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Assessment of Healthcare Workers' Adherence to Infection Prevention and Control Measures in Najran City, Saudi Arabia, in the Post-COVID-19 Pandemic Era

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Abstract

Infection prevention and control (IPC) standards have a unique role in controlling infection transmission. In Saudi Arabia, every healthcare facility is required to establish an IPC program to identify and reduce the risk of infection acquisition and transmission. This study aimed to estimate adherence to IPC measures after the COVID-19 pandemic among healthcare workers (HCWs) in Najran City, Saudi Arabia. This cross-sectional study was conducted among HCWs in Najran City during the period of May to August 2023. A self-administered questionnaire was given to HCWs consisting of three parts: demographic data, profile of healthcare facility and healthcare professional regarding infection control, and questionnaire to assess the adherence of HCWs regarding infection control measures. The study recruited 580 HCWs, of whom 57.6% were males, and 46.6% were aged between 31 and 40 years. The overall mean adherence score was 103.2±9.71 out of 150 points. Accordingly, 88.4% were classified as having moderate adherence, 10.2% were good, and only 1.4% were classified as having poor adherence. Some of the factors associated with increased adherence to IPC measures, include being female, being a nurse, being a practitioner, working in the hospital emergency department, and having a recognized antimicrobial stewardship program team/unit at a healthcare facility.There was satisfactory adherence among HCWs regarding infection prevention and control measures. Being a female, a nurse, a practitioner, working in a hospital emergency department, being a staff of a non-MOH (Ministry of Health) hospital, and having a recognized antimicrobial stewardship program team/unit were identified as significant predictors of increased adherence. IPC measures can be optimized by setting up institutional IPC teams, necessary PPE, and periodic provision of IPC training.

Keywords: Infection Prevention and Control Measures, Healthcare Workers, Adherence, Antimicrobial Stewardship, Saudi Arabia

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INTRODUCTION

Major outbreaks of infectious diseases such as the Severe Acute Respiratory Syndrome (SARS) coronavirus, H1N1 influenza, Middle East respiratory syndrome coronavirus (MERS) Coronavirus, Ebola virus, Zika virus, Coronavirus disease 2019 (COVID-19), and monkeypox virus have emerged in the past two decades.[1] Clearly, the infection prevention and control (IPC) norms play a special part in preventing the spread of infections. Moreover, a significant part of healthcare-associated infections (HAIs) is preventable.[2] Successful infection control and prevention lowers HAIs by at least 30%.[3] However, globally 7-10% of patients will acquire at least one HAIs.[4] Unfortunately, some reports suggest that 10.6-80% of cases were acquired in hospital for COVID-19, and MERS-CoV and SARS-CoV.[5]

World Health Organization (WHO) describes IPC as a scientific strategy and workable solution intended to reduce the risk of infection-related harm to patients and medical personnel. In 2021, it is reported that the majority of participating nations have IPC programs and standards in place, but few have set aside the resources required to implement the programs.[6] In Saudi Arabia, every healthcare facility is required to establish an IPC program to identify, and reduce the risk of infection acquisition and transmission.[7]

To achieve potent infection prevention and control measures, it is critical to ensure good practices among HCWs regarding IPC, particularly during endemics. In January 2020, a cross-sectional study was done in Wuhan city, China, showed that majority of HCWs had better IPC behaviors during the COVID-19 pandemic compared to before the outbreak.[8] In contrast, one study in Addis Ababa, Ethiopia, reported that COVID-19 pandemic did not improve the level of adherence to IPC procedures among HCWs.[9] It is reported that poor infection control measures were linked to SARS-CoV-2 seropositivity among HCWs during the second and third COVID-19 waves.[10] The study conducted in Al Riyadh, Saudi Arabia, uncovered that 80.2% of healthcare workers (HCWs) demonstrated good infection control practices in hospitals, a rate lower than estimates in other locations. This finding highlights significant regional variations in infection control practices (ICP) (1). The results underscore the need for a re-evaluation of infection prevention and control (IPC) measures due to their seemingly insignificant role in certain regions. Understanding the reasons behind poor adherence is crucial for ensuring the effective utilization of IPC measures in healthcare settings.[11]

