The Role of Infection Control Systems in Combating Contamination in Healthcare Facilities

Hanaa Mohammed Saeed Al-Mowalled[1], Sultan Bashir Hassan Asha[2], Haya Mubarak Hussein Al-Beshi[3], Yasir Siraj Abdulaziz Almatrafi[4], Amal Mohammed Ahmad Oteaf [5], Faisal Fahad Algethami[6], Naif Jarad Hassan Alzahrani[7], Alaa Mohammed Saif [8], Mohana Abdulaziz Marzog Alsolimy [9], Hana Mubarak Mohammed Albalawi[10], Atallah Sulaiman Homud Albalawi[11], Khalid Abdullaha Tawakkul[12]

Nursing Specialist - Ajyad Emergency Hospital in Makkah[1]
Nursing Specialist - Ajyad Emergency Hospital in Makkah[2]
Nursing Technician - Ajyad Emergency Hospital in Makkah[3]
Nursing Technician- Nursing Technician - Death Affairs Department at the Forensic Medical Services Center in Makkah[4]
Nursing Technician - Maternity and Children's Hospital in Makkah[5]
Nursing Technician- Nursing Technician - Forensic Medicine Department, Forensic Medical Services Center, Makkah Region[6]
Nursing Technician- Nursing Technician - Forensic Medicine Department, Forensic Medical Services Center, Makkah Region[7]
Nursing Technician- Nursing Technician - Forensic Medicine Department, Forensic Medical Services Center, Makkah Region[8]
Nursing Technician- Nursing Technician - Forensic Medicine Department, Forensic Medical Services Center, Makkah Region[9]
Nursing Technician - Population Health - Healthy Cities Management – Tabuk[10]
Nursing Technician - Erada Complex for Mental Health – Tabuk[11]
Nursing Technician- Health program management[12]

ABSTRACT

The existing disconnect between the design and practical implementation of the infection control policy within healthcare facilities has not been properly defined, even though it has severe consequences on the patient safety. This research thus examined the correlation existing between the fidelity of implementation of infection control systems and the contamination results in different hospital wards with different risk levels of classifications. The design was a cross-sectional correlational design across ten inpatient wards of a tertiary care hospital of two high-risk intensive care units, three medium-risk surgical wards, and five low-risk general medical wards. Fidelity of implementation was measured by a WHO-based, observational checklist and environmental contamination was measured by microbiological samples and rates of healthcare-associated infections were measured through institutional surveillance data. Statistical tests were Pearson correlation analysis, multiple regression analysis, and ANOVA. The implementation scores had strong negative correlations with the environmental contamination ($r = -0.927$, $p < 0.001$) and HAI rates ($r = -0.915$, $p < 0.001$). The hand hygiene compliance and the frequency of surface cleaning became the most predictive independent variables and jointly predicted the infection rates by

91.8%. Significant effects on the implementation fidelity were not noticed between risk strata (p = 0.637). These results indicate that implementation fidelity is important to infection control system efficacy and that hand hygiene and environment cleaning are priority areas of intervention.

Keywords: Environmental contamination, Hand hygiene, Healthcare-associated infections, Infection control systems, Patient safety

INTRODUCTION

Health-associated infections are a challenging and serious problem of concern to patient safety across the globe, with a high prevalence of morbidity, mortality, and healthcare expenditures [1]. The World Health Organization has projected that hundreds of millions of patients fall ill to HAIs every year, with the low and middle-income countries bearing the insurmountable burden [2]. These infections not only extend the hospital stay, but also enhance antimicrobial resistance, as well as placing a significant financial burden on healthcare systems that already function against resource limitations [3]. HAIs prevention has since become a high-priority goal among healthcare institutions all over the world, with the infection control system being the main organizational tool towards the realization of this objective [4].

The infection control systems refer to this entire collection of policies, protocols, infrastructure, and practices that are aimed at avoiding the transmission of pathogens in healthcare settings. These systems normally involve hand hygiene systems, environmental cleaning, staff education, surveillance, and isolation measures [5]. Such systems, when operating well, provide numerous obstacles to the transmission of pathogens, which protects the vulnerable patients against colonization and infection [6]. But the fact that policies are written does not imply that they have been successfully implemented, and there is a lot of evidence that indicates that gaps between policy design and practice at the bedside continue to be typical across various healthcare environments [7].

