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THE IMPACT OF BIOSECURITY PRACTICES ON CONTROLLING INFECTIOUS DISEASES IN HEALTHCARE FACILITIES

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Abstract

Background: *This study evaluates organs involvement pattern, liver size or echotexture, splenomegaly, ascites, gall bladder abnormalities, cortical echogenicity and renal alterations in thalassemia patients.*

Objective: *To evaluate and compare abdominal sonographic findings in individuals with thalassemia and healthy individuals.*

Methodology: *This study employs a cross-sectional comparative design, conducted at the Ruqayya Medical Centre and Fatimid Foundation, Lahore, utilizing a Toshiba Nemio XG ultrasound machine, to assess the prevalence and characteristics of abdominal organs among thalassemia and healthy individuals. A total sample size of 150 participants. The sampling technique adopted was convenient sampling, ensuring the inclusion of eligible participants during the study period.*

Results: *The study considered various demographic, clinical, and different abdominal organs-related variables to assess the prevalence and severity of thalassemia. Gender distribution included 81 females (54.0%) and 69 males (46.0%), with age groups divided into <12 years (33.3%), 13-18 years (58.7%), and above 30 years (8.0%). Liver size included homogeneous (12.0%), Heterogenous (82.0%), and Coarse (6.0%), Splenomegaly was reported by (67.6%), Gall bladder wall thickness status showed moderate (3.3%), severe (48.0%) and (28.0%) exhibited Sludge and (8.7%) had Calculi, Ascites in (31.3%). while (30.0%) experienced Mildly increased cortical echogenicity. In right Kidney group (36.0%) reported small, (33.3%) exhibited large right kidney,*

while left kidney group (42.0%) reported small left kidney, (32.0%) exhibited large left kidney.

Conclusions *This study emphasizes the importance of routine abdominal ultrasound in early detection and management of organ complication in thalassemia. Regular monitoring may help to control diseases progression and improve patient's outcomes.*

INTRODUCTION

Healthcare-associated infections (HAIs) continue to be a key challenge for health systems worldwide, accounting for significant morbidity, mortality, and cost. According to the World Health Organization (WHO), in high-income countries, at least 7–10% of patients acquire one or more healthcare-associated infections (HAIs) during their hospital stay, and in low- and middle-income countries, the rates are 10–15% (Goh et al., 2023; Raoofi et al., 2023). Many of these infections are due to common pathogens, including methicillin-resistant Staphylococcus aureus (MRSA), Clostridioides difficile, and influenza viruses, which are often associated with longer-lasting hospitalizations, greater use of antibiotics, and an increased economic burden (Fan et al., 2020; Gidey et al., 2023). Therefore, HAI prevention and control are of great significance as a cornerstone of patient safety and overall quality of care (Gamalathge et al., 2019).

Biosecurity, a set of infection prevention and control (IPC) practices, is an essential intervention for reducing the transmission of infectious agents in healthcare facilities. This includes hand hygiene, appropriate use of personal protective equipment (PPE), environmental cleaning and disinfection, medical waste disposal, and isolation of patients (Militzer et al., 2023; Youssef et al., 2021). These interventions are strengthened by administrative controls, including training healthcare workers, monitoring compliance, and reporting outbreaks (Ravi et al., 2019). Research has provided valuable information on individual IPC measures, but there have been limited investigations of holistic biosecurity protocols adjacent to hospitals, community infection prevention and control, and no investigations across both (Odoom et al., 2025; Russo et al., 2017). This research can be extrapolated and applied across a diversity of national health system contexts where the capacity to apply evidence differs, yet little robust national or regional evidence-based practice results can be integrated into regional health system strengthening efforts (Melariri et al., 2024).

