not merely advisable but essential for patient survival (Wooten et al., 2022). Consequently, dialysis facilities worldwide prioritize IPC as a cornerstone of quality assurance, with performance metrics increasingly tied to patient safety outcomes and regulatory accreditation standards (Davies et al., 2025).

Nurses serve as the primary guardians of IPC integrity within HD units, executing multifaceted responsibilities that span hand hygiene compliance, aseptic technique during vascular access, appropriate use of personal protective equipment (PPE), environmental disinfection, biomedical waste segregation, and patient education on self-care practices (Gašpert, 2025). Evidence consistently demonstrates that nursing-driven IPC adherence correlates strongly with reduced HAI incidence; for instance, structured nurse-led bundles targeting CLABSI prevention have achieved reductions exceeding 40% in diverse settings (Iqbal et al., 2025). However, optimal performance hinges not only on foundational knowledge but also on sustained clinical experience, mentorship, and regular competency validation. While standardized training aligned with Centers for Disease Control and Prevention (CDC) guidelines enhances procedural accuracy, real-world adherence often falters without supportive supervision, adequate staffing, and reliable resource availability, factors that vary dramatically across healthcare contexts (Hinson et al., 2024).

The Gaza Strip (GS) presents a uniquely challenging environment for IPC implementation, shaped by protracted conflict, political fragmentation, and chronic under-resourcing of the health system (Tabash et al., 2024). Governmental hospitals in GS contend with recurrent shortages of essential IPC supplies (e.g., antiseptics, sterile gloves, and dialysis catheters), frequent electricity outages compromising water treatment and sterilization processes, severe overcrowding, and restricted access to continuing professional development opportunities (Irfan et al., 2025). Compounding these infrastructural deficits, HD units operate under extreme patient-to-nurse ratios and pervasive workforce burnout, diminishing capacity for meticulous adherence to multistep IPC protocols even among experienced clinicians (Kuhail et al., 2025). During acute escalations of hostilities, these challenges intensify as facilities face direct damage, staff displacement, and near-total collapse of the supply chain, conditions under which IPC practices may be deprioritized despite heightened infection risks. However, empirical data on HD nurses' actual IPC performance within this crisis-affected setting remain scarce, limiting evidence-based advocacy for targeted interventions (Shaqura et al., 2022).

This study aims to comprehensively assess hemodialysis nurses' performance in implementing IPC measures in governmental hospitals across the Gaza Strip and to identify systemic, organizational, and individual barriers that influence practice consistency. By employing mixed-methods evaluation, including direct observational audits of clinical procedures, structured knowledge assessments, and qualitative exploration of contextual constraints, this research seeks to generate granular insights into the gap between IPC guidelines and real-world

application in a protracted humanitarian emergency. Findings will inform the development of context-adapted strategies to strengthen IPC capacity, such as simulation-based refresher training, simplified protocol checklists for resource-limited settings, and advocacy for supply chain stabilization (Lee & Yang, 2025). Ultimately, enhancing HD nurses' IPC performance in Gaza is not only a clinical imperative but a humanitarian necessity to safeguard one of the most vulnerable patient populations amid ongoing adversity.

## **METHOD**

### **Study Design**

This was a cross-sectional descriptive study to assess knowledge and practice of IPC measures among HD nurses at governmental hospitals in the GS. The cross-sectional approach was chosen to provide a snapshot of the current adherence levels and identify associated factors at a specific point in time.

### **Study Setting**

The study was conducted in six major governmental hospitals in the GS, selected based on their capacity to provide HD services and the availability of dedicated HD units, which include Nora Al Ka'bey Center, Al Shifa Medical Complex, Al Rantesy Hospital, Al Aqsa Martyrs' Hospital, Hind Al Daghma Center, and Al Najjar Hospital. These hospitals serve a significant proportion of the HD patient population in the region and represent the region's healthcare infrastructure.