In light of recurrent epidemics, there is an expectation for healthcare workers (HCWs) to demonstrate heightened vigilance in adhering to proper infection prevention practices. Our hypothesis posits that HCWs exhibit improved infection prevention and control (IPC) practices post the COVID-19 outbreak compared to earlier periods. The current study aims to assess the medical practices related to IPC measures among HCWs in Najran city, Saudi Arabia, following the COVID-19 pandemic. This evaluation seeks to leverage insights gained from past experiences to effectively manage ongoing outbreaks and enhance preparedness for future epidemics. The specific objectives include:

1. Examine Adherence to IPC Measures: Evaluate the extent of adherence to IPC measures among HCWs in Najran city.
2. Assess the Influence of COVID-19 Pandemic: Investigate the impact of the COVID-19 pandemic on the daily practices of HCWs in Najran city, particularly regarding infection prevention.
3. Identify Key Predictors of Adherence: Identify the primary factors influencing HCWs' adherence to IPC measures in Najran city.

METHODOLOGY

In Najran City, situated in the southern region of Saudi Arabia, a comprehensive facility-based study was undertaken between May and August 2023. This cross-sectional investigation, employing both descriptive and analytical approaches, aimed to assess the adherence of healthcare workers to infection control measures within healthcare facilities post the COVID-19 pandemic. The study focused on evaluating the practices and compliance of healthcare workers in Najran City regarding infection control during the specified period. There are more than 50 healthcare facilities 32 primary healthcare centers, 10 hospitals, and many private polyclinics.

The sampling technique was conducted in two stages.

In the first stage: a simple random sampling method has been used to select healthcare facilities.

In the second stage: we recruited the healthcare workers (physicians, dentists, pharmacists, nurses, laboratory technicians, radiology technicians, and paramedics) who work in selected healthcare facilities and who agreed to participate in the study (n=580).

Data were collected by self-administrated questionnaire. The questionnaire was created by reviewing relevant literature and adapting statements from previous studies. The statements in the questionnaire were modified and refined to enhance the validity of the instrument and ensure its suitability for the specific objectives of the current study. The questionnaire was self-administered by direct guidance of interviewer, consisted of 3 parts. The first part contained the demographic data which includes healthcare workers' age, gender, family status, nationality, job title, position, qualifications, healthcare facility, workplace, years of experience. Second part is profile of healthcare facility and health care professional regarding infection control including having a recognized infection control program team/unit, and infection control standards at healthcare facility, effect of COVID-19 pandemic on applying of infection control measures and professional's adherence to infection control measures, vaccination status for annual influenza, 3rd dose and seasonal booster dose against the Coronavirus, having evidence of immunity by documentation for vaccines, laboratory evidence of immunity, laboratory confirmation of disease, and diagnosis or verification of a history of disease by a healthcare provider. The third part is about the practice of health care providers regarding infection control measures which include 15 phrases for the practice of hands hygiene section, 11 phrases the use of PPE (Vest, Gloves, Face Masks) section, and four phrases for safe handling/ disposal of medical waste section. For second part; participants labelled his/her response either Yes, No, or don't know. Participants was encouraged to self-report his/her practice through Likert scale way (always, often, sometimes, rarely, never).

Ethical clearance

The ethical approval was taken from the Regional Research Ethics Committee. All fundamental ethics were maintained for participants include autonomy, confidentiality, and data security, and justice.

Questionnaire criteria

The adherence of HCWs toward infection prevention and control measures was been assessed using a 30-item questionnaire with 5-point Likert scale categories ranging from "Never" coded with 1 to "Always" coded with 5 as answer options. The total adherence score was calculated by summing up all 30 items, with a possible score ranging from 30 to 150 points. The higher the score, the higher the adherence to infection prevention and control measures. By using 50% and 75% as cut-off points to determine the level of adherence. HCWs were considered as having poor adherence if the score was below 50%; 50% to 75% were considered moderate, and above 75% were considered good adherence level.