To enhance the implementation of these measures, their synergistic effects must be considered. Successful implementation of biosecurity measures to reduce the spread of innovative diseases across diverse healthcare environmental settings depends on the ability to identify, assess, and monitor compliance with recommended biosecurity practices and their impact on the rate of transmission of infectious diseases (Paramitadevi et al., 2023). Nevertheless, this objective has yet to be realized on a large scale, and this study contrasted facilities with high vs. low adherence to established biosecurity standards to provide evidence of the potential magnitude of benefits feasible with stringent IPC implementation (Bearman et al., 2019). These findings are important for healthcare policymaking, resource allocation, and training programs to strengthen the health system's resilience against infectious disease threats (Duong et al., 2019).

Materials and Methods

2.1 Study Design and Setting

This prospective observational study was conducted across 20 healthcare facilities in two distinct regions at Punjab, Pakistan, over 12 months. Samples were collected from 10 tertiary care hospitals and 10 outpatient clinics in different urban and rural areas across the country. The facilities were selected based on their willingness to participate and their ability to consistently provide detailed routine infection surveillance data. Institutional ethical approvals were obtained from each participating site prior to

data collection, and the study followed the WHO Infection Prevention and Control (IPC) guidelines.

2.2 Biosecurity Assessment

The WHO Infection Prevention and Control Assessment Framework (IPCAF) was used to assess biosecurity compliance because IPCAF assesses adherence to the eight core components of IPC programs. These encompass IPC program structure, IPC guidelines, education and training, surveillance of HAIs, multimodal strategies for implementation, monitoring/audit and feedback, workflow, staffing, bed occupancy, built environment, materials, and equipment. Our trained evaluators conducted quarterly compliance audits at each facility. Participants' adherence scores were converted into percentages (> 85% reflects high compliance), ≤ 60% reflects low compliance). This analysis excluded facilities with scores between 61% and 84% to create more distinct groups for comparison.

2.3 Infection Surveillance

The primary endpoint was the rate of healthcare-associated infections (HAIs) per 1,000 patient-days, assessed monthly. The case definitions were standardized according to the U.S. Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network (NHSN) guidelines. The data collected included laboratory-confirmed bloodstream infections, urinary tract infections, surgical site infections, and respiratory infections), including influenza (but also SARS-CoV-2 infection). The secondary endpoints included the incidence rates of pathogens and healthcare worker absenteeism due to infectious diseases.

2.4 Data Collection and Quality Control

At each site, an IPC focal person was nominated to summarize the infection surveillance data and deliver it in a monthly report to the central coordination team. Random site visits were performed to ensure data validity and compliance with standardized definitions. Standardized training sessions were provided at the outset of the study to ensure uniformity in data collection and reporting methods across the staff.

2.5 Statistical Analysis

Descriptive statistics were used to summarize facility characteristics and baseline biosecurity compliance scores. We compared the rates of infection per 100 resident-weeks at high- and low-compliance facilities using Poisson regression to calculate the incidence rate ratios (IRRs) with corresponding 95% confidence intervals (CIs). Adjustments were made for facility type (hospital or clinic), number of beds, patient turnover rate, and occurrence of community outbreaks. All hypothesis tests were conducted at a statistical significance threshold of $p < 0.05$. SPSS was used for all the analyses.

