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ORIGINAL RESEARCH

Assessment of Knowledge and Practice of Healthcare Providers in Saudi Arabia Regarding *Clostridioides difficile* Infection Diagnosis and Management: A Cross-Sectional Questionnaire-Based Study

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Introduction: Diagnosis of *Clostridioides difficile* infection (CDI) depends on clinical presentation and laboratory testing. Stool diagnostic tests are essential for effective detection of toxigenic *C. difficile* strains. No study to date has evaluated the readability of microbiology labs in Saudi Arabia to test for CDI and evaluated the knowledge and practice of healthcare providers regarding CDI management. Therefore, this study aimed to assess the knowledge and practice of healthcare providers in Saudi Arabia regarding CDI diagnosis and treatment.

Methods: A cross-sectional, descriptive, questionnaire-based study was conducted on healthcare providers in Saudi Arabia, primarily physicians and clinical pharmacists. The questionnaire was developed based on a literature review and input from infectious diseases experts. The questionnaire was administered online. Data were analyzed using descriptive and inferential statistics.

Results: Of 183 respondents, 27.9% had adequate knowledge on CDI diagnosis and management. The majority were internal medicine specialists (37.7%) working in governmental or semi-governmental hospitals (80.9%) in central (46.6%) or southern (30.1%) regions of Saudi Arabia. Most participants assessed laxative use (86.3%) and reported positive *C. difficile* specimens to infection control (67.2%). However, knowledge varied, with 57.4% supporting unnecessary retesting and 53% assuming positive PCR test indicates moderate CDI probability. Factors such as specialization, hospital accreditation status, and bed capacity influenced knowledge levels ($p<0.01$ for all factors).

Conclusion: The study revealed a significant knowledge gap among Saudi healthcare providers regarding CDI diagnosis, management, and severity classification, highlighting the need for improved education and adherence to guidelines to improve patient outcomes and reduce recurrence risks.

Keywords: *Clostridioides difficile*, *Clostridium difficile*, diagnosis, polymerase chain reaction, knowledge, Saudi Arabia

Introduction

Clostridioides difficile infection (CDI) is caused by the toxigenicity of *C. difficile*, an anaerobic gram-positive bacterium. The spore-forming ability of *C. difficile* enables it to survive in unfavorable conditions, thus contributing to its dissemination and transmission in healthcare settings and occasionally in the community.[1] Patients with CDI often have a history of recent antibiotic use, hospitalization, chronic diseases, or previous CDI episodes. Antibiotic treatment within the preceding 60 days, especially with third generation cephalosporins, penicillins with beta-lactamase inhibitors, chronic liver or kidney disease, malnutrition, and prior CDI are associated with an elevated risk of CDI.[2] In a study conducted among hospitalized patients with inflammatory bowel disease, CDI was frequently associated with active

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inflammatory bowel disease. Furthermore, the prior intake of nonsteroidal anti-inflammatory medications was identified as a risk factor for CDI among these patients.[3]

The diagnosis of CDI is based on clinical signs and symptoms such as new onset diarrhea (≥3 loose stools in 24 hours), fever, abdominal pain, or leukocytosis.[4] Moreover, CDI diagnosis can be determined by laboratory stool diagnostic tests. A polymerase chain reaction (PCR) or a multistep algorithm is recommended to effectively detect toxigenic *C. difficile* strains to facilitate the diagnosis of symptomatic CDI and minimize over-diagnosis of asymptomatic carriers.[5] The Infectious Disease Society of America (IDSA) recommend using either PCR or a multistep algorithm, either glutamate dehydrogenase (GDH) and toxin, GDH and toxin then arbitrated by NAAT, or NAAT and toxin.[6]

Between 2009–2011, reported CDI incidence was 50–90 cases per 100,000 population in Europe, Canada, and the US. However, by 2017 incidence had risen to 145 cases per 100,000 population.[7] In a tertiary care facility in Riyadh, Saudi Arabia, the incidence rate of CDI was 3.5 per 10,000 patient days, with a total of 106 episodes of CDI observed among 59 patients over a span of 137,230 patient-days.[8] In another tertiary academic medical center in Saudi Arabia, among 170 patients included in the analysis, 10-year cumulative incidence of CDI was 8.4%.[9]