Statistical analysis

All categorical data were shown as frequencies and proportions (%). All continuous data were calculated and summarized as mean and standard deviations. The adherence score was compared with the socio-demographic characteristics and profile of HCWs regarding infection control by using the Whitney Z-test and the Kruskal Wallis H-test. The normality test (i.e., statistical collinearity) was performed using the Shapiro-Wilk test as well as the Kolmogorov-Sminov test. The total adherence score follows the non-normal distribution. Therefore, the non-parametric tests were applied. Statistical significance was established at $p<0.05$ level. Post-hoc analysis was also conducted to determine the differences in the score of adherence in relation to job title. All statistical data were performed and analyzed using SPSS version 26 (Statistical Packages for Social Sciences, Armonk, NY: IBM Corporation). This study enrolled 580 HCWs. As shown in Table 1, 46.6% were aged between 31 and 40 years, of whom 57.6% were males, and approximately two-thirds (66.9%) were non-Saudis. Respondents who were nurses constituted

Table 1. Socio-demographic characteristics of the HCWs (n=580)

Study variables	N (%)
Age group	
• 22 – 30 years	193 (33.3%)
• 31 – 40 years	270 (46.6%)
• 41 – 50 years	94 (16.2%)
• >50 years	23 (04.0%)
Gender	
• Male	334 (57.6%)
• Female	246 (42.4%)
Nationality	
• Saudi	192 (33.1%)
• Non-Saudi	388 (66.9%)
Job title	
• Physician	127 (21.9%)
• Pharmacist	87 (15.0%)
• Dentist	44 (07.6%)
• Nurse	153 (26.4%)
• Lab-Technician	57 (09.8%)
• Rad-Technician	51 (08.8%)
• Paramedics	54 (09.3%)
• Others	07 (01.2%)
Position	
• Not mentioned	14 (02.4%)
• Supervisor	335 (57.8%)
• Practitioner	231 (39.8%)
Qualification	
• Not mentioned	116 (20.0%)
• Diploma	60 (10.3%)
• Bachelor	354 (61.0%)
• Master	49 (08.4%)
• PhD	01 (0.20%)
Healthcare facility	
• Not mentioned	70 (12.1%)
• PHC Center	75 (12.9%)
• Hospital-Outpatient Clinic	217 (37.4%)
• Hospital-Emergency Department	171 (29.5%)
• Polyclinic	47 (08.1%)
Workplace	
• Not mentioned	12 (02.1%)
• MOH	343 (59.1%)
• University Health Services	91 (15.7%)
• Military Health Services	55 (09.5%)
• National Guard Health Services	13 (02.2%)
• Interior Ministry Health Services	57 (09.8%)
• Private Sector	09 (01.6%)
Years of working experience	
• 1 year or less	307 (52.9%)
• 2-3 years	171 (29.5%)
• 4-6 years	102 (17.6%)

26.4% and supervisors constituted 57.8%. With respect to education, 61% were bachelor's degree holders. Approximately 37.4% were working in the hospital outpatient clinics, with 59.1% being staff of MOH. Furthermore, 52% of the participants had less than one year of experience.

In Figure, 55.5% and 58.4% indicated having antimicrobial stewardship program team/ unit or standard policies and procedures at their healthcare facilities. Approximately 88.6% and 88.4% reported that the COVID-19 pandemic improved the infection control measures and adherence at their healthcare facilities. 78.3%, 86.2%, and 56.9% were vaccinated against the influenza virus in the current year, vaccinated with 3rd dose, or vaccinated with a seasonal booster dose against COVID-19. 66.7%, 51%, 36.4%, and 35.9% had evidence of immunity by documentation for vaccines, laboratory evidence of immunity, laboratory confirmation of disease, and diagnosis or verification of a history of disease by a healthcare provider.