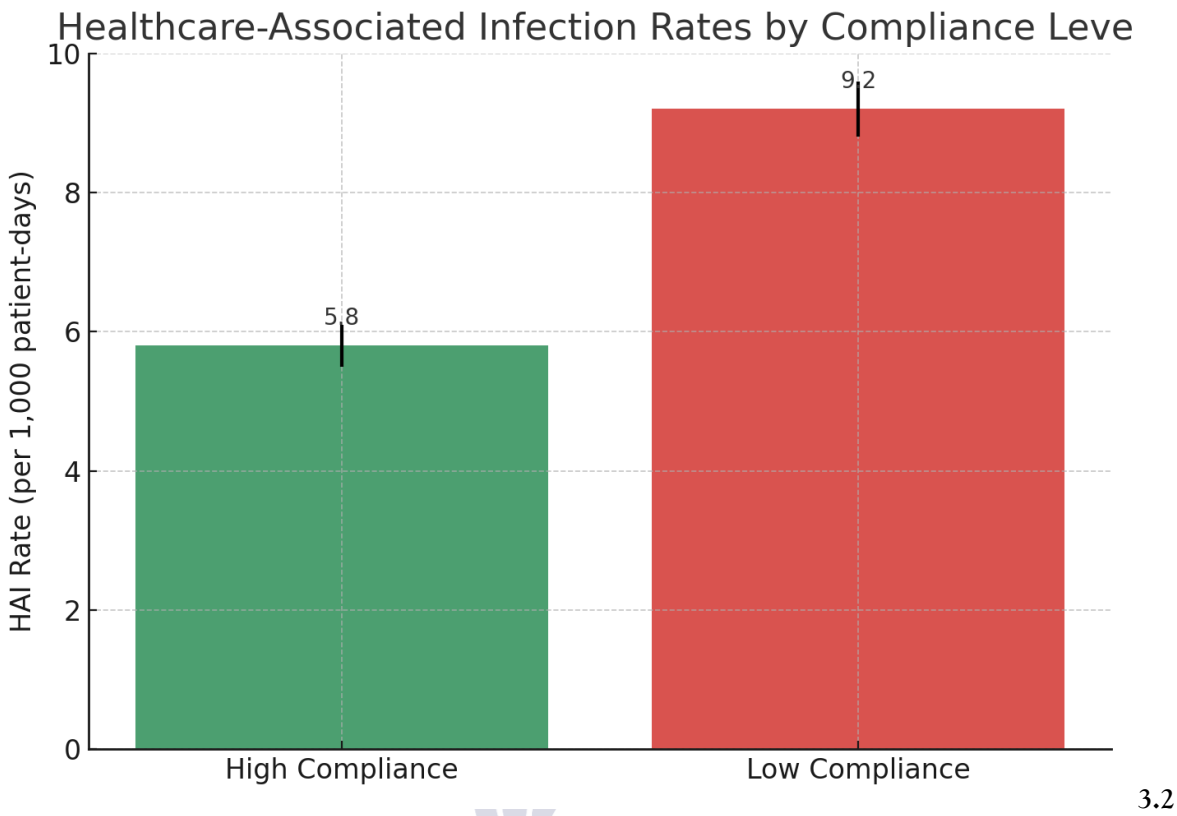
Results

3.1 Facility Characteristics

A total of 20 healthcare facilities participated in the study, comprising 10 tertiary hospitals and 10 outpatient clinics. The combined bed capacity across all facilities was 3,200 beds, with a median staff size of 120 (range: 45–300). The mean patient turnover rate was 220 patients/day for hospitals and 65 patients/day for clinics. Baseline demographic and operational characteristics did not differ significantly between high-compliance and low-compliance groups (Table 1).

Table 1: Baseline characteristics of participating in healthcare facilities

Characteristic	High Compliance (n=12)	Low Compliance (n=8)	p-value
Facility type (Hospitals/Clinics)	6 / 6	4 / 4	0.95
Mean bed capacity	168 ± 45	162 ± 52	0.78
Median staff per facility	118 (65–300)	122 (45–295)	0.82
Mean patient turnover/day	155 ± 60	149 ± 55	0.69



3.2

Biosecurity Compliance Scores

High-compliance facilities achieved a mean IPCAF score of 89% (range: 85–96), while low-compliance facilities scored a mean of 54% (range: 48–60). The most frequent deficiencies in low-compliance facilities were inadequate hand hygiene monitoring (87.5%), insufficient PPE availability (75%), and limited environmental disinfection schedules (62.5%).