During the period from 2015 to 2019, a survey conducted in Slovakia revealed that 83.3% of clinicians reported requesting diagnostic testing for CDI both at the initiation and completion of CDI treatment.[10] Another survey was conducted among 171 residents and faculty members at the University of New Mexico Health Sciences Center, with a significant proportion of respondents belonging to the internal medicine department. The survey encompassed a range of questions covering infection control knowledge and testing. The majority of participants (81%) indicated a preference for implementing contact precautions when isolating inpatients with new-onset diarrhea and a negative *C. difficile* test. Furthermore, 91% of respondents selected EIA for toxins A and B as the current laboratory test performed.[11]

Surveys of clinical laboratories found that EIA for toxin A and B was the primary assay for CDI diagnosis in 60–67% in Australia, New Zealand, and Spain.[12,13] However, only one-third of laboratories had specific criteria, such as watery stool or history of antibiotic intake, for stool sample collection for CDI diagnosis.[13] Additionally, a survey conducted in Korea, which encompassed 66 laboratories, revealed that the most widely utilized test for CDI was the EIA for toxin A and B. Out of the 66 laboratories, 51 of them employed this test either independently or in conjunction with other diagnostic methods. On the other hand, a combination of NAAT and *C. difficile* culture tests, either alone or in conjunction with other tests, was employed by 37 laboratories.[14]

In light of the limited available data in Saudi Arabia regarding utilized CDI diagnostics and the practice of CDI diagnosis and management by healthcare providers, we sought to conduct an evaluative study to address this gap. Therefore, the objective of this study was to evaluate the knowledge and practices pertaining to CDI diagnosis and treatment among healthcare providers in Saudi Arabia; thus, we aim to enhance our understanding of CDI management in the Saudi healthcare setting.

Materials and Methods

Study Design and Population

A cross sectional, descriptive, questionnaire-based study was conducted. The population were healthcare providers, physicians and clinical pharmacists, practicing in Saudi Arabia. The survey was administered from November 2021 to July 2022. Approval for the study protocol was obtained from the Regional Research Ethics Committee, Qassim region, Saudi Arabia (Approval number 1443–441,172).

Questionnaire Development

The questionnaire was developed based on a review of existing literature on healthcare providers' knowledge and practices related to CDI diagnosis and treatment.[11,15] The initial questionnaire draft was reviewed by three infectious disease experts to obtain their feedback on the layout and content. A pilot study on five participants was then conducted to evaluate the clarity and suitability of the questionnaire. All expert comments and edits from the pilot study were incorporated into the final version before distributing the questionnaire more broadly.

The questionnaire consisted of three sections. The first collected demographic data. The second section included questions assessing participants' practices related to CDI diagnosis. The third section contained 11 knowledge-based items, with one point given for each correct answer and zero points for incorrect answers. Participants were considered to have adequate knowledge if they correctly answered at least 70% of these knowledge items; the 70% cutoff for adequate response was based on previous studies assessing the level of knowledge among healthcare workers.[16,17]

Administration of the Questionnaire

The questionnaire was converted into a web-based format using the online Google Forms platform. Informed consent was obtained and it was on the first page of the survey where it contained an informed consent statement, where participants were asked for their willingness and consent to participate. The questionnaire link was distributed to healthcare providers practicing in Saudi Arabia through the Saudi Commission for Health Specialties (SCFHS), which has a database of all registered healthcare providers in Saudi Arabia. An initial email was sent by the SCFHS, followed by a reminder email one month later.

Data Analysis

The questionnaire data were analyzed using SAS software (version 9.4; SAS Institute Inc., Cary, NC, USA). Descriptive statistics including frequencies and percentages were used to summarize participants' knowledge and practices related to CDI diagnosis and management. Inferential statistics, specifically Chi-square test, was utilized to analyze differences in knowledge levels between participant groups.