Regarding the assessment of HCW's adherence toward infection control measures composed of three domains (Table 2), for the domain of adherence to hand hygiene, the top three statements with the highest ratings include "Hand hygiene should be applied before preparing a clean or aseptic procedure" (mean score: 4.85), "Hand hygiene should be applied before entering the patient environment and touching a patient" (mean score: 4.82), and "Hand hygiene should be applied after bodily fluid exposure or risk" (mean score: 4.81). The total mean score for hand hygiene adherence was 4.71 (SD 0.46). For the PPE domain, the top three statements with the highest rating were "Wear gloves whenever in contact with blood, other body substances or contaminated tools and surfaces and when in an isolation room" (mean score: 4.73), "Clean hands before and after wearing PPE" (mean score: 4.68), and "Remove gloves promptly after use and before touching clean items and environmental surfaces" (mean score: 4.67). The total mean score of the PPE domain was 4.55 (SD 0.60). For the domain of safe handling/disposal of medical waste, the highest rated statement was "Place medical waste in identifiable (color-coded) bags or appropriate containers" (mean score: 4.71). The total mean score for safe handling/disposal of medical waste

Table 2. Assessment of adherence of HCWs regarding infection control measures (n=580)

Statement	Mean ± SD	
1.	Hand hygiene should be applied before preparing a clean or aseptic procedure	4.85±0.66
2.	Hand hygiene should be applied before entering the patient environment and touching a patient	4.82±0.52
3.	Hand hygiene should be applied after bodily fluid exposure or risk	4.81±0.51
4.	Hand hygiene should be applied after touching a patient	4.78±0.55
5.	Hand hygiene should be applied after leaving the patient's environment or surroundings	4.75±0.58
6.	Ensure fingernails are clean, short and that artificial nails or nail products are not worn	4.71±0.65
7.	The hand-washing process includes rubbing hands together and rubbing palms and backs of hands, fingers, and spaces between fingers and wrists.	4.70±0.60
8.	The hands are rinsed with sufficient running water.	4.69±0.67
9.	Use the alcohol rub on hands when there is no visible soiling, such as blood or bodily fluid	4.68±0.69
10.	Use hand wash with water when there is visible soiling.	4.66±0.74
11.	For using alcohol rub, fill the palm of the hand & apply enough hand rub to cover all areas of the hands and rub hands until dry	4.66±0.68
12.	Cover all cuts or abrasions with a waterproof dressing.	4.65±0.76
13.	Washing hands with clean water & soap for at least 30 seconds	4.64±0.73
14.	Dry hands with a paper towel, individual towel, or electronic hand dryer	4.64±0.69
15.	Remove all hand and wrist jewelry before performing hand hygiene	4.57±0.83
Adherence of hand hygiene total mean score		**4.71±0.46**
16.	Wear gloves whenever in contact with blood, other body substances or contaminated tools and surfaces and when in an isolation room	4.73±0.71
17.	Clean hands before and after wearing PPE	4.68±0.73
18.	Remove gloves promptly after use and before touching clean items and environmental surfaces	4.67±0.75
19.	Perform hand hygiene immediately after removing gloves	4.66±0.78
20.	PPE is put on before contact with a patient and their environment.	4.65±0.78
21.	Wear gloves before any intervention	4.62±0.84
22.	Wear an N95 mask when indicated to enter an airborne isolation room, & remove it only when outside of the room.	4.57±0.90
23.	Wear a mask to cover the mouth and nose.	4.54±0.87
24.	Change gloves between tasks/procedures on the same patient	4.44±0.93
25.	Change mask between patients and sooner if mask becomes wet, moist or torn	4.37±1.01
26.	Wear a vest inside the health center	4.13±1.22
PPE (vest, gloves, facemasks) total mean score		**4.55±0.60**
27.	Place medical waste in identifiable (color-coded) bags or appropriate container	4.70±0.74
28.	Follow local guidance for waste management	4.65±0.75
29.	Follow any manufacturer guidance on cleaning, for example, electronic equipment	4.48±0.79
30.	Equipment that is reusable, such as stethoscopes, wheelchairs, crutches, bath aids, etc., are routinely cleaned and decontaminated	4.36±0.85
Safe handling/disposal of medical waste total mean score		**4.54±0.67**
Total adherence score		**103.2±9.71**
Level of adherence		N (%)
• Poor		08 (01.4%)
• Moderate		513 (88.4%)
• Good		59 (10.2%)