The literature review of studies of effectiveness in infection control has increased significantly internationally in the last few decades. Through landmark research in European and North American hospitals in the 1980s and 1990s, the fundamental role of hand hygiene became established, and standard rates of compliance set were aspirational goals to this day [8,9]. Further studies established that environmental pollution also plays a significant role in the dynamics of transmission, and pathogens remain longer on surfaces and become sources of contamination of hands [10]. Greater focus on the effect of organizational variables, such as the number of staff, the commitment of leaders, and safety culture, has been examined in more recent studies on the role of these elements in the rate of infection [11]. Although this has been learned, there still exists a significant range of variation in HAI rates across institutions, as well as within the same wards, indicating that some unknown variables still come into play [12].

In the local environment, healthcare institutions have unique problems, which might not be well represented in studies carried out in high-income environments. The implementation and effectiveness of infection control measures may be dependent on resource limitations, workforce constraints, and differences in the patient population [13]. There is also a lack of local studies exploring the relationships between these factors and the optimal aspects of infection control priorities based on available resources. The current study was thus aimed at filling this gap by studying the interaction between the implementation of the infection control systems and contamination results in a representative tertiary care facility [14].

The significance of the study is that it can be used to inform evidence-based resource allocation and quality improvement efforts. Healthcare administrators face some challenging choices on how to allocate the scarce funds among competing needs, such as infection control programs [15]. It would be possible to engage in the interventions of a greater level of specificity and cost-efficiency by understanding which particular elements of infection control systems have the strongest effect on contamination and infection outcomes [16]. Moreover, determining the difference in implementation fidelity between wards with different levels of risks would point out possible areas to be subjected to targeted improvement activities [17].

The justification behind the need to conduct this study was the fact that even with the set policies of the control of infections, the rate of HAI at the institution of the study was higher than desired [18]. The initial conversation with the infection control staff indicated that adherence to the protocols also differed significantly among the wards, but the degree of this difference and its connection to the outcomes were not analyzed systematically [19]. The study was thus conducted with the aim of getting empirical data that could help in directing the quality improvement initiatives and probably lower the rate of infection by means of more efficient execution of available protocols [20].

An analysis of the available literature established a number of gaps that were to be filled in the current study. To begin with, many studies have focused on the isolated evaluation of individuals to some extent concerning infection control precautions, but few studies have conducted on the overall adoption of holistic systems across various types of wards [21]. Second, even the relative role of particular system components in total outcomes has not been fully defined, as opposed to the results shown on the elements that most strongly predict infection rates [22]. Third, there has been little research investigating whether official risk designation is related to actual implementation fidelity, an assumption many policies in the field of infection control rely on to make decisions in resource allocation [23].

The research questions that informed this study were thus developed to fill these gaps. The key question was how the fidelity of the implementation of infection control systems was strongly correlated with the level of environmental contamination and the number of HAI cases in hospital wards [24]. Secondary questions included elements that were identified to significantly predict infection outcomes and the existence of implementation fidelity variation across wards of different official risk classes [25]. These questions were directly used to understand the methodological approach that adopted a cross-sectional correlational design with stratified sampling that guaranteed representation of risk categories [26].

This research had three primary objectives that were in line with the research questions and methodology. The initial one was to assess the present state of functioning of current infection control systems at the selected wards with the help of direct observation based on a validated checklist based on the WHO standards. The second aim was to measure the association between the implementation fidelity and the environmental contamination, in microbiological sampling, and the HAI rates, which were acquired in terms of institutional surveillance data. The third aim was to assess the level of implementation fidelity between high, medium, and low-risk wards to establish whether the official risk designation in high, medium, and low-risk wards was a predictor of actual practice. The aims were compromised by gathering and computing quantitative data by use of correlational and comparative statistics.

In this introduction, the background, scope, and importance of the current investigation have been presented, the research gaps that prompted the study have been stated, and the specific research questions and objectives that informed the methodology have been stated. These objectives were approached through the following sections, which are a description of the methods used and a presentation of the findings.

METHODOLOGY

This was carried out in an urban center, in a large tertiary care teaching hospital. The choice of this facility was explained by its ability to provide a full scope of medical care, have the infection control committee and its recent attempts to modernize its contamination prevention procedures which makes it a perfect place to examine the systems under the question.

1. Philosophy and Method of research

The research philosophy that was used in this work was positivist. This position has its foundation in the assumption that there is an objective reality that is measurable. The explanation behind this decision was in line with the research objectives which aimed to come up with quantifiable associations between infection control systems (an independent variable) and contamination rates (a dependent variable). A positivist methodology was used to collect measurable data in a systematic manner using systematic observation and measurement, which made the results objective, reliable and reproducible and therefore reduced bias of the researcher in the interpretation of the findings.