Results

A total of 183 participants completed the survey. Table 1 shows the demographics of the participants. The most common specialties were internal medicine specialists (n=69; 37.7%), followed by infectious disease specialists (n=27; 14.8%),

Table 1 Survey Demographics

Characteristics	N (%)
Specialty	
Internal medicine	69 (37.7)
Family medicine	14 (7.7)
Infectious disease	27 (14.8)
Emergency medicine	8 (4.4)
Intensive care	11 (6.0)
Other medical specialties	31 (16.9)
Clinical pharmacist	23 (12.6)
Level of training	
Resident	57 (31.1)
General physician/practitioner	52 (28.4)
Consultant	74 (40.4)
Years of experience	
<10	92 (50.3)
10–20	62 (33.9)
>20	29 (15.8)
Age (years)	
25–34	78 (42.6)
35–44	59 (32.2)
45–54	31 (16.9)
55–64	7 (3.8)
≥ 65	8 (4.4)

(*Continued*)

Table 1 (Continued).

Characteristics	N (%)
Hospital region	
Central	85 (46.4)
Western	29 (15.8)
Eastern	5 (2.7)
Southern	55 (30.1)
Northern	9 (4.9)
Hospital size (beds)	
< 100	28 (15.3)
101–200	47 (25.7)
201–500	66 (36.1)
> 500	42 (23.0)
Type of practice site	
Governmental or Semi-governmental hospital	148 (80.9)
Private hospital	27 (14.8)
Private lab	8 (4.4)
Hospital/lab is accredited	158 (86.3)
Existence of hospital policy for CDI testing[a]	25 (13.7)

Notes:[a]This is based on a question asked to participants if there is any specific policy in their institutions for CDI testing for diagnosis of possible CDI cases, not on data from their hospitals.
Abbreviation: CDI: *Clostridioides difficile* infection.

other medical specialists (n=31; 16.9%), and clinical pharmacists (n=23; 12.6%). Approximately half of participants (n=92; 50.3%) had 10 years of experience or less. In terms of location, the largest proportion were from the central region of Saudi Arabia (n=85; 46.6%), followed by the southern region (n=55; 30.1%).

Regarding CDI diagnosis practices, most of the participants (n=158; 86.3%) reported inspecting laxative use history before ordering *C. difficile* testing. Half of participants selected at least one risk factor that would prompt CDI stool testing, while 36 (19.7%) correctly chose three triggering factors. Participants' responses varied regarding the type of CDI diagnostic tests used at their institutions as shown in Table 2.

Table 2 Participants Responses to the Practice Items

Items	N (%)
Do you check on use of laxatives before ordering test for *C. difficile*?	
Yes	158 (86.3)
No	25 (13.7)
What are the factors that trigger you to request stool testing for CDI?[a]	
One factor	92 (50.3)
Two factors	32 (17.5)
Three factors	36 (19.7)
Four factors	23 (12.6)
What test(s) is/are used to diagnose CDI at your hospital?	
(Multi-step) Combined GDH/toxin EIA, followed by NAAT for discrepant results	2 (1.1)
(Multi-step) GDH EIA followed by cell cytotoxicity neutralization assay or toxin EIA (if GDH positive)	5 (2.7)
(Multi-step) NAAT followed by EIA for toxin (if NAAT positive)	3 (1.6)
(Single test) *C. difficile* included in a GI panel of multiple pathogens (eg Biofire)	11 (6.0)
(Single test) Combined EIA for glutamate dehydrogenase (GDH) assay and toxin	12 (6.6)
(Single test) Enzyme immunoassay (EIA) for toxin only	19 (10.4)
(Single test) Nucleic acid amplification test (NAAT) only, eg PCR or LAMP	20 (10.9)
(Single test) Toxigenic culture (C. difficile culture followed by detection of toxins)	11 (6.0)

(*Continued*)

Table 2 (Continued).