Response has a range from "Never" coded with 1 to "Always" coded with 5

Table 3. Association between adherence score among the Socio-demographic characteristics and the profile of the HCWs regarding infection control (n=580)

Factor	Adherence Score (150) Mean ± SD	Z-test	P-value §
Age group			
• 22-30 years	102.9±8.41	3.644	0.162 ‡
• 31-40 years	102.8±11.1		
• >40 years	104.8±8.09		
Gender			
• Male	102.8±9.59	2.303	**0.021** **
• Female	103.9±9.86		
Nationality			
• Saudi	102.9±9.16	0.589	0.556
• Non-Saudi	103.4±9.98		
Job title †			
• Physician	104.3±8.24	25.174	**<0.001** ** ‡
• Pharmacist/Dentist	100.3±10.1		
• Nurse	104.7±9.71		
• Technician/Paramedics	103.3±10.1		
Position †			
• Supervisor	102.2±10.2	4.088	**<0.001** **
• Practitioner	104.6±9.03		
Healthcare facility †			
• PHC Center/Polyclinic	103.0±6.95	8.879	**0.012** ** ‡
• Hospital-Outpatient Clinic	101.6±10.4		
• Hospital-Emergency Department	104.3±7.43		
Workplace †			
• MOH	102.7±8.69	2.898	**0.004** **
• Non-MOH	104.5±10.8		
Years of working experience			
• 1 year or less	103.4±9.94	1.872	0.392 ‡
• 2-3 years	102.2±10.4		
• 4-6 years	104.3±7.43		
Having a recognized antimicrobial stewardship program team/unit at your healthcare facility †			
• Yes	102.7±8.87	2.492	**0.013** **
• No	99.9±11.1		
Having antimicrobial stewardship standard policies and procedures in your healthcare facility †			
• Yes	103.3±8.40	2.340	**0.019** **
• No	100.5±12.2		
COVID-19 pandemic improve the infection control measures in your healthcare facility†			
• Yes	103.1±9.33	1.837	0.066
• No	100.6±10.6		
COVID-19 pandemic improves your adherence to infection control measures†			
• Yes	103.1±9.33	2.482	**0.013** **
• No	100.6±10.6		

Table 3. Cont...

Factor	Adherence Score (150) Mean ± SD	Z-test	P-value §
Get vaccination against the Influenza virus for this year †			
• Yes	103.7±8.70	1.308	0.191
• No	101.9±11.9		
Get vaccination with 3rd dose against the coronavirus †			
• Yes	103.2±9.26	0.731	0.465
• No	104.4±10.7		
Get vaccination with a seasonal booster dose against the coronavirus †			
• Yes	102.9±9.94	0.762	0.446
• No	103.8±8.79		
Having evidence of immunity by documentation for vaccines †			
• Yes	103.2±8.15	3.429	**0.001** **
• No	104.8±10.6		
Having evidence of immunity by laboratory evidence of immunity †			
• Yes	102.7±8.45	3.564	**<0.001** **
• No	104.3±10.1		
Having evidence of immunity by laboratory confirmation of disease †			
• Yes	102.8±7.56	3.281	**0.001** **
• No	104.0±9.17		
Having evidence of immunity by diagnosis or verification of a history of disease by a healthcare provider †			
• Yes	102.8±9.01	1.319	0.187
• No	103.3±9.04		

† Not mentioned or Don't know cases were excluded from the analysis.
§ P-value has been calculated using Mann-Whitney Z-test.
‡ P-value has been calculated using Kruskal-Wallis H-test.
** Significant at p<0.05 level.

was 4.54 (SD 0.67). Based on the given criteria, the overall adherence score was 103.2 (SD 9.71), with poor, moderate, and good adherence accounting for 1.4%, 88.4%, and 10.2%, respectively.