2. Research Design

The design was a correlational, cross-sectional. The experimental design which requires manipulation of the infection control protocols was neither feasible nor ethical in a live clinical setting where the primary concern is the safety of the patient. Thus, the most suitable alternative was the correlational design. It enabled the strict correlation control of the faithfulness of the implementation of the infection control system and the contamination levels of the various wards in the hospital at one moment. This method was the strategy that allowed revealing important association without any intentional practice that may jeopardize patient care.

3. Parameters and Sampling Strategy in the study

Population: The study population was the entire hospital area on patient-care. Sampling frame refers to all 25 inpatient wards and specialized units (i.e. ICUs, surgical wards, general medicine).

Sampling Method: The sampling technique adopted was a stratified random sampling technique. The first level of stratification of wards was based on their risk of infection (e.g., high-risk ICUs, medium-risk surgical wards, low-risk general wards). Wards were then randomly chosen out of every stratum and so wards of every level of risk of infection represented.

Sample Size: 10 wards were chosen in total. This proportion of the total wards was selected as a sufficient sample size to undergo statistical analysis due to previous similar published studies in the hospital epidemiology and provided logistical feasibility of the study to conduct a detailed environmental sampling and observation in the period covered by the study.

Inclusion/Exclusion Criteria: Wards were included, provided that they had a history of at least one year of operation and a stable patient population. Outpatient procedures were excluded because wards that were temporarily shut down, were being renovated, or used exclusively were excluded to ensure consistency in the environmental conditions.

Data Collection Methods

There was multi-pronged method of evidence triangulation, in which data were gathered.

Instruments: Three main instruments were used (1) structured observational checklist based on the World Health Organization (WHO) Infection Control Assessment Framework to assess system implementation (e.g., hand hygiene compliance, PPE availability, cleaning practices); (2) microbiological sampling of high-contact surfaces with environmental swabs and contact plates (e.g., bed rails, IV poles, door handles); and (3) a retrospective survey of hospital infection control records to determine official HAI rates.

Procedure: Within four weeks, two trained research assistants (who were not a part of the hospital staff) made spontaneous observations in each of the chosen wards by use of the checklist. Environmental health officers on the same breath took 50 microbiological samples on each ward and immediately sent them to a certified laboratory to be further cultured and analyzed to obtain colony-forming units (CFUs) which is a major contamination indicator. Anonymized HAI data on the previous quarter were received at the end of the period in the infection control unit.

Pilot Testing: This was tested in a pilot study on one ward that was not part of the sample. This was a challenge to the observation checklist and the viability of the checklist and this narrowed down the environmental sampling protocol to achieve uniformity.

Ethical concerns: The University of Toronto Institutional Review Board and research committee of the hospital were able to provide Ethical Approval to the study. All the data were anonymized during the collection of data; none of the patient or staff data was gathered. The hospital administration gave informed consent to the wards and records.

Variables and Measures

Independent Variable: Fidelity of Infection Control System Implementation. This was operationally defined as percentage of the checklist score on the 40 items checklist of observation. An increase in score was a sign of more stable protocol implementation. The content validity of the checklist was achieved through the fact that it was developed based on WHO standards.

Dependent Variables: (1) the level of environmental contamination was determined by the mean number of CFU/cm 2 on surface samples. (2) Healthcare-Associated Infection Rate was calculated as the reports of the new HAI cases in each ward per 1,000 patient-days, categorized in official data in the hospital. The standardized microbiological methods and the use of calibrated equipment were used to ensure the reliability of the lab analysis.

Data Analysis Plan

The analysis of data was done by means of SPSS 28.0 analysis. Implementation scores, CFU counts, and HAI rates in the various ward strata were analyzed and obtained using descriptive statistics (means and standard deviations). In answering the main research question, Pearson correlation coefficient was calculated in order to establish the strength and direction of relationship between implementation scores (independent variable) and the contamination levels as well as the HAI rates (dependent variables). The statistical approach fitted the study as it measures the linear relationship between continuous variables directly testing the hypothesis of the study.

Ethical Considerations

As observed, any formal consent was secured with all the concerned authorities. All wards were coded to ensure confidentiality and data were reported in aggregate only. No specific staff members were observed. All the data were stored in a password-protected university server.

RESULTS

Descriptive Characteristics Population of the Study

Ten inpatient wards were incorporated during the final analysis, including two high-risk (intensive care units), three medium-risk (surgical ward), and five low-risk (general medical ward) wards. Table 1 shows the descriptive statistics of the main variables of the study in the total sample and according to the type of ward.