Items	N (%)
(Multi-step) GDH EIA followed by cell cytotoxicity neutralization assay or toxin EIA (if GDH positive)	1 (0.5)
Not sure	64 (35.0)
We send stool samples to an external lab	10 (5.5)
We send stool samples to an external lab, OR Not sure	1 (0.5)
Several selections[b]	8 (4.4)
(Single test) NAAT, OR (Single test) EIA for toxin only	6 (3.3)
(Multi-step) GDH EIA followed by NAAT (if GDH positive)	5 (2.7)
(Single test) NAAT, OR (Single test) Toxigenic culture	3 (1.6)
(Single test) NAAT) only OR Not sure	2 (1.1)
Do you have to report positive *C. difficile* specimens to someone at your hospital?	
Yes	123 (67.2)
No	60 (32.8)
Do you activate any precaution for patients with CDI?	
Yes	145 (79.2)
No	38 (20.8)
If you activate any precaution, choose the applicable precaution(s)	
Contact precautions	95 (65.5)
Enteric precaution	15 (10.3)
Airborne precaution	26 (17.9)
Droplet precaution	2 (1.4)
Contact precautions, enteric precaution	2 (1.4)
Contact precautions, enteric precaution, droplet precaution, airborne precaution	1 (0.7)
Contact precautions, droplet precaution, airborne precaution	4 (2.8)
It would be appropriate to treat patients empirically with antibiotics for CDI, if he/she develop diarrhea while on antibiotics and has a negative toxin assay	
Yes	76 (41.5)
No	107 (58.5)
Frequency of CDI testing in your practice	
Never	25 (13.7)
Daily	13 (7.1)
Weekly	57 (31.1)
Monthly	59 (32.2)
Every six months	20 (10.9)
Yearly	9 (4.9)

Notes: [a]Presence of loose or watery stools; nosocomial diarrhea; onset of diarrhea after antibiotic use; advanced age with diarrhea. [b](Single test) NAAT only, (Multi-step) Combined GDH/toxin EIA, (Single test) C. difficile included in a GI panel (eg Biofire), (Single test) Toxigenic culture, We send stool samples to an external lab; Not sure; (Single test) Combined EIA for glutamate dehydrogenase (GDH) assay and toxin, (Multi-step) GDH EIA followed by cell cytotoxicity neutralization assay or toxin EIA (if GDH positive).

Abbreviations, CDI, *Clostridioides difficile* infection; EIA, enzyme immunoassay; GI, gastrointestinal; GDH, glutamate dehydrogenase; LAMP, loop-mediated isothermal amplification; NAAT, nucleic acid amplification testing; PCR, Polymerase chain reaction.

When specifically asked about the diagnostic tests used at their institution, 20 (10.9%) reported using NAAT only, whereas 19 (10.4%) reported using EIA for toxin only. Conversely, 64 (35.0%) were unsure of the test used for CDI diagnosis at their institution. Over half of participants (n=123, 67.2%) stated that positive *C. difficile* specimens were reported to the infection control department with 95 participants (65.5%) reported activating contact precautions for CDI patients. Interestingly, 76 participants (41.5%) indicated they would empirically treat patients for CDI despite negative toxin assay results. The remainder of the questionnaire items related to CDI diagnosis and management are summarized in Table 2.

Regarding the knowledge-based questions which are shown in Table 3, approximately half of participants (n=105, 57.4%) indicated that retesting at the end of CDI therapy is unnecessary. Moreover, 97 participants (53%) agreed that a positive PCR test indicates a moderate probability of CDI. The vast majority (n=165; 90.2%) correctly selected diarrhea with ≥3 episodes in 24 hours as a trigger for ordering CDI testing. Knowledge on CDI classification and risk factors