When measuring the association between the score of adherence in relation to the socio-demographic characteristics and the profile of the HCWs regarding infection control (Table 3), it was observed that a higher adherence score was significantly associated with female gender (Z=2.303; p=0.021), being a nurse (H=25.174; p<0.001), being a practitioner (Z=4.088; p<0.001), working in the hospital emergency department (H=8.879; p=0.012), non-MOH employee (Z=2.898; p=0.004), having a recognized antimicrobial stewardship program team/unit at healthcare facility (Z=2.492; p=0.013), having antimicrobial stewardship standard policies and procedures at healthcare facility (Z=2.340; p=0.019), believed that COVID-19 pandemic improves adherence to infection control measures (Z=2.482; p=0.013), having no evidence of immunity by documentation for vaccines (Z=3.429; p=0.001), having no evidence of immunity by laboratory evidence of immunity (Z=3.564; p<0.001), and having no evidence of immunity by laboratory confirmation of disease (Z=3.281; p=0.001).

When conducting post-hoc analysis (Table 4), it was revealed that there was a significant difference in the score of adherence between physician versus pharmacist/dentist (p=0.006), between nurse versus pharmacist/dentist (p=0.001), and between technician/paramedics versus pharmacist/dentist (p=0.045).

Table 4. Multiple mean differences of the adherence score in terms of Job title

(I) Job title recode	(J) Job title recode	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Physician	Pharmacist/Dentist	3.96953*	1.19951	0.006	0.7938	7.1452
	Nurse	-0.49313	1.15628	1.000	-3.5544	2.5681
	Technician/Paramedics	0.93098	1.14162	1.000	-2.0915	3.9534
Pharmacist/ Dentist	Physician	-3.96953*	1.19951	0.006	-7.1452	-0.7938
	Nurse	-4.46266*	1.14659	0.001	-7.4983	-1.4270
	Technician/Paramedics	-3.03854*	1.13181	0.045	-6.0350	-0.0421
Nurse	Physician	0.49313	1.15628	1.000	-2.5681	3.5544
	Pharmacist/Dentist	4.46266*	1.14659	0.001	1.4270	7.4983
	Technician/Paramedics	1.42411	1.08588	1.000	-1.4508	4.2990
Technician/ Paramedics	Physician	-0.93098	1.14162	1.000	-3.9534	2.0915
	Pharmacist/Dentist	3.03854*	1.13181	0.045	0.0421	6.0350
	Nurse	-1.42411	1.08588	1.000	-4.2990	1.4508

Post-hoc test has been conducted using Dunn-Bonferroni test.
*The mean difference is significant at the 0.05 level.

