Original Article

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Role of Structured Infection Prevention and Control Training Program in Reducing Surface Contamination and hospital acquired infections: A Single Centre Study

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Author`s Contribution

[1,2]Substantial contributions to the conception or design of the work; or the acquisition, [4,6]Active participation in active methodology, [2,3]analysis, or interpretation of data for the work, [5]Drafting the work or revising it critically for important intellectual content

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ABSTRACT

Objective: To assess the impact of a structured IPC training program on reducing surface contamination and the frequency of HAIs. The findings aim to support effective infection control strategies and improved outcomes in healthcare settings.

Methodology: Retrospective interpreted time series (ITS) analysis of monthly environmental cultures from six critical areas of Tertiary care teaching hospital (June 2022 to Dec 2023) was conducted. Surface culture reports and HAI records were analyzed before and after IPC training implementation. Descriptive statistics and chi-square tests assessed the changes in surface contamination and HAI rates.

Results: Among 619 environmental samples from six critical areas, 32 (5.1%) showed microbial growth. Positive cultures rates declined significantly across study period from 11.9% to 3.1% and 1.7% following IPC program implementation ($\chi^2 = 23.37$, df = 2, $p < 0.001$). ICUs had highest contamination, predominantly Gram-positive cocci, including coagulase-negative Staphylococci. Hospital-acquired infections decreased in critical areas, with a significant shift after IPC implementation ($\chi^2 = 9.95$, df = 3, $p = 0.019$).

Conclusion: There is a significant impact of implementation of infection prevention and control policies followed by regular and structured training sessions of healthcare professionals on surface bacterial contamination of critical areas and hospital associated infections in a tertiary care hospital.

Key words: Infection control, Surface contamination, hospital-acquired infections.

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Introduction

Infection Prevention and Control has become a cornerstone of patient Safety and quality care within healthcare settings, particularly as the burden of hospital-acquired settings, particularly as the burden of Hospital-acquired Infections (HAIs) continues to pose significant challenges to patient outcomes and healthcare systems globally.[1] World health organization (WHO) has addressed Healthcare Acquired Infection (HAI) as global safety issue.[2] These infections like device-associated infections, surgical site infections (SSIs), bloodstream infections, ventilator-associated pneumonia, and urinary tract infections often arise due to complex interactions between patient factors, invasive procedures, and environmental contamination in healthcare settings. Intensive care units (ICUs) are high-risk environments due to the vulnerability of critically ill patients, frequent use of invasive devices, and the high density of care interventions. [3]A recent study has shown a high burden of hospital associated drug resistant infections with global number to be 136 million/year and Pakistan being second highest in number.[4]

Contaminated hospital environment including frequently touched surfaces like bad railing, door handles, stethoscopes, monitors, catheters and environmental surfaces like sinks, trolleys and tables harbor pathogens

extensively and can be a cause of HAI more so in critical areas like Intensive Care Units (ICUs) and Operation Theatres (OTs)[5]. This necessitates the implementation of robust training programs aimed at enhancing knowledge and skills of healthcare workers in infection control practices.[6] A 24-hour point prevalence study conducted in 88 ICUs reported a 54% prevalence of suspected or confirmed infections, with 22% of cases originating in ICUs.[7]A study conducted in Iraqi operation theatres reported bacterial contamination on surgical equipment, with Staphylococcus epidermidis (26.1%) being the most common, followed by Bacillus spp. (18%), S. aureus (16.9%), Klebsiella spp. (14%), Enterobacter spp. (12.5%), P. aeruginosa (3.7%), and E. coli(3.7%).[8]

Several factors contribute to the persistence of surface contamination, including gaps in cleaning protocols, inadequate hand hygiene, and non-compliance with infection prevention and control (IPC) measures.[9] Periodic environmental cultures through close collaboration of infection control department and increasing awareness among health care professionals can also reduce the rate of hospital acquired infections.[10] In addition to environmental cultures, fumigation of such area and practicing proper hand hygiene also reduces HAIs.[11]Implementation of structured educational program directly improves the knowledge of health care professions /nurses.[12] These programs equip healthcare personnel with essential knowledge and practical skills, while routine monitoring ensures compliance and allows for timely corrective actions.[9] The role of such programs becomes especially critical in tertiary care hospitals, where patient bulk, invasive procedures, and antimicrobial resistance converge to elevate infection risks.[13]

This study aims to investigate the specific role of a structured IPC training program in a single healthcare facility, focusing on its impact on reducing surface contamination and Hospital Acquired Infections. The findings of the study are expected to contribute to the broader discourse on effective infection control strategies, highlighting the importance of ongoing education and real-time monitoring in sustaining compliance and enhancing patient care. Ultimately, this research aims to support healthcare facilities in their efforts to improve patient outcomes and reduce the healthcare costs associated with HAIs, thereby reinforcing the critical role of structured IPC training in contemporary healthcare practice.