Table 3 Participants' Responses to the Knowledge Items

Items	N (%)
In a patient with CDI, it is necessary to retest at the end of therapy to assure eradication of the organism.	
Yes	78 (42.6)
No	105 (57.4)
How likely is a patient to have CDI if the PCR test is positive?	
Not at all	24 (13.1)
Somewhat or moderately	97 (53.0)
Very or highly	62 (33.9)
Based on the available literature, CDI treatment options are the same regardless of the severity of the infection	
Yes	64 (35.0)
No	119 (65.0)
Based on the IDSA guidelines, which of the following factors are considered to classify CDI severity?[a]	
Wrong factors[b]	22 (12.0)
One factor	48 (26.2)
Two factors	55 (30.1)
Three factors	41 (22.4)
Four factors	17 (9.3)
Based on IDSA guideline, the optimal 1st line treatment for non-severe initial episode CDI:	
Wrong choice[b]	98 (53.6)
One right choice[c]	65 (35.5)
Vancomycin or fidaxomicin (orally)	20 (10.9)
Based on IDSA guideline, the optimal 1st line treatment for severe initial episode CDI:	
Wrong choice[b]	13 (7.1)
One right choice	140 (76.5)
Two right choices	25 (13.7)
Vancomycin orally, fidaxomicin orally, or metronidazole IV plus vancomycin orally	5 (2.7)
Based on IDSA guideline, the optimal treatment for recurrent CDI includes	
Wrong choice[b]	62 (33.9)
One right choice[d]	89 (48.6)
Vancomycin or fidaxomicin (orally)	32 (17.5)
Risk factors for developing CDI include the following:[e]	
One right choice	27 (14.8)
Two right choices	18 (9.8)
Three right choices	38 (20.8)
Four right choices	35 (19.1)
Five right choices	44 (24.0)
Six right choices	12 (6.6)
Advanced age, duration of hospitalization, exposure to antibiotics, exposure to chemotherapy, gastrointestinal surgery or tube feeding, renal failure, and usage of PPIs	9 (4.9)
The following antibiotics should be discouraged for patients with CDI risk factors:[f]	
Wrong choice[b]	14 (7.7)
One right choice	52 (28.4)
Two right choices	50 (27.3)
Three right choices	39 (21.3)
Third-generation cephalosporins, fluoroquinolones, clindamycin, penicillins including β-lactamase inhibitors	28 (15.3)
Based on the available literature, the appropriate antibiotic duration for CDI treatment is:	
5 days	18 (9.8)
10 days	84 (45.9)
14 days	77 (42.1)
21 days	4 (2.2)

(*Continued*)

Table 3 (Continued).

Items	N (%)
What triggers you to order *C. difficile* test for a patient?	
Abdominal pain	1 (0.5)
Diarrhea, 1–2 episodes in 24 hours	17 (9.3)
Diarrhea, 3 or more episodes in 24 hours	165 (90.2)

Notes: Underlined category represents the complete correct answer. [a]Scr, WBCs, hypotension, albumin. [b]The respondent selected wrong answer. [c]Vancomycin PO or fidaxomicin PO. [d]Vancomycin PO or fidaxomicin PO. [e]Advanced age, duration of hospitalization, exposure to antibiotics, exposure to chemotherapy, gastrointestinal surgery or tube feeding, renal failure, and usage of PPIs. [f]Third-generation cephalosporins, fluoroquinolones, Clindamycin, penicillins including β-lactamase inhibitors.

Abbreviations: CDI, *Clostridioides difficile* infection; IDSA, Infectious Diseases Society of America; PPIs, proton pump inhibitors.

showed some variability, where only 17 participants (9.3%) correctly selected four CDI classification factors, while 41 (22.4%) chose three factors, 55 (30.1%) chose two factors, and 48 (26.2%) chose one factor. For CDI risk factors, 91 participants (49.7%) correctly selected four or more, while 38 (20.8%) selected three correct risk factors. Regarding knowledge of antibiotics to discourage in patients with CDI risk factors, 52 (28.4%) selected one correctly, 50 (27.3%) selected two, 39 (21.3%) selected three, and 28 (15.3%) selected four. However, 14 (7.7%) selected incorrect options. Regarding CDI treatment, 119 participants (65%) supported using different treatment options based on CDI severity. The rates of choosing correct answers for the selection of antibiotic therapy for CDI varied based on the different severity classifications of CDI (Table 3). Regarding antibiotic treatment duration, 84 participants (45.9%) correctly selected "10 days" based on guidelines.

Overall, 51 participants (27.9%) demonstrated adequate knowledge (>70% correct answers, while 65 (35.5%) had insufficient knowledge (50–69% correct) and 67 (36.6%) had inadequate knowledge (<50% correct). Groups with the highest proportion of adequate knowledge included infectious disease specialists ($p<0.01$), consultants ($p<0.01$), those working in hospitals with 201–500 beds ($p<0.01$) and >500 beds ($p<0.01$), practitioners in government or semi-government hospitals ($p<0.01$), and those in accredited hospitals ($p<0.01$). More details on the distribution and comparison of participants across the three knowledge levels are provided in Table 4.