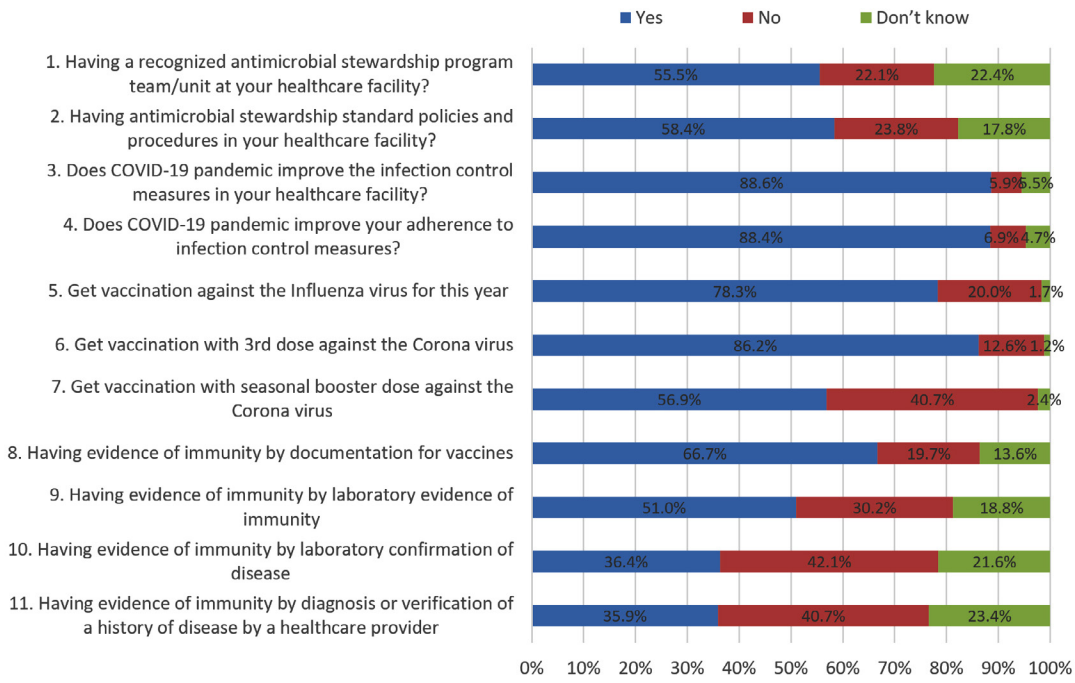

Figure. Profile of healthcare facility & HCWs regarding infection control

DISCUSSION

Infection prevention and control (IPC) measures play a crucial role in minimizing the transmission of infectious diseases within healthcare settings. HCWs have a vital responsibility in implementing and adhering to IPC measures to protect both themselves and their patients from acquiring and spreading infections. During the COVID-19 pandemic, there has been a heightened emphasis on IPC measures worldwide. HCWs have been at the forefront of the pandemic response, and their compliance with IPC measures has become increasingly important. Studies and observations have shown that HCWs' adherence to IPC measures has improved significantly during this period, with specific focus on hand hygiene, personal protective equipment (PPE) usage, and medical waste disposal as crucial benchmarks of compliance.

The objective of this study is to assess the extent to which healthcare workers (HCWs) comply with infection prevention and control (IPC) measures following the COVID-19 pandemic. To our knowledge, this is the first study in southern region of Saudi Arabia that measures the adherence of HCWs regarding IPC measures in the post-COVID-19 era.

The results of this study are significant as they provide validation regarding whether HCWs sustained or enhanced their adherence to IPC measures after the COVID-19 pandemic. The study found that HCWs demonstrated satisfactory compliance with IPC measures in the post-pandemic period. Based on our criteria, the overall mean adherence score was 103.2 out of 150 points, with majority (88.4%) considered to have moderate adherence, 10.2% were good, and only 1.4% were considered to have poor levels of adherence. This is consistent with the study of Yang *et al.* in Wuhan, China.[8] According to their findings, HCWs demonstrated good IPC behavior during the pandemic; however, their compliance regarding goggle and gown usage was relatively low. This corroborates with the results of a study conducted in Malaysia by Mohammed *et al.*,[12] with 63.7% of HCWs showing compliance with IPC, which was also in accordance with the report of Ashinyo *et al.* in Ghana.[13] Contradicting these reports, lower compliance with IPC has been documented by Bahegwa *et al.*, in Tanzania, reporting that only 22.5% of HCWs had high infection prevention and control standard precautions (IPCSPs).[14]

The current study provides evidence of improved IPC adherence among HCWs. However, periodic training might be beneficial to maintain their compliance even after the pandemic.

Demographic data such as females, nurse practitioners, and working in hospital emergency department were the significant predictors of increased adherence. In AlDawadmi, Saudi Arabia,[7] perception of the infection prevention climate was significantly associated with clinical experience, nationality, and attendance to seminars or training. In Dammam, Saudi Arabia,[15] Healthcare providers (HCPs) preventive behavior was significantly higher among those with more knowledge of COVID-19, positive attitude, higher fear, and nursing profession (p=0.01). In Ethiopia,[9] HCWs who received training on IPC protocols and working in treatment centers had an increased attitude of following IPC standards by at least four times higher compared to those without training, while in Tanzania,[14] the identified predictors of HCWs' compliance with IPCSPs include years of work experience, having experienced a needlestick injury, and previous IPC training or an IPC seminar. Moreover, our study also noted that HCWs who have a recognized antimicrobial steward program team/unit or have antimicrobial stewardship standard policies and procedures at healthcare facilities, those who believe that the COVID-19 pandemic improves adherence to IPCs, those with evidence of immunity by documentation for vaccines, or by laboratory evidence of immunity, or by laboratory confirmation of disease were seen to have an increased IPC adherence. A study in the Philippines found that the organization and environmental factors significantly impacted compliance with IPC measures.[16] However, the knowledge, perception, attitude, and adherence to IPC measures were not affected by the risk of COVID-19 infection. In China,[8] better behaviors of gown use were significantly associated among HCWs working in high-risk departments. In addition, HCWs who had encountered confirmed or suspected COVID-19 patients demonstrated worse goggle and gown use behaviors.