Methodology

Retrospective interpreted time series analysis of monthly environmental cultures from six critical areas of Tertiary care teaching hospital from June 2022 to Dec2023 was done with respect to Infection Prevention and Control training program and hospital acquired infections. Environmental monitoring and surveillance reports were withdrawn from the hospital laboratory management system (LMS) and infection control record after the approval of ethical committee Ref No 223/IMDC/REB-2025. These critical areas included Operation theatre, ICU, PICU, NICU, ER-minor OT and Obstetrics-Gynecology Operation theatre. Reports of surface samples from suction bottle, incubation trolley, instrument trolley, bed, oxygen flow meter, keyboard, crash cart trolley, OT table, OT light, anesthesia machine, suction machine, air outlet, ventilator, incubator, medication trolley, dressing trolleys and air-duct were analyzed. Sterile culture swab was used to collect samples. The sterile cotton swabs were moistened with normal saline rolled on targeted surfaces and transported to Microbiology section of hospital lab for further processing. The samples were inoculated on Blood agar and MacConkey agar plates. Plates were labeled and incubated at 37 degrees Celsius for 24 hours. Organisms were identified based on appearance of the colonies and bacterial identification was performed using Gram staining, microscopy and biochemical tests.

After baseline evaluation of IPC practices and documentation, frequency of positive surface contamination, Hospital acquired infections including Surgical Site Infections (SSIs) from Jun-Dec 2022, the structured training program was conducted by the Infection Prevention and Control (IPC) nurse, comprising PowerPoint presentations and hands-on sessions aligned with national and International IPC guidelines. The formal training sessions for doctors, nurses, nursing assistant, laboratory personnel and housekeeping staff were held every Saturday (approximately 10 hours per month) and were led by the IPC nurse. Policies and SOPs are implemented and compliance is checked through regular audits. IPC program is shown in table-1. Impact of IPC training program was evaluated by checked by change in frequency of positive surface contamination, Hospital Acquired Infection rates including Surgical Site Infections.

Table I: Summary of IPC program activities.

Component	Description
Policy and Development	Development and implementation of 27 SOPs and guidelines.
Internal teaching	Weekly IPC training of hospital staff (on-floor doctors, nurses and housekeeping staff). 50 sessions of teaching of Nursing, House Keeping and OT staff.
Infrastructure	Updating the infrastructure as per IPC requirements (Installation of sinks, hand sanitizers and waste management
Environmental monitoring	Monthly surface cultures of critical areas of hospital and quarterly chemical and microbiological analysis of water (Drinking Bottle supply and tap)
Surveillance of infectious diseases	Reporting of Surgical site Infections, Hospital acquired Infection and disease outbreaks
Internal audits	To check the compliance with hospital IPC SOPs and Hand hygiene practices, use of PPEs, cleaning and disinfection (surface, floors, equipment), sterilization.
Reporting	Monthly reporting of IPC activities and observations to Hospital Infection Prevention and control committee and Hospital Management

Descriptive data was presented in frequency, percentage and graphs. The association between IPC program implementation with environment culture positivity and rates of Hospital Acquired Infections (HAIs) was assessed by Chi-square test of independence.

Results

A total of 32/619(5.1%) samples reports retrieved from the six critical areas of ANTH showed positive microbial growth. The frequency of the positive culture results in 3 halves of the study period with ongoing IPC program declined from 11.9% to 3.1% and finally to 1.7% in last half. There is statistically significant reduction in the positive environmental culture after IPC Program implementation with chi-square value (χ^2) of 23.37, df of 2 with p-value of < 0.001 (Table I)

ICU harbored the maximum number of positive cases and Gram-positive cocci (GPC) including Coagulase negative Staphylococcus (CoNS) were most frequent.