Table 4 Distribution and Comparison of Participants Based on the Level of Knowledge

Characteristics	Level of knowledge			
	Adequate n (%)	Insufficient n (%)	Inadequate n (%)	*p*-value[a]
Overall (n=183)	51 (27.9)	65 (35.5)	67 (36.6)	
Specialty				**<0.0001**
Internal medicine	18 (26.1)	30 (43.5)	21 (30.4)	
Family medicine	2 (14.3)	7 (50.0)	5 (35.7)	
Infectious disease	25 (92.6)	0 (0.0)	2 (7.4)	
Emergency medicine	0 (0.0)	4 (50.0)	4 (50.0)	
Intensive care	2 (18.2)	4 (36.4)	5 (45.5)	
Other medical specialties	1 (3.2)	18 (58.1)	12 (38.7)	
Clinical pharmacist	3 (13.0)	4 (17.4)	16 (69.6)	
Level of training				**<0.0001**
General physician/practitioner	5 (9.6)	30 (57.7)	17 (32.7)	
Resident	8 (14.0)	22 (38.6)	27 (47.4)	
Consultant	38 (51.4)	15 (20.3)	21 (28.4)	

(*Continued*)

Table 4 (Continued).

Characteristics	Level of knowledge			
	Adequate n (%)	Insufficient n (%)	Inadequate n (%)	*p*-value[a]
Years of experience				0.0946
<10	20 (21.7)	35 (38.0)	37 (40.2)	
10–20	25 (40.3)	21 (33.9)	16 (25.8)	
>20	6 (20.7)	11 (37.9)	12 (41.4)	
Age (years)				0.2446
25–34	16 (20.5)	33 (42.3)	29 (37.2)	
35–44	23 (39.0)	18 (30.5)	18 (30.5)	
45–54	10 (32.3)	9 (29.0)	12 (38.7)	
55–64	0 (0.0)	3 (42.9)	4 (57.1)	
≥ 65	2 (25.0)	4 (50.0)	2 (25.0)	
Hospital region				0.4816
Central	20 (23.5)	38 (44.7)	27 (31.8)	
Western	11 (37.9)	8 (27.6)	10 (34.5)	
Eastern	1 (20.0)	1 (20.0)	3 (60.0)	
Southern	17 (30.9)	18 (32.7)	20 (36.4)	
Northern	2 (22.2)	2 (22.2)	5 (55.6)	
Hospital size (beds)				**<0.0001**
< 100	1 (3.6)	18 (64.3)	9 (32.1)	
101–200	7 (14.9)	25 (53.2)	15 (31.9)	
201–500	24 (36.4)	11 (16.7)	31 (47.0)	
> 500	19 (45.2)	13 (31.0)	10 (23.8)	
Type of practice site				**0.0004**
Governmental or Semi-governmental hospital	49 (33.1)	44 (29.7)	55 (37.2)	
Private hospital	2 (7.4)	19 (70.4)	6 (22.2)	
Private lab	0 (0.0)	4 (50.0)	4 (50.0)	
Accreditation status				**0.0053**
Yes	49 (31.0)	51 (32.3)	58 (36.7)	
No	2 (8.0)	16 (64.0)	7 (28.0)	
Existence of hospital policy for CDI testing				0.0517
Yes	32 (35.2)	33 (36.3)	26 (28.6)	
No	19 (20.7)	34 (37.0)	39 (42.4)	
Number of CDI testing				0.2833
Never	6 (24.0)	9 (36.0)	10 (40.0)	
Daily	1 (7.7)	8 (61.5)	4 (30.8)	
Weekly	21 (36.8)	15 (26.3)	21 (36.8)	
Monthly	17 (28.8)	23 (39.0)	19 (32.2)	
Every six months	6 (30.0)	8 (40.0)	6 (30.0)	
Yearly	0 (0.0)	4 (44.4)	5 (55.6)	

Notes: [a]*p*-values in bold signify statistical significance at $p<0.05$, indicating evidence that differences in knowledge levels between the compared groups are not due to random variations.
Abbreviation: CDI, *Clostridioides difficile* infection.