### **Study Population**

The target population comprised all registered nurses working in the HD units of the selected governmental hospitals during the study period. Inclusion Criteria: Registered nurses with at least six months of experience working in HD units. Exclusion Criteria: Nurses on leave or not actively involved in patient care during the study period, volunteer nurses, and student nurses.

### **Sample and Sampling**

The study employed a census sampling technique, including all 112 registered nurses working in HD units at governmental hospitals in the GS. These nurses were distributed across Nora Al Ka'bey Center 22 (19.6%), Al Shifa Medical Complex 33 (29.5%), Al Rantesy Hospital 10 (8.9%), Al Aqsa Martyrs' Hospital 15 (13.4%), Hind Al Daghma Center 22 (19.6%), and Al Najjar Hospital 10 (8.9%). The census approach ensured that the entire eligible nursing population was included, providing comprehensive and unbiased data.

### **Data Collection Tools**

A structured, self-administered questionnaire was developed specifically for this study. The questionnaire comprised three main sections: (1) Personal variables: This section collected data on age, gender, marital status, educational level, years of HD nursing experience, and previous participation in IPC training programs. (2) Knowledge of IPC Measures: This section included 21 multiple-choice questions based on CDC IPC guidelines and local protocols specific to HD units. (3) Practice of IPC Measures: This section consisted of 73 items assessed using a Likert scale (0 = not competent, 1 = need remediation, 2 = competent) to evaluate the level of HD nurses' adherence to IPC practices based on CDC IPC guidelines.

Table 1. Scoring system for the level of IPC knowledge

Score Range (%)	Knowledge Level	Description
25 – 39%	Poor	Limited understanding of IPC principles, significant knowledge gaps, and high risk of noncompliance.
40 – 54%	Fair	Basic knowledge of IPC measures, with noticeable gaps that may lead to inconsistent application.
55 – 69%	Good	Moderate understanding of IPC guidelines, with some deficiencies requiring further training.
70 – 84%	Very Good	Firm grasp of IPC practices, with minor gaps that may occasionally affect adherence.
85 – 100%	Excellent	Comprehensive knowledge of IPC protocols, demonstrating consistent adherence and ability to guide others.

Table 2. Scoring system for the level of IPC practice

Score Range (%)	Practice Level	Description
25 – 39%	Poor	Frequently fails to adhere to IPC protocols, demonstrates unsafe practices, and poses a high risk of infection transmission.
40 – 54%	Fair	Inconsistent adherence to IPC measures, with noticeable lapses that could compromise patient safety.
55 – 69%	Good	Generally, follows IPC protocols, but with occasional noncompliance or minor technique errors.
70 – 84%	Very Good	Demonstrates strong adherence to IPC standards, with only minor lapses that do not significantly impact infection control.
85 – 100%	Excellent	Consistently follows IPC protocols with high precision, ensuring maximum infection prevention and setting an example for others.

### Data Collection Procedure

Data collection was conducted over three months, from January to March 2023. The following steps were undertaken: (1) Ethical Approval: Approval was obtained from the administrative authorities of the selected hospitals in MoH. Ethical considerations included ensuring participant anonymity, confidentiality, and the right to withdraw from the study at any time. (2) Participant Recruitment: Nurses were approached through their respective HD units. An introductory meeting was held to explain the study’s purpose, significance, and procedures. Written informed consent was obtained from all participants before they completed the questionnaire. (3) Distribution and Collection of Questionnaires: Questionnaires were distributed in sealed envelopes to ensure privacy. Participants were given sufficient time (approximately 20-30 minutes) to complete the questionnaire. Completed questionnaires were collected on the same day to minimize non-response and ensure data integrity.

### Data Analysis

Data analysis was performed using SPSS version 26, including descriptive statistics, such as frequencies, percentages, means, and standard deviations. Inferential statistics, including chi-square tests, t-tests, ANOVA, and Pearson's correlation, were used to examine associations among knowledge, practice, and demographic factors. A significance level of  $p < 0.05$  was applied throughout the analysis.