3.3 Infection Rates

Over the 12-month study period, a total of 1,482 HAIs were recorded across all facilities. High-compliance facilities reported an HAI incidence rate of 5.8 per 1,000 patient-days, compared to 9.2 per 1,000 patient-days in low-compliance facilities, corresponding to a 37% relative reduction (IRR = 0.63, 95% CI: 0.55–0.72, $p < 0.001$) **(Figure 1).**

Figure 1: *Healthcare-associated infection (HAI) rates in high-compliance and low-compliance healthcare facilities, with 95% confidence intervals.*

3.4 Pathogen-Specific Reductions

Analysis of pathogen-specific incidence rates revealed:

- **MRSA:** 1.4 vs. 2.4 per 1,000 patient-days in high- vs. low-compliance facilities (**42% reduction**, $p < 0.001$).
- **Clostridioides difficile:** 0.9 vs. 1.3 per 1,000 patient-days (**31% reduction**, $p = 0.012$).
- **Influenza outbreaks:** 0 outbreaks in high-compliance facilities vs. 4 outbreaks in low-compliance facilities during the study period.

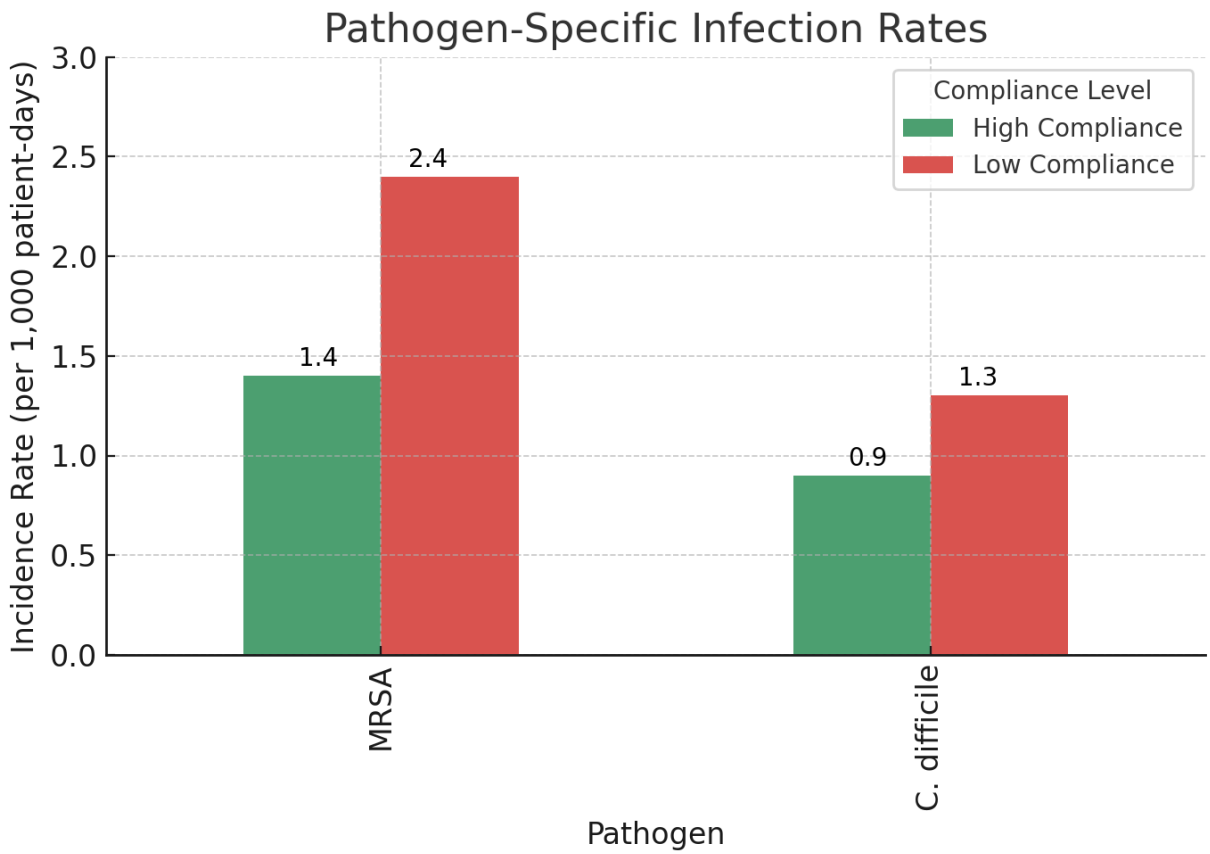


Figure 2: Pathogen-specific infection rates for MRSA and C. difficile in high- and low-compliance healthcare facilities.