Hospital acquired infections also showed coherence with frequency of environmental surveillance of frequently touched surfaces and equipment. In July-Dec 2022, 19 cases of bedsores, CVP associated infections (CVP AI), surgical site infections (SSI) and blood stream infections (BSI) were reported collectively. These infections including SSI, BSI and few Ventilators associated infection (VAI) declined to 9 cases in July-Dec 2023. This is significant change in the frequency distribution of HAIs type following the IPC implementation with chi-square (χ^2) 9.95, df of 3, and p-value of 0.019. (Table III)

Discussion

In critical care settings poor cleaning practices and disinfection measures may result in contaminated surfaces which can pose risk of HAIs for patients.[14] Surface contaminations are monitored through cultures of frequently touched surfaces and equipment. In our study the highest number of positive surface cultures were collected from ICU followed by NICU and PICU whereas OTs had least number of positive cases. These findings are comparable with studies conducted by Russotto V et al &

Table II: Environmental culture in Pre and Post IPC program implementation period.

Critical areas	2022			2023			2023			p-value
	July-Dec			Jan-Jun			Jul-Dec			
	Positive cultures	No. of Samples	%	Positive cultures	No. of Samples	%	Positive cultures	No. of Samples	%	
ICU	10	24	41.7	5	27	18.5	2	27	0	<0.001
NICU	4	22	18.2	1	24	0	1	24	0	
PICU	4	18	22.2	1	29	0	1	29	0	
OT	2	70	2.9	0	78	0	0	79	0	
ER(MINOR)	0	18	0.0	0	23	0	0	24	0	
Gyne &Obs OT	1	24	4.2	0	39	0	0	40	0	
Total	21	176	11.9	7	220	3.1	4	223	1.7	

Table III: Surgical Site Infection (SSI) Data.

Surveillance Period	SSI	Specialty	Total Surgeries Performed	No of Cases	%
July – Dec 2022	1	General Surgery	2200	5	0.22%
	4	Obstetrics and Gynecology			
Jan – June 2023	2	Orthopedic	1998	3	0.15%
	1	General Surgery			
July- Dec 2023	1	General Surgery	1619	4	0.24%
	3	Obstetrical Gynecology			

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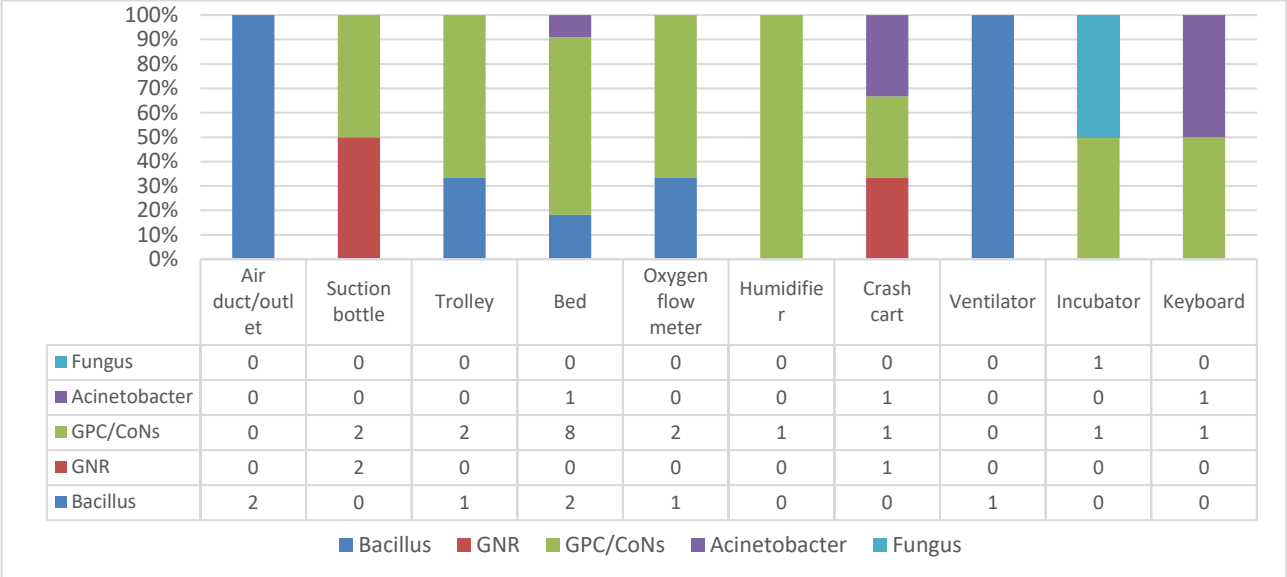