**Ethical Considerations**

The study adhered to the ethical standards outlined in the Declaration of Helsinki. Ethical considerations included: (1) Informed Consent: All participants provided informed consent after being informed about the study’s objectives, procedures, and their rights; (2) Confidentiality: Participants’ responses were kept confidential; and (3) Voluntary Participation: Participation was entirely voluntary, with no incentives provided. Nurses were assured that their participation or non-participation would not affect their employment status or professional standing.

**Limitations of the Study**

The cross-sectional design captures IPC adherence at a single point in time, limiting the ability to assess trends. The study was confined to a single region (the Gaza Strip), limiting generalizability to other settings. The sample size was relatively small despite the census approach. Some data were self-reported, introducing the possibility of response or recall bias. Resource and time constraints prevented direct observation and the use of a longitudinal design.

**RESULT**

**Characteristics of Participants**

The study included 112 nurses working in HD units; their characteristics are presented below.

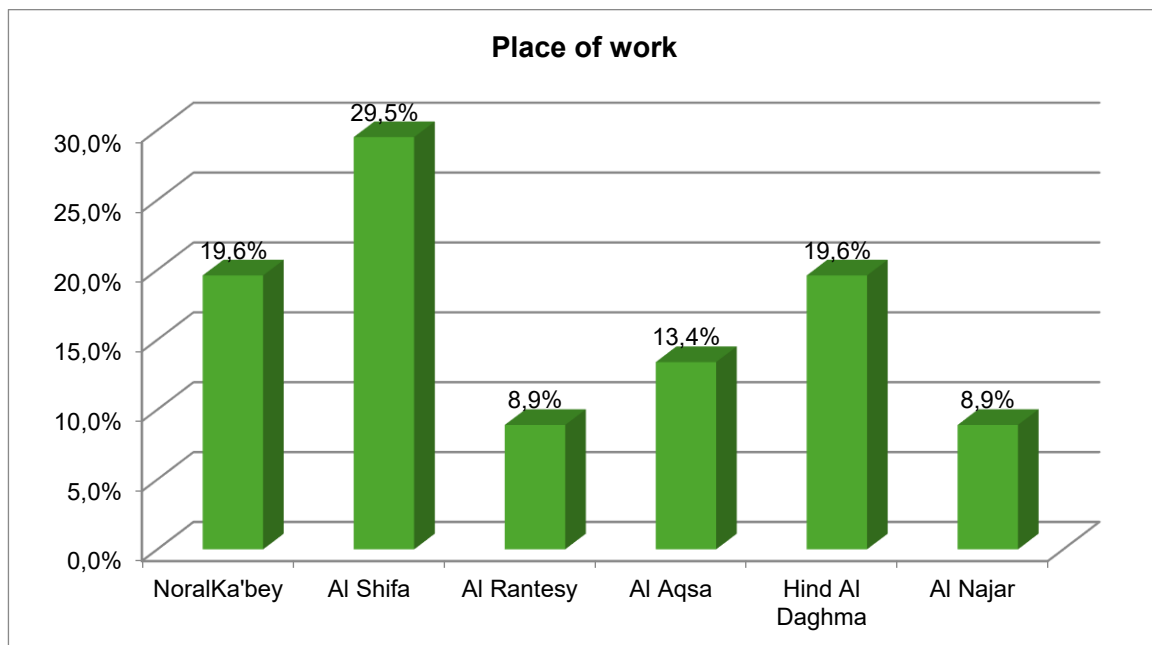


Figure 1. Distribution of study participants according to place of work

Figure 1 showed that 22 (19.6%) of study participants are working in Nora Al Ka'bey Center for HD, 33 (29.5%) are working in Al Shifa hospital, 10 (8.9%) from Al Rantesy hospital, 15 (13.4%) from Al Aqsa hospital, 22 (19.6%) from Hind Al Daghma center, and 10 (8.9%) from Al Najjar hospital.