Regarding the specific assessment of IPC adherence, our study suggests that hand

hygiene (HH) practices were seen to have the highest ratings (mean score: 4.71, out of 5 points), followed by Personal Protective Equipment (PPE) used (mean score: 4.55, out of 5 points) and the third was safe handling/disposal of medical waste (mean score: 4.54, out of 5 points). This is almost consistent with the study of Ashinyo *et al.*, in Ghana,[13] 88.4% reported HH compliance during healthcare interactions and 90.6% of PPE usage. On IPC compliance toward performing AGPs (aerosol-generating procedures), HH compliance was 97.5%, with an identical proportion (97.5%) for PPE usage. This has been concurred by the study conducted in Philippines by Mae & Angelo, wherein HH showed the highest compliance score, followed by sharps disposal, and PPE utilization was the lowest.[16]

Compliance of the healthcare facility toward IPC measures was seen to improve at the time of the pandemic. This was also observed in the current study. HCWs indicated that the COVID-19 pandemic improved their healthcare facilities' IPC measures and adherence, reaching at least 88.6% and 88.4%, respectively. Most of the HCWs adhere to COVID-19 vaccination (86.2%), including its seasonal booster (56.9%). A global survey at the time of the pandemic compromising 103 countries documented that 62.5% of those countries had national IPC programmes, but those with a dedicated budget were only 26.1%. Low-income countries were seen to have a lack of resources and implementation of IPC programs.[6] This scenario was shown in Pakistan, as 40.8% of HCWs disclosed that their healthcare facility does not have a functional IPC team, and 58.3% did not receive IPC training.[17]

The COVID-19 pandemic has served as a catalyst for improving HCWs' compliance with IPC measures. The increased awareness of the importance of infection control, coupled with enhanced training, availability of resources, and rigorous enforcement of IPC guidelines, has contributed to significant improvements in adherence. Additionally, the pandemic has highlighted the critical role of IPC in protecting both HCWs and patients, further motivating HCWs to prioritize compliance.[18,19]

It is important to sustain this improved compliance beyond the pandemic. Ongoing education, training, and reinforcement of IPC practices should be prioritized to ensure long-term adherence. Healthcare facilities should continue to provide necessary resources and support systems to facilitate compliance with IPC measures. Regular monitoring, auditing, and feedback mechanisms can help identify areas of improvement and maintain high levels of compliance.[20]

CONCLUSION

The study found that HCWs demonstrated satisfactory compliance with IPC measures in the post-pandemic period. Increased adherence was more prevalent in female nurses working in a hospital emergency department who had a recognized antimicrobial stewardship team or unit at their healthcare facility. Among IPC measures, hand hygiene compliance showed the highest, while safe handling/disposal of medical waste showed the least. The study's future implications underscore the importance of targeted interventions, emphasizing hand hygiene, addressing gaps in medical waste management, implementing continuous follow-up and safety drills, and enhancing readiness for future epidemics. By focusing on these areas, healthcare facilities can improve compliance with IPC measures among HCWs and strengthen their overall infection prevention and control strategies.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTION

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

FUNDING

None.

DATA AVAILABILITY

All datasets generated or analyzed during this study are included in the manuscript.

ETHICS STATEMENT

This study was apporved by the Regional Scientific Research Ethics Committee, Najran University, Najran, Saudi Arabia, with reference number CSR/NU/2022/1023.

INFORMED CONSENT

Written informed consent was obtained from the participants before enrolling in the study.

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