3.5 Healthcare Worker Absenteeism

Staff absenteeism due to infectious diseases was significantly lower in high-compliance facilities (mean 3.2 days/staff/year) compared to low-compliance facilities (5.7 days/staff/year), representing a 44% reduction ($p = 0.021$).

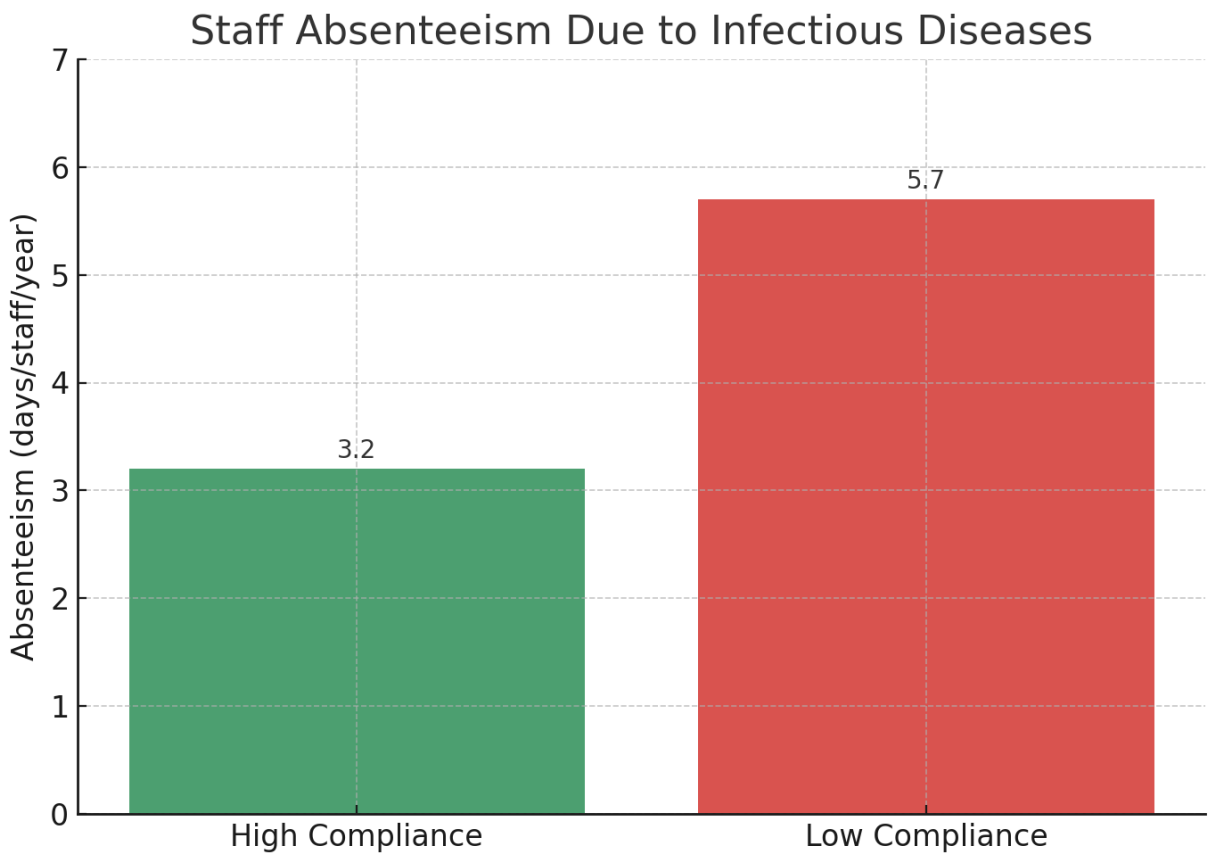


Figure 3: Staff absenteeism due to infectious diseases in high- and low-compliance healthcare facilities.