Table 3. Personal characteristics of study participants (n=112)

Variable	Number	Percent (%)
Gender		
Male	80	71.4
Female	32	28.6
Age (mean 35.76±7.311 years)		
30 years and less	30	26.8
31 – 40 years	61	54.5
41 years and more	21	18.8
Marital status		
Single	1	0.9
Married	111	99.1
Education level		
Diploma	20	17.9
Bachelor	88	78.6
Master's degree	4	3.6

The analysis of Table 3 highlights the demographic distribution of the study participants. Most participants are male (71.4%) and fall within the 31–40-year age group (54.5%), with a mean age of 35.76 ± 7.311 years. Most participants are married (99.1%) and hold a bachelor's degree (78.6%), with only a small percentage having a diploma (17.9%) or a master's degree (3.6%), reflecting a predominantly male, middle-aged, and well-educated cohort with a high marital rate.

Table 4. Work-related characteristics of study participants (n=112)

Variable	Case n (%)	Control n (%)
Type of HD service		
Adult	102	91.1
Pediatric	10	8.9
Years of experience in HD (mean 5.79±5.123 years)		
1 – 5 years	66	58.9
6 – 10 years	25	25.0
11 years or more	18	16.1
Received previous training about HD		
No	57	50.9
Yes	55	49.1
When did you receive the last training? (n= 55)		
Less than one year	26	47.3
1 – 5 years old	2	3.6
More than 5 years ago	27	49.1

Table 4 presents the participants' work-related characteristics. Most of them (91.1%) are involved in adult HD services, with only 8.9% working in pediatric HD. The average experience in HD is 5.79 ± 5.123 years, with the majority (58.9%) having 1–5 years of experience, and only 16.1% having over 10 years. Nearly half (49.1%) of the participants have undergone prior HD training, with 47.3% receiving it within the past year and 49.1% more than 5 years ago. This highlights the need for more frequent, standardized training to enhance skills and maintain up-to-date practices.

### Hemodialysis nurses' Performance toward IPC measures

Table 5. Level of HD nurses' Performance toward IPC measures

Domain	Mean	SD
Knowledge		
Overall mean knowledge score	47.86	12.78
Practice		
Arteriovenous fistula/graft cannulation observation	54.85	12.18
Arteriovenous fistula/graft decannulation observation	49.7	12.62
Catheter connection observation	43.9	13.14
Catheter disconnection observation	43.16	11.72
Catheter exit site care observation	52.38	13.81
Hemodialysis injectable medication preparation	66.45	12.56
Hemodialysis injectable medication administration	26.5	12.45
Hemodialysis station routine disinfection observation	48.5	12.42
Overall mean practice score	48.18	12.61

The analysis of Table 5 reveals that HD nurses' overall knowledge score towards IPC measures is moderate (mean = 47.86, SD = 12.78). At the same time, their overall practice score is moderate (mean = 48.18, SD = 12.61), with notable variations across domains, including a high score in HD injectable medication preparation (mean = 66.45) and a low score in HD injectable medication administration (mean = 26.5). These findings align with previous research, indicating a pattern of moderate knowledge and noncompliance with IPC practices in HD settings. For example, a study in Gaza reported higher knowledge levels among nurses (78.5%) compared to the current study (El-Kass et al., 2024), while research in Egypt showed poor knowledge and noncompliance in several areas, highlighting the importance of education and training (Bello et al., 2024; Abbasi et al., 2021). Additionally, an international study in northern India emphasized the need for ongoing education to improve infection control practices in HD units (Singh et al., 2023), further underscoring the importance of ongoing training to enhance knowledge and adherence to IPC measures, thereby improving patient safety and care quality.