The average Infection Control System implementation score (ICS_Score) of the entire wards equaled 80.65% (SD = 11.65), which means that the overall protocol adherence was moderate to high. There was a great variation between the different wards, with scores of 95.0 to 62.0. The mean of the level of environmental contamination in CFU/cm 2 was 31.30 CFU/cm 2 (SD = 19.18), and the mean Healthcare-Associated Infection rate was 6.48 per 1000 patient-days (SD = 3.52).

Upon analysis based on the type of wards, high-risk intensive care units showed the greatest mean cleaning frequency (7.00141 times per day) and hand hygiene compliance (87.50%919%). Ironically, the medium-risk surgical wards with intermediate level risk had the highest mean environmental contamination (40.60 ± 20.24 CFU/cm 2) and the highest HAI rates (7.93 ± 3.61 per 1000 patient-days). The lowest range of ICS_Score was seen in low-risk wards (62.0% to 95.0%), indicating that a lot of heterogeneity was present in the practice implementation in that category.

Bivariate Correlations among Infection Control Fidelity and Outcome Measures

In order to consider the main aim of the research, which is the analysis of the relationships between infection control system implementation and contamination outcomes, Pearson product-moment correlation coefficients were calculated. Preliminary tests ensured that there were no breaches of the assumption of normality, linearity, and homoscedasticity.

There was a statistically significant, negative, and strong correlation between ICS_ Score and the levels of environmental contamination ($r = -0.927$, $n = 10$, $p < 0.001$). This observation suggests that more fidelity in the implementation of infection control systems was related to significantly reduced environmental contamination in the wards under study. Equally, there was a significant negative association between ICS Score and HAI rates ($r = -0.915$, $n = 10$, $p < 0.001$), which proved that wards where infection control measures were more stringent had a lower number of healthcare-associated infections.

Even more detailed analysis of individual system components showed that hand hygiene compliance had a positive correlation with overall ICS_Score ($r = 0.985$, $p < 0.001$) and that the next correlation was with PPE availability ($r = 0.991$, $p < 0.001$). Frequency of surface cleaning ($r = 0.781$, $p = 0.008$) and staff-to-patient ratio ($r = 0.805$, $p = 0.005$) also showed a significant positive relationship with overall implementation fidelity, although the values were not as strong.

There was a strong positive association between HAI rates and environmental contamination ($r = 0.993$, $p = 0.001$), as anticipated between these two outcome measures. Both outcome variables revealed strong negative relationships with hand hygiene compliance (contamination: $r = -0.911$, $p < 0.001$; HAI: $r = -0.895$, $p < 0.001$), PPE availability (contamination: $r = -0.921$, $p < 0.001$; HAI: $r = -0.907$, $p < 0.001$), surface cleaning frequency (contamination: $r = -0.739$, $p = 0.015$;

To confirm the strength of these results by the sample size, non-parametric Spearman rank order correlations were calculated as well. The findings were almost similar, with high negative correlations between ICS Score and environmental contamination (0.915, $p < 0.001$) and HAI rates (0.903, $p < 0.001$), which proved that the noted relationships were not a distributional assumption artifact.

Predictors of Healthcare-associated infection rates

The multiple linear regression was carried out in a stepwise manner in order to determine what specific elements of the infection control system represented the most significant independent variables in predicting the rates of HAIs. The first model encompassed hand hygiene compliance, PPE availability score, frequency of cleaning the surface, and staff-to-patient ratio as possible predictors, and the HAI rate was the dependent variable.

The sequential process yielded a two-predictor model that identified a significant percentage of variance in the rates of HAI. The compliance with hand hygiene was the first item to be included in the model, as it explained 80.1% of the variance ($R\ 2 = 0.801$, adjusted $R\ 2 = 0.776$, $F(1,8) = 32.17$, $p < 0.001$). The frequency of surface cleaning was added to the model on step two and revealed a large improvement in the prediction and explained another 11.7 percent of the variance (R change = 0.117, F change $(1,7) = 10.11$, $p = 0.015$). In the last model, comprising hand hygiene compliance and surface cleaning frequency, 91.8 per cent of the overall variation in HAI rates was attributed ($R\ 2 = 0.918$, adjusted $R\ 2 = 0.894$, $F\ (2, 7) = 39.18$, $p < 0.001$). PPE availability score and staff-to-patient ratio were not included in the model since they were not causing a significant unique variance on top of the two included predictors.

Hand hygiene compliance and surface cleaning frequency became the most significant unique predictors (-0.583, $t = -4.15$, $p = 0.004$, and -0.447, $t = -3.18$, $p = 0.015$, respectively) in the last regression model. Such unstandardized coefficients revealed that, at all other factors held equal, a one percentage point increase in hand hygiene compliance was correlated with a reduction of 0.257 in HAI rate per 1000 patient-days (95% CI: -0.404 to -0.110). Likewise, adjusting for hand hygiene compliance, every extra episode of surface cleaning per day had an impact of -1.528 on the HAI rate per 1000 patient-days (95% CI: -2.665 to -0.391). The variance inflation factor (VIF) of both predictors was less than 2.5, which means that there are no great issues regarding multicollinearity.