	Air duct/outlet	Suction bottle	Trolley	Bed	Oxygen flow meter	Humidifier	Crash cart	Ventilator	Incubator	Keyboard
Fungus	0	0	0	0	0	0	0	0	1	0
Acinetobacter	0	0	0	1	0	0	1	0	0	1
GPC/CoNs	0	2	2	8	2	1	1	0	1	1
GNR	0	2	0	0	0	0	1	0	0	0
Bacillus	2	0	1	2	1	0	0	1	0	0

Figure 1. Microorganisms according to site of positive surface cultures.

GNR- Gram Negative Rods

GPC/CoNS- Gram Positive Cocci/ Coagulase Negative Staphylococci

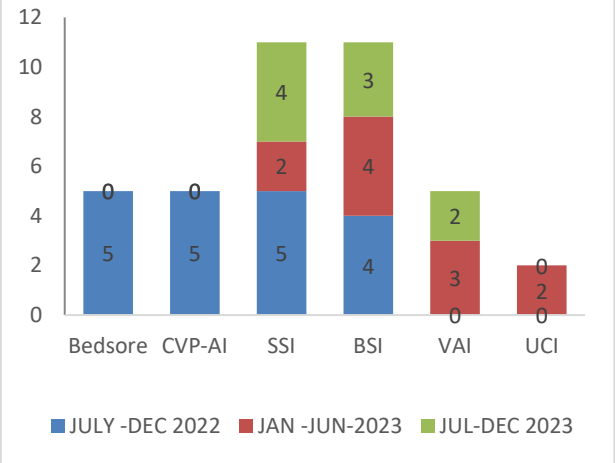

Figure 2. Break-up of Hospital acquired infections.

CVP-AI- CVP Associated Infection

SSI- Surgical Site Infection

BSI- Blood stream Infection

VAI- Ventilator Associated Infection

UCI= Urinary Catheter Infection

Vincent J et al which also showed highest growth rates in ICUs. [5,7] Mathew et al. conducted a case study in Northern Nigeria and documented high bacterial load in operation theatres, particularly on surfaces that were presumed to be sterile.[17] Studies conducted by Ojanperä H et al &Sigh S et al also showed high bacterial growth rates in OTs while in a study conducted in Nepal NICU harbored maximum bacterial contamination of as high as 74% (109/146). 9.[10,15] The presence of pathogenic organisms in such sterile environments highlights poor cleaning practices and inadequate infection control measures and so increases the risk of hospital associated infections.

Equipment and frequently touched surfaces act as a reservoir of bacteria and are major contributors to the development and transmission of HAIs.[16,14,15]A study conducted in Kenya showed isolation of multidrug resistant pathogenic bacteria from 12.6% frequently touched surfaces like beddings, sinks, baby cots and incubators.[14] Our monthly reports comprised of cultures collected from suction bottle, incubation trolley, instrument trolley, bed, oxygen flow meter, keyboard, crash cart trolley, OT table, OT light, anesthesia machine, suction machine, air outlet, ventilator, incubator, medication trolley, dressing trolleys and air-ducts. We observed a high rate of bacterial contamination from bed railings (11/32=34.3% cases) across multiple critical care areas. These surfaces, due to their frequent contact with healthcare workers and patients, provide an ideal environment for microbial persistence and transmission. Our findings are consistent with those of Odoyo et al who reported bacterial contamination having multidrug resistant sensitivity from frequently touched surfaces across various departments in Kenyan hospitals.[16] The study emphasized that contaminated hospital surfaces implicates in the spread of resistant pathogens such as Acinetobacter baumannii, Klebsiella pneumoniae, and Pseudomonas aeruginosa and poses an elevated risk of HAI. Bhatta et al demonstrated substantial bacterial contamination in NICUs, raising concerns about the safety

of neonates who are especially vulnerable to infections due to their underdeveloped immune systems. [15]