### Differences in knowledge and practice regarding infection prevention and control related to personal variables

Table 6. Differences in performance regarding IPC to personal variables

Variable	Knowledge of IPC			Practice toward IPC		
	Mean	SD	p-value	Mean	SD	p-value
Place of work						
N. Al Ka'bey	42.56	9.76	0.039*	47.35	10.74	0.002*
Al Shifa	43.37	8.86		45.64	9.56	
Al Rantesy	62.14	13.65		52.67	11.67	
Al Aqsa	56.98	12.15		43.71	8.02	
H. Al Daghma	60.82	5.62		50.71	11.54	
Al Najjar	44.28	7.35		37.98	10.65	
Age						
30 years and less	47.726	12.993	0.301	70.433	17.051	0.063
31-40 years	45.164	11.711		76.623	19.602	
41 years and more	61.087	39.759		66.523	15.351	
Gender						
Male	52.734	25.761	0.120	71.987	19.188	0.330

Variable	Knowledge of IPC			Practice toward IPC		
	Mean	SD	p-value	Mean	SD	p-value
Female	42.934	11.080		75.781	16.713	
Educational level						
Diploma	38.988	13.509	0.135	73.600	15.735	0.188
Bachelor	51.348	23.277		72.204	18.159	
Master	41.666	12.366		89.500	34.307	
Type of HD service						
Adult	48.161	22.358	0.002*	70.372	16.584	0.000*
Pediatric	62.142	18.849		100.600	14.818	
Years of experience						
1-5 years	48.449	28.247	0.057	74.772	17.569	0.470
6-10 years	49.908	11.319		71.535	21.131	
11 years or more	50.935	16.088		69.222	17.873	
Previous IPC training						
Yes	45.025	13.940	0.797	71.894	17.965	0.496
No	53.794	27.877		74.290	19.168	

The analysis of Table 6 revealed that significant differences in IPC knowledge ( $P = 0.000$ ) and practice ( $P = 0.000$ ) across various HD service settings and types of HD service. In which AI Rantesy HD (pediatric) services show the highest scores (knowledge mean = 62.14, practice mean = 52.67), suggesting that service type and institutional context influence IPC adherence. On the other hand, there are no statistically significant differences between other personal variables and HD nurses' performance toward IPC measures. This aligns with similar studies, including a Saudi Arabian study that emphasized the importance of assessing HD nurses' knowledge and practices to ensure patient safety (Tafere et al., 2024; Singh et al., 2023; Lubbad et al., 2022). Collectively, these studies underscore the importance of tailored educational programs and institutional support to enhance IPC adherence and patient safety, notably by addressing gender differences and factors such as education and experience.

## DISCUSSION

This study reveals that hemodialysis nurses in governmental hospitals in the Gaza Strip demonstrate moderate levels of knowledge and practice in infection prevention and control (IPC), with overall knowledge and practice mean scores of 47.86 and 48.18, respectively, on standardized assessments. These findings reflect a critical gap between recommended international IPC standards—such as those articulated by the CDC and WHO—and real-world implementation in a protracted humanitarian setting (Qureshi et al., 2022). The moderate performance aligns with studies from comparable resource-constrained environments in Egypt and India, where fragmented training, infrastructural deficits, and high clinical workloads consistently undermine adherence to multistep IPC protocols (Singh et al., 2023). Notably, however, Gaza's context intensifies these challenges through chronic electricity shortages that affect water purification systems, recurrent disruptions to medical supplies, and facility overcrowding exacerbated by ongoing conflict—factors that render theoretical knowledge insufficient as a safeguard against HAIs without parallel investments in system-level enablers.