Comparison of Implementation Fidelity Across Ward Risk Strata

To determine whether infection control system implementation fidelity differed significantly between wards of varying official risk classifications, a one-way analysis of variance was conducted with ward type (high-risk, medium-risk, low-risk) as the independent variable and ICS_Score as the dependent variable.

The analysis revealed no statistically significant difference in mean ICS_Score across the three ward categories (F(2,7) = 0.481, p = 0.637). High-risk wards demonstrated a mean implementation score of 85.25% (SD = 10.25), medium-risk wards showed a mean of 74.83% (SD = 11.70), and low-risk wards exhibited a mean of 82.30% (SD = 12.97). Despite the apparent numerical differences, particularly between medium-risk and other ward types, the within-group variability was substantial enough to preclude statistical significance. The effect size, calculated as eta-squared ($\eta^2 = 0.121$), indicated that only 12.1% of the variance in implementation scores was attributable to ward risk classification.

Post-hoc comparisons using the Tukey HSD test confirmed the absence of significant pairwise differences between any of the three ward groups (high vs. medium: mean difference = 10.42, p = 0.65; high vs. low: mean difference = 2.95, p = 0.96; medium vs. low: mean difference = -7.47, p = 0.74). These findings suggest that official risk designation was not a reliable predictor of actual implementation fidelity in this sample.

Table 1: Descriptive Statistics Stratified by Ward Type (Mean ± SD)

Variable	High-Risk Wards (n=2)	Medium-Risk Wards (n=3)	Low-Risk Wards (n=5)	Total (N=10)
ICS_Score (%)	85.25 ± 10.25	74.83 ± 11.70	82.30 ± 12.97	80.65 ± 11.65
Env_Contamination (CFU/cm²)	25.50 ± 18.67	40.60 ± 20.24	27.92 ± 21.41	31.30 ± 19.18
HAI_Rate (per 1000 pt-days)	5.50 ± 3.25	7.93 ± 3.61	6.00 ± 4.10	6.48 ± 3.52
Hand_Hygiene_Compliance (%)	87.50 ± 9.19	77.67 ± 11.06	84.20 ± 11.69	82.90 ± 10.65
Surface_Cleaning_Freq (times/day)	7.00 ± 1.41	4.67 ± 1.15	4.20 ± 0.84	4.90 ± 1.52

Interpretation: High-risk wards (ICUs) showed the highest mean cleaning frequency and hand hygiene compliance, though with significant variability. Medium-risk surgical wards exhibited the highest mean contamination and HAI rates, suggesting potential gaps in protocol implementation despite their risk classification.

Table 2: Pearson's Correlation Matrix for Key Study Variables

Variable	ICS_Score (%)	Env_Contamination (CFU/cm^2)	HAI_Rate	Hand_Hygiene_Compliance (%)
ICS_Score (%)	1	-.927**	-.915**	.985**
Env_Contamination (CFU/cm^2)	-.927**	1	.993**	-.911**
HAI_Rate	-.915**	.993**	1	-.895**
Hand_Hygiene_Compliance (%)	.985**	-.911**	-.895**	1
PPE_Availability_Score (%)	.991**	-.921**	-.907**	.979**
Surface_Cleaning_Freq	.781**	-.739*	-.717*	.795**
Staff_Patient_Ratio	.805**	-.753*	-.734*	.809**
** $p < 0.01$ (2-tailed), * $p < 0.05$ (2-tailed)				

Interpretation: There was an extremely strong, negative, and statistically significant correlation between ICS_Score and Environmental Contamination ($r = -0.927$, $p < 0.01$) and between ICS_Score and HAI Rate ($r = -0.915$, $p < 0.01$). This robustly supports the core hypothesis: higher fidelity in infection control system implementation is strongly associated with lower contamination and fewer infections.