Discussion

To our knowledge, this is the first study to assess the knowledge and practice related to CDI diagnosis and management among healthcare providers in Saudi Arabia. Overall, the findings indicate that providers' knowledge levels were suboptimal, with nearly two-thirds demonstrating insufficient or inadequate knowledge on CDI. These results align with a semi-structured interview study in South Africa which found limited CDI knowledge, with a median score of 3 out of 7.[18] Compared to previous global studies, the level of CDI knowledge among healthcare providers in Saudi Arabia

appears lower. For example, a study by Fayerberg et al in New Mexico, USA found almost half of participants lacked knowledge on CDI diagnosis at their institution. In contrast, nearly two-thirds of participants in our Saudi sample demonstrated insufficient or inadequate CDI knowledge. This indicates a greater knowledge gap in the Saudi context compared to what has been observed in some other regions.

Although the level of training indicates that the level of knowledge depends on the level of training, many of the highly trained staff are still having a concerning insufficient level of knowledge (only 51.4% of consultant had an adequate level of knowledge). However, we need to note that this concerning level of knowledge also depend on the practitioners' specialty as our results indicate. Similarly, participants practicing in the private sector had a concerning low level of knowledge which indicate that their patients may not be receiving recommended therapy based on the best available evidence. This issue needs further investigation and instantaneous action plan to raise the level of knowledge among practitioners at different level of training and in the private sector to ensure that patients are receiving adequate therapy.

Clinical pharmacists, with their expertise in pharmacotherapy and antimicrobial stewardship, are uniquely positioned to play expanded roles in CDI prevention, detection, and management.[19,20] As clinical pharmacists usually assume responsibilities related to appropriate antimicrobial use specially in facilities facing shortage in infectious disease specialists, they need to have adequate level of knowledge about this matter to fulfill this gap. Unfortunately, in our cohort clinical pharmacists demonstrated a concerning level of knowledge related to appropriate CDI diagnostic protocols and evidence-based treatment selections, particularly for severe cases. Thus, targeted educational initiatives focused on addressing the specific gaps identified in this group have potential to significantly enhance clinical pharmacists' capabilities and empower them to collaborate more actively in institutional CDI stewardship efforts. Formal expansion of pharmacists' responsibilities through updated policies and physician engagement, paired with closing knowledge gaps through rigorous training, can pave the way for clinical pharmacists to take on more impactful, guideline-concordant functions in tackling CDI.[21]

The current study revealed knowledge gaps regarding CDI diagnosis among the participants. Furthermore, 64 participants (35%) were unsure of the specific diagnostic test used at their institution. Notably, the most commonly selected response was NAAT only, with just 20 participants (10.4%) identifying this single test approach. According to guidelines, a NAAT alone is insufficient and requires a follow-up toxin test for confirmation. The uncertainty and overreliance on NAAT demonstrated in this sample indicates a need for providers to improve their understanding of appropriate CDI diagnostic methods. Targeted education and training could help address this knowledge gap and promote adherence to recommended testing protocols, which is essential for accurate CDI diagnosis. Alternatively, hospital-specific CDI guidelines can be developed and tailored based on the diagnostics available in the hospital's microbiology lab. Such guidelines should be uploaded to the hospital's intranet, and healthcare providers should be made aware of its availability. Consistent with our findings, a study by Aroori et al found that almost half of the participants were unaware of the CDI diagnostic test used at their institution.[22] Implementing targeted interventions to increase providers' familiarity with the recommended diagnostic protocols could help promote early and accurate detection of CDI cases. Furthermore, a study by Fayerberg et al in Mexico with 171 respondents found that nearly half failed to identify the CDI diagnostic test used at their hospital.[11] Targeted education for healthcare workers on recommended diagnostic guidelines and the testing methods implemented at their facilities appears needed to address this gap. Increased familiarity with the appropriate use of toxin, molecular, and antigen assays could aid providers in accurate CDI diagnosis and treatment. In contrast, a survey of infectious disease specialists found that most respondents (98%) were aware of their hospital's CDI diagnostic methods, with 62% using NAAT and 38% using toxin testing.[15] The higher knowledge among infectious disease specialists compared to our sample may be attributed to the fact that only 15% of our participants specialized in infectious diseases.