Domain-specific analysis uncovered pronounced heterogeneity in IPC performance, with hemodialysis injectable medication preparation representing a relative strength (mean = 66.45) while medication administration emerged as a critical vulnerability (mean = 26.5). This dissociation between preparation and administration competence suggests that procedural

complexity, time pressure during active dialysis sessions, or fatigue-related lapses may compromise aseptic technique at the point of patient contact (Masudi et al., 2026). Similarly, suboptimal scores in catheter connection (43.9) and disconnection (43.16) procedures are particularly concerning, given that central venous catheters remain the predominant vascular access modality in Gaza due to late nephrology referrals and limited surgical capacity for fistula creation. These procedural gaps directly elevate CLABSI risk—a leading cause of mortality among HD patients globally—and underscore the urgent need for targeted simulation-based training focused on high-risk moments in the dialysis cycle, complemented by simplified visual job aids at the point of care to reinforce critical steps under resource constraints (Qtait et al., 2025).

Significant variations in IPC performance were observed across healthcare facilities and between adult versus pediatric HD services, with Al-Rantisi Hospital (pediatric service) achieving the highest knowledge (mean = 62.14) and practice (mean = 52.67) scores. This facility-level heterogeneity likely reflects differences in unit leadership, availability of IPC focal persons, microsystem resource allocation, and institutional culture rather than individual nurse competence alone. The superior performance in pediatric services—despite lower patient volumes—may stem from heightened vigilance toward immunologically vulnerable children, more stringent supervision protocols, or investments in specialized training (Yilma et al., 2024). Conversely, the absence of significant associations between IPC performance and nurses' age, gender, educational level, years of experience, or prior training history challenges conventional assumptions that seniority or formal education alone ensures practice excellence. Critically, nearly half of the participants who reported previous IPC training had received it more than five years prior, suggesting that one-time educational interventions without refreshers or competency validation yield transient benefits in high-stress environments.

These findings must be interpreted within Gaza's unique humanitarian reality, where systemic barriers fundamentally constrain IPC implementation regardless of individual nurse motivation or knowledge. Chronic shortages of chlorhexidine for catheter care, inconsistent water quality for dialysate preparation, and electricity outages that disrupt environmental cleaning schedules create conditions in which even highly trained nurses cannot consistently implement evidence-based protocols (Hamamra et al., 2025). This contextual reality reframes IPC noncompliance not as a failure of individual accountability but as a systems-level breakdown requiring structural interventions. International guidelines emphasizing "bundles" for CLABSI prevention, while effective in well-resourced settings, require adaptation to Gaza's constraints through pragmatic modifications such as alcohol-based catheter hub disinfection when chlorhexidine is unavailable, or task-shifting environmental cleaning to dedicated support staff to alleviate nursing workload (Amaro et al., 2025).

Strengthening IPC in Gaza's hemodialysis units demands a dual approach: (1) context-adapted clinical interventions including quarterly simulation drills focused on high-risk procedures (catheter manipulation, medication administration), simplified visual checklists integrated into workflow, and peer-to-peer coaching models; and (2) advocacy for systemic enablers including stabilized supply chains for essential IPC commodities, backup power solutions for water treatment systems, and protected time for competency validation (Lubbad et al., 2022). Future research should evaluate the impact of such bundled, context-sensitive strategies on HAI incidence rather than solely on knowledge metrics. Ultimately, protecting Gaza's hemodialysis-dependent population, a group entirely reliant on functioning health infrastructure for survival, requires reframing IPC not merely as a clinical protocol but as a fundamental component of

humanitarian healthcare delivery deserving sustained international support and protection under global health security frameworks.

## CONCLUSION

This study revealed that hemodialysis nurses in governmental hospitals in the Gaza Strip exhibit moderate levels of knowledge and practice in infection prevention and control, with notable strengths in medication preparation but significant gaps in environmental disinfection protocols. Performance variations were observed across different facilities, service types, and genders, highlighting the influence of contextual and demographic factors on IPC adherence. These findings underscore the urgent need for targeted, competency-based training programs and systematic monitoring mechanisms to strengthen IPC practices and enhance patient safety in resource-constrained dialysis settings.

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## CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest related to this study.

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