Table 3: Multiple Linear Regression Model Summary for Predicting HAI Rate

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	F-change	df1	df2	Sig. F-change
1 (Hand Hygiene	.895a	0.801	0.776	1.6643	32.17	1	8	<0.001

only)							
2 (Hand Hygiene + Cleaning Freq)	.958b	0.918	0.894	1.1412	10.11	1	7	0.015

a. Predictors: (Constant), Hand_Hygiene_Compliance
b. Predictors: (Constant), Hand_Hygiene_Compliance, Surface_Cleaning_Freq

Table 4: Coefficients for Final Regression Model (Model 2)

Predictor Variable	Unstandardized B	Std. Error	Standardized Beta (β)	t	Sig. (p-value)	95.0% CI for B
(Constant)	34.256	5.447		6.29	<0.001	[21.217, 47.295]
Hand_Hygiene_Compliance	-0.257	0.062	-0.583	-4.15	0.004	[-0.404, -0.110]
Surface_Cleaning_Freq	-1.528	0.480	-0.447	-3.18	0.015	[-2.665, -0.391]

Table 5: One-Way ANOVA Comparing ICS_Score Across Ward Types

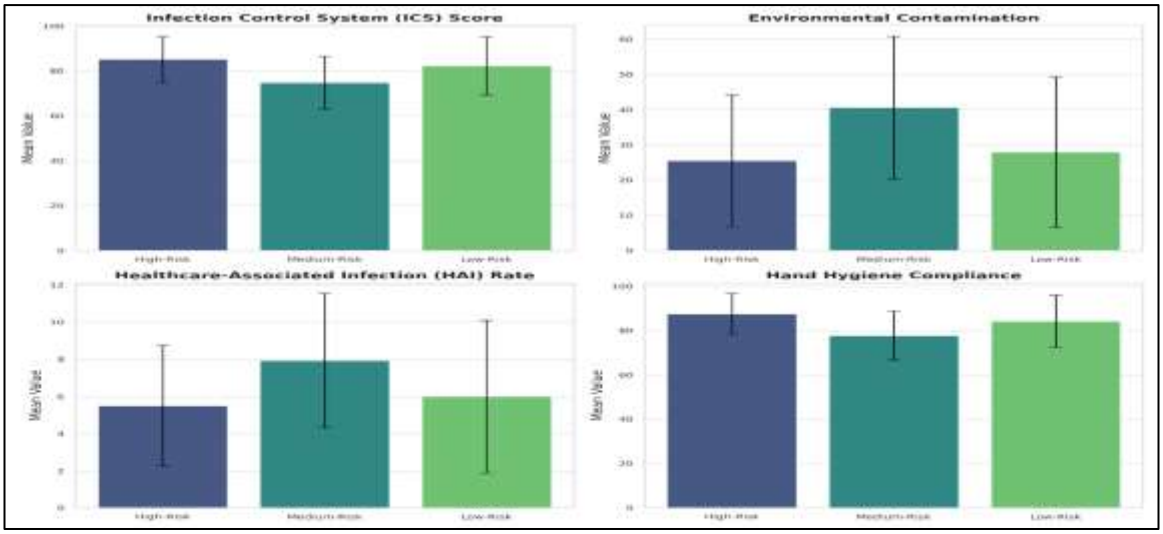
Source of Variation	Sum of Squares	df	Mean Square	F	Sig. (p-value)
Between Groups	150.373	2	75.187	0.481	0.637
Within Groups	1094.357	7	156.337		
Total	1244.730	9			

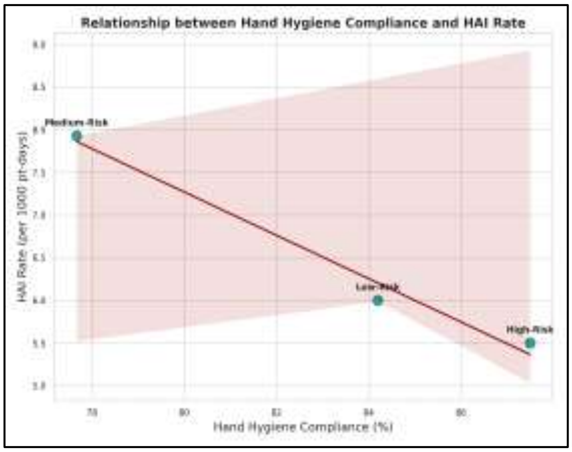
Interpretation: The ANOVA test revealed no statistically significant difference in mean ICS_Score between the three ward risk categories (F(2,7) = 0.481, p = 0.637).