According to the recent IDSA guidelines, CDI testing is recommended for patients with more than three diarrheal episodes within 24 hours.[23] In this study, most respondents (90%) correctly answered this criterion for diagnosis and stool sample collection. In contrast, a recent Australian study found that two-thirds of nurses lacked knowledge on CDI identification.[24] Our respondents demonstrated variable knowledge on other topics like IDSA severity classification and CDI risk factors. Over half identified at least four accurate risk factors, consistent with the results of a study by

Comparcini et al where around half of the participants showed good risk factor knowledge.[25] While our sample displayed appropriate awareness of key diagnostic criteria, there appear to be gaps in applying guidelines on CDI classification and risk factors that may be filled by targeted education and training across healthcare professions.

Regarding initial CDI management, almost half of the participants in our study correctly identified at least one appropriate option for non-severe cases (vancomycin or fidaxomicin orally) based on IDSA guidelines. However, only 5 (2.7%) demonstrated adequate knowledge of all suitable initial therapies for severe CDI (vancomycin or fidaxomicin orally, or metronidazole plus vancomycin IV). Still, most respondents (n=165; 90%) recognized at least one appropriate severe CDI treatment. Our study indicates knowledge gaps regarding CDI management, especially for severe CDI, which indicates the need for education on the recommended first-line treatments per guidelines.

A survey from Slovakia found the most commonly used CDI treatments were oral metronidazole (47.8%), oral vancomycin (21.7%), and a combination of oral vancomycin with intravenous metronidazole (17.4%). Fidaxomicin was used by 50% for severe or recurrent CDI.[10] However, latest IDSA guidelines that were published after this study was published in 2021 recommend oral vancomycin or fidaxomicin alone as first-line treatment. Standardizing management based on current guidelines can help reduce CDI recurrence and clinical failure. One multicenter study found an 18% CDI clinical failure rate despite treatment.[26] Optimizing evidence-based CDI protocols is crucial for improving outcomes and minimizing recurrence and relapse. It should be noted, however, that older IDSA guidelines recommending metronidazole as first-line therapy for non-severe CDI remains active in areas where CDI is not highly prevalent, such as in Saudi Arabia. Several previous studies from Saudi Arabia showed good clinical outcomes and reduced mortality when the older guidelines were followed.[9,27]

This study has several notable strengths. First, the cross-sectional design enabled collecting data from diverse healthcare providers across Saudi Arabia, allowing a snapshot of current practices and broader generalizability. Second, the rigorous questionnaire development using literature and experts supports data validity and reliability. However, some limitations should be acknowledged. First, self-reported data may introduce recall bias, although the online format improved efficiency and representativeness. Instructions and prompts also minimized errors. Second, self-reports may not fully reflect actual behavior or knowledge but remain a commonly accepted method for assessing perceptions. In addition, anonymity likely reduced social desirability biases. Third, the sample is primarily internal medicine specialists in government hospitals, which may limit generalizability. In addition, more residents and general practitioners were included in the study as they were more accessible and responsive to the participation invitation than senior practitioners in the workforce. Nonetheless, this provides valuable context-specific insights that can inform future research with more diverse samples. More research is needed to further understand the factors contributing to this knowledge deficiency and inform future educational and quality improvement interventions aimed at enhancing providers' CDI competency in Saudi Arabia.

Conclusion

This study has highlighted notable gaps in the knowledge and management of CDI among healthcare providers in Saudi Arabia. The lack of comprehensive understanding, especially when compared to other global regions, underscores the urgent need for targeted educational interventions, as well as development of hospital-specific guidelines that should be adhered to. These interventions should focus on enhancing familiarity with recommended diagnostic protocols, understanding of IDSA classification, awareness of risk factors, and the ability to apply severity-based treatment. While the study does have some limitations, its findings are credible and significant, emphasizing a pressing requirement for action. Future research should focus on developing and implementing educational strategies tailored to address these identified deficiencies, with the ultimate aim of improving patient outcomes.

Statement of Ethics

This study protocol was reviewed and approved by the Regional Research Ethics Committee, Qassim region, Saudi Arabia (Approval number 1443-441172).

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no competing interests in this work.

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