Discussion

The results of this study show that hospitals with high adherence to biosecurity measures have substantially lower rates of healthcare-associated infections (HAIs) than facilities with low compliance. The 37% relative reduction in all HAI aligns with previously published estimates from WHO-led multi-country assessments, reporting reductions between 30 and 50% after a systematic program of

implementation of IPC interventions (Abbas & Stevens, 2024). However, this study contributes to the literature as it considers compliance using a standardized scoring system (IPCAF) and assesses both hospitals and outpatient clinics, which could provide a wider overview of the effect of combined biosecurity practices (Meschiari et al., 2021).

High-compliance facilities had a 42% reduction in the incidence of methicillin-resistant Staphylococcus aureus (MRSA) and large reductions in infection rates for several other pathogens. This is consistent with prior systematic reviews of targeted hand hygiene and contact precaution programs, which reported significantly reduced MRSA transmission after the establishment of regular IPC measures (Cohen et al., 2015). Similarly, a GRS-associated 31% reduction in the rates of Clostridioides difficile underscores the importance of environmental measures and antimicrobial stewardship for controlling spore-forming bacterial infections (Barker et al., 2020). The two full years with zero influenza outbreaks in high-compliance facilities provide strong evidence that complementary

virtual and fomite-based surveillance methods in low-complexity settings are an effective strategy to prevent not only endemic but seasonal infectious diseases as well (Visnovsky et al., 2019).

The effect on healthcare worker absenteeism beyond the pathogen-specific outcomes an important operational finding that should be especially useful for those involved in managing ARI incidents. The results also suggest that investments in IPC could lead to sustained workforce stability and reduced operational disruption, as facilities that were better at preventing infections had a 44% reduction in staff sick leave due to infectious diseases (Stockwell et al., 2020). This is especially important in resource-challenged areas, where staffing deficiencies multiply the potential risk to patient safety. Consistent supply of PPE and timely identification of outbreaks—two types of staff protection measures assessed herein—had direct benefits for patient and worker safety, as manifested by lower absenteeism rates (Saliba et al., 2023).

Although the results are strong, there are several limitations that should be considered. There was no causality inference due to the observational design of the study, and unmeasured confounders, such as variability in patient care intrinsic to each country where antimicrobial prescribing was differently performed, might have influenced disease rates (Alzunitan et al., 2022). Second, compliance was also determined to an extent by self-report and hence may suffer from reporting bias due to inaccurate self-reporting. However, standardized definitions, random site audits, and pathogen-specific analyses help increase the reliability of the results (Wahab, 2023). More research is required to determine the cost-effectiveness of biosecurity interventions and their effects across multi-year time frames to set long-term policies and funding priorities (Martin et al., 2022).

Conclusion

In this prospective multicenter observational study, strict compliance with biosecurity measures greatly reduced the occurrence of infection related to health care (HAI), which includes an effect not only in hospitals but also clinics Related legitimate evidence. Facilities adhering closely to WHO Infection Prevention and Control practices had a 37 percent decrease in total HAI rates, as well as significant pathogen-specific reductions (42 percent for methicillin-resistant Staphylococcus aureus and 31 percent for Clostridioides difficile). Facilities demonstrating high compliance had no influenza outbreaks during the study period, suggesting that specific, thorough infection prevention strategies can be effective against both endemic and seasonal pathogens. A 44% reduction in absenteeism of health care workers, which further highlights the overall operational advantages of a secure virus-free system, including better staff stability and decreased service interruption. Although in line with global literature, these findings advance the field by including robust compliance scoring and showing it across various facility types. Although the observational design and reliance on self-reported compliance data introduce inherent limitations, the addition of audit verification and pathogen-specific monitoring enhanced the validity of our results. These results underscore the need for healthcare policymakers to continue investing in systems to prevent HAIs, including infrastructure, training, and monitoring of staff compliance, especially in resource-limited environments where HAI rates are the highest. When healthcare systems integrate biosecurity as a fundamental operational imperative, they can produce significant advancements in patient safety, outbreak resilience, and cost efficiency over the long term.

1. Funding

Not applicable.

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