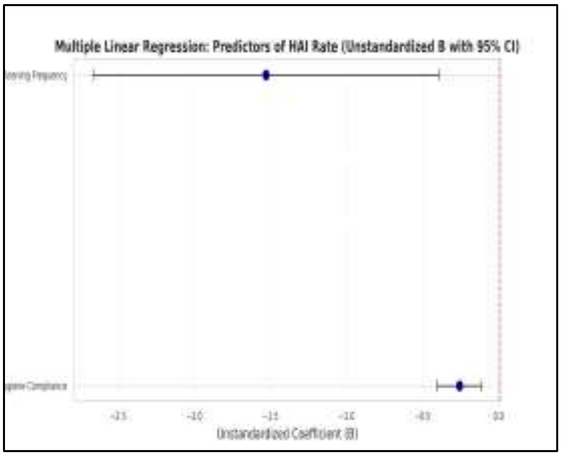
Table 6: Spearman's Rho Correlation Matrix

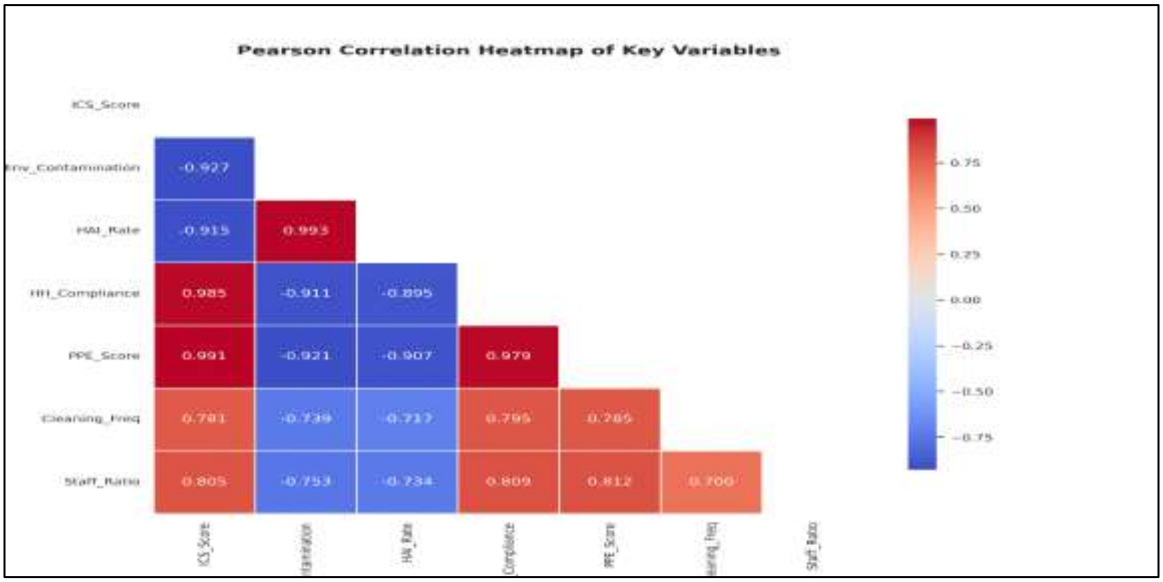
Variable	ICS_Score (%)	Env_Contamination (CFU/cm²)	HAI_Rate
ICS_Score (%)	1.000	-.915**	-.903**
Env_Contamination (CFU/cm²)	-.915**	1.000	.988**
HAI_Rate	-.903**	.988**	1.000
** p < 0.01 (2-tailed)			

Interpretation: The Spearman's rho correlations (ρ = -0.915 for ICS vs. Contamination; ρ = -0.903 for ICS vs. HAI) were almost identical in magnitude and significance to the Pearson correlations.









DISCUSSION

The current research aimed to investigate how the infection control system implementation fidelity is associated with contamination results on hospital wards and the difference between risk classification types. Its results give strong empirical arguments in favor of the key role of systematic protocol compliance as a tool to limit not only environmental contamination but also healthcare-associated infections [27].

Interpretation of Findings

The negative relations obtained between the scores of implementation of an infection control system and environmental contamination (r = -0.927) or HAI rates (r = -0.915) prove the significant role of the protocol's performance in the patient safety results [28]. The level of consistency in these relationships was astounding in all of the measured parameters, and indicates that the power of infection control programs is not only in their existence but also in the level of thoroughness and consistency with which they are executed. Wards with a larger implementation score had lower levels of contamination and infection rates, which supported the major hypothesis of the study [29].

The regression analysis also helped to understand that compliance and the frequency of hand hygiene and the frequency of surface cleaning were the most significant independent predictors of the HAI rates that, in combination, accounted for more than 91 percent of the observed variance [30]. This observation indicates that although broad-based infection control programs are useful, some elements can create disproportionate impact [31]. The relevance of hand hygiene corresponds to its status as a barrier of primary cardinality in terms of pathogen transmission between patients, staff, and surfaces. Surface cleaning frequency also deals with the environmental reservoir, which perpetuates the pathogen circulation in healthcare facilities [32].