Microorganism isolated from surfaces can vary from normal flora to pathogenic micro-organisms. The frequency of various organisms isolated from specialized wards in our setting were 55% Gram positive cocci (GPC) including Coagulase negative Staph (CoNS),28% bacillus,14% Gram negative rods (GNRs) including Acnetobacter and 3% fungal isolate. The pattern of pathogens is comparable with results of a study conducted by Singh S in our neighboring country.[10] Another study reported microbial contaminants from the major OTs included Staphylococcus aureus, CoNS, Bacillus and GNRs in decreasing order of frequency.[17] A high rate of E-coli followed by Enterobacter and Pseudomonas specie, Staphylococcus aureus, and Streptococcus pneumoniae were detected from high touched surfaces in another study.[18]

Above findings collectively emphasize the critical role of environmental hygiene and rigorous infection control protocols in reducing the burden of HAIs. A recent study by Verhougstraete et al demonstrated that inadequate cleaning rooms in high risk areas significantly increase the risk of subsequent patients acquiring HAI.[19] Methods and types of disinfectants used in hospital settings also have a direct impact on bacterial contamination of the surfaces. More emphasize is now on efficacy of different disinfectants e.g. use of probiotic cleaning, use of Ultraviolet markers to check effectiveness of disinfectants audit or use of bundled evidence-based strategies.[20,21,22] Effective disinfection strategies targeting high-touch surfaces, combined with regular microbiological surveillance and staff training are essential to mitigate the risk of pathogen transmission in healthcare settings.[23]

For a sustainable infection prevention practices structured and regular training session are vital[24].A recent study has highlighted the fact that regular trainings and continuous motivation leads to sustainable results as compare to one time intervention.[25] This practice is highlighted in a study conducted in Israel over three phases of implementation of CDC guidelines in prevention of CLABSI. Results showed that pooled mean (SD) incidence of CLABSI per 1,000 central line-days dropped from 7.4 (0.38) in phase I to 2.1 (0.13) in phase III. These phases included phase I of introduction of baseline CDC guidelines, phase II of proper implementation of these guidelines and phase III of implementation of additional measures as per guidelines.[26] We also found a positive impact of awareness strategies of infection prevention and control policy on the frequency of surface contamination. Regular training sessions were conducted in our hospital among healthcare professionals. During the weekly training program involving nurses, nursing assistants and housekeeping staff, with specific emphasis on the importance of hand hygiene and WHO recommended methods of securing hand hygiene were regularly given. It is the most basic and cost-effective way of preventing spread of hospital associated infection.[27] In one of the studies related to Clostridium difficile spread, in addition to other infection control measures stringent hand hygiene practices amongst health care worker and patients proved to be an effective way of preventing this important hospital acquired infection.[28] A local study conducted in a tertiary care hospital in Pakistan showed that only 17% of health professionals were aware of proper hand hygiene technique while only 4.9% actually practiced it in daily routine.[29]

A major category of HAIs documented in our study are surgical site infections and blood stream infections. We just noticed the trends of various HAI during study period and factors other than surface contamination and infection control measures were not addressed. Prevalence of SSI is associated with factors such as prolonged surgery duration, emergency procedures, perioperative infection control measures ,optimization of antibiotic prophylaxis, and meticulous wound care practices.[30,31]Regarding blood stream infection a Logistic regression analysis ia a study identified severe sepsis or septic shock incidents, inadequate empirical antimicrobial therapy and corticosteroids use preceding infection onset as the independent predictors of 28-day mortality of carbapenem-resistant *Klebsiella pneumoniae* bloodstream infection(CRKP-BSI)patients.[32]

In our study regular training sessions, environmental monitoring, surveillance of infectious diseases, internal audit and reporting of various hospital acquired infections has also shown a positive and persistent effect on the rate of surface contamination and hospital acquired infections.

Conclusion

There is a significant impact of implementation of infection prevention and control policies followed by regular and structured training sessions of healthcare professionals on surface bacterial contamination of critical areas and hospital associated infections in a tertiary care hospital.

Limitations of study: Antimicrobial sensitivity pattern of the organism isolated from various surfaces were not performed. Air quality of these specialized areas could not be evaluated

which also has direct effect on healthcare associated infections. Correlation of surface contamination and hospital acquired infections require more comprehensive analysis.

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