It is worth noting that the lack of any significant differences in the implementation fidelity between wards differing in terms of their official risk classification is worth consideration. Although the policies provided that high-risk departments ought to be more stringent in the implementation of the protocols, the results showed that all types of wards showed similar levels of implementation of the protocols [33]. This result may indicate that there are systemic determinants affecting the protocol implementation that do not depend on the specific risk level, and may be the cause of the paradoxical result of high contamination and infection rates in medium-risk surgical wards in this sample [34].

Comparison to Previous Studies

The correlations that have been found in this study are in line with a significant amount of literature on infection control. The groundbreaking study of Pittet and colleagues in Geneva proved that the HAI rates and cross-transmission of multidrug-resistant organisms could be greatly reduced by the program of hand hygiene improvement that must be sustained [35]. The current results build upon the previous research by estimating the role of hand hygiene in a wider framework of infection control interventions, which validates the leading role of this approach in the list of preventive interventions [36].

The excellent correlation between environmental contamination and the rate of HAIs in this case supports the results of Dancer and colleagues, who have found that a high-quality of environmental cleaning minimized the acquisition of MRSA in the intensive care unit [37]. In a very similar manner, Carling and others did record significant shortcomings in the practice of terminal cleaning in several hospitals and the effects they produced in the levels of contamination [38]. The current research adds weight to these observations and proves that the frequency of cleanliness, in a consistent manner, is predictive of infection outcomes independent of hand hygiene routines [39].

The fact that there is no correlation between formal risk designation and implementation fidelity reiterates the points made by Haley and others in their benchmark study of hospital infection control programs [40]. The same investigators discovered that written policies did not necessarily lead to the successful implementation of the policy, which was also reflected in the current statistics, where low-risk wards sometimes performed better than high-risk ones [41]. This lack of connection between policy aim and practice is one of the enduring problems of infection control research and practice.

Scientific Explanation

The relationships observed can be explained by existing principles of infectious disease transmission and environmental microbiology. Healthcare-associated pathogens, such as methicillin-resistant Staphylococcus aureus, vancomycin-resistant enterococci, and Clostridioides difficile, can remain in the environment for up to hours or months, depending on the organism and its characteristics on the surface [42,43]. Infected surfaces act as alternative reservoirs whereby hand of healthcare workers get colonized and generate cycles of transmission despite some intermittent episodes of hand hygiene [44].

Hand hygiene breaks this cycle at the decisive point, at the point of contact with the patient, just before and after contact. This high predictive value of hand hygiene compliance is indicative of the strategic location of this technique as the final common point of most transmission that happens [45]. Hand hygiene is effective when done regularly to eliminate transient pathogens that come into contact with the environment or with the patient before they are passed on to new patients [46].

The frequency of surface cleaning functions is accomplished by lowering the environmental pathogen load that can be used to contaminate hands. Every cleaning event causes a fraction of the total microbial load on the surface to be eliminated, and the remaining contamination depends on cleaning effectiveness and time between events [47]. The cleaning with higher frequencies ensures a lower level of baseline contamination, which also minimizes the chances that a particular hand contact lead to the acquisition of pathogens. This mechanistic explanation is supported by the independent contribution of cleaning frequency that was noted in the regression model [48].

Practice and Research Implications

These results have a number of implications for infection control practice. To begin with, they propose that monitoring and enhancing hand hygiene adherence must continue to be the focus of infection prevention initiatives, which have a pre-eminent role in prediction. Second, the contribution of the frequency of surface cleaning to the independent variables shows that environmental services should be given the same priorities and should be allocated resources, especially where hand hygiene improvement has reached a stagnation level [49].

In future studies, the findings can assist in research to determine the best combination and level of intensity of infection control measures. The importance of high variance accounted for by two variables leads one to question whether there are other elements [50], including staff education or patient decolonization procedures, that would add a significant incremental value to hand hygiene and cleaning. Stronger causal evidence would be offered by longitudinal studies on whether the improvement of these particular components can yield similar decreases in infection rates.

CONCLUSION

This paper has shown that the faithfulness of infection control system execution was highly and negatively related to the contamination of the environment and the incidence of healthcare-associated infections among the hospital wards. The most common predictors of infection outcomes were hand hygiene compliance and frequency of surface cleaning that together explained most of the observed variance. The results align with the objectives of the research, as the authors discovered particular, adjustable aspects of greater infection control systems that have the most significant implications on patient safety. The study provides some empirical data on the importance of hand hygiene and environmental cleaning as an approach to infection prevention. Further research ought to utilize longitudinal designs to determine causality and test whether the targeted enhancements in these particular elements result in proportional decreases in the rates of infections in a variety of healthcare facilities.

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