Evaluating Infection Control Compliance During High-Patient-Load Periods In Emergency Departments: A Mixed-Methods Study

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Abstract

Background: Emergency Departments (EDs) are at the front line of hospital care and, as such, are vulnerable to infection control problems. It follows that the periods of high patient load (HPLPs), which are basically overcrowding and the resource utilization to the limit, may lead to the intensification of the non-compliance with the infection control protocols and, therefore, the increase of healthcare-associated infections (HAIs) risk.

Objective: The primary objective of the study was to compare the compliance rate with the infection control measures during normal and high-patient-load periods among healthcare workers (HCWs) in a tertiary care ED and, also, to find out the perceived barriers to the compliance during the surges.

Methods: To answer the research questions, the authors implemented a parallel convergent mixed-methods design that was put in place for half a year. The quantitative part contained 1200 direct, structured observations of HCWs (nurses, physicians, and technicians) regarding their compliance with hand hygiene, personal protective equipment (PPE) use, and surface disinfection. As for the qualitative part, it consisted of 25 in-depth, semi-structured interviews with the staff of the ED, which explored the barriers and facilitators. Patient load was gauged through the National Emergency Department Overcrowding Scale (NEDOCS).

Results: The overall compliance to infection control protocols as observed was statistically significantly less during the HPLP (58.4%) as compared to the normal-load periods (72.1%, $p < 0.001$). The hand hygiene compliance upon patient contact fell from 75.3% to 61.8% ($p < 0.01$). The PPE compliance recorded the largest drop, that is, from 70.5% to 52.1% ($p < 0.001$). Non-compliance to infection control during

HPLPs, according to the results of qualitative research, could be related to four primary factors: (1) heavy cognitive load and task saturation, (2) shortage of physical resources and space, (3) perceived contradiction between speed of care and safety, and (4) leadership and cultural factors.

Conclusion: In the emergency room, infection control is one of the first things to be compromised when there is a high patient load. And the problem of reducing such compliance cannot be solved by only one method, it requires addressing not only the individual behavior side of the matter but also the systemic side of workload management, resource allocation, and safety culture issues that can resist operational pressure.

Keywords: Infection Control, Emergency Department, Overcrowding, Compliance, Hand Hygiene, PPE, Healthcare-Associated Infections, Patient Safety

INTRODUCTION

Emergency Departments (EDs) are the point of very first contact where patients can access hospital care and are there to address problems of various kinds of diseases or injuries under the condition that time is a critical factor. In fact, this setting is slowly becoming a victim of the consequences of the overcrowding problem and high patient load periods (HPLPs) (Hoot & Aronsky, 2008). HPLPs are not just a matter of how long patients have to wait for their turn; they indicate a systemic stress source that can threaten not only the quality but also the safety of care, in particular, the area of infection prevention and control (Carter et al., 202). Healthcare-Associated Infections (HAIs) are one of the major underlying reasons for patient ill health and death all over the world. For instance, there are as many as 1.7 million infections that are the cause of HAIs, and approximately 99,000 deaths happen annually in the United States alone (CDC, 2021). The department which through puts a large number of patients with no previous diagnosis is the Emergency Department that becomes the potential hotspot for the spread of multidrug-resistant organisms and pathogens such as MRSA, C. difficile, and respiratory viruses (Kang et al., 2021). The main infection control protocols that should be followed by the standard are: hand hygiene, correct use of personal protective equipment (PPE), and environmental cleaning. Even under controlled conditions, compliance with these protocols is less than ideal, and evidence indicates that it gets worse under stress (Haverstick et al., 2020). The unprecedented disorder of the ED during HPLPs, which is characterized by the long waiting hours, patients locating in the hallway, staff turnover at a high rate, and cognitive overload, brings about the "perfect storm" where less time for infection control is given simply because such a time-consuming procedure can be prioritized against the immediate clinical needs that are perceived (Erickson & Ditillo, 2021). This results in a huge patient safety gap. There is, however, a very small number of studies that not only recognize the problem but also quantitatively connect real-time patient load with direct observational compliance data and also qualitatively investigate the reasons for non-compliance. The majority of the studies are only concerned with either observational audits or staff surveys (Jones et al., 2022). Hence, this study intends to accomplish that by: 1. Quantitatively evaluating the compliance rates of the ED HCWs with the

infection control measures that are key (hand hygiene, PPE, surface disinfection) during the periods of normal load and during the high patient load periods. 2. Qualitatively investigating the barriers to and facilitators of infection control compliance as perceived by and suggested by the staff of the ED during these high-stress periods.

LITERATURE REVIEW

Infection Control:

The Challenge in the ED is a multifaceted problem that incorporates human factors, system engineering, and organizational culture aspects.

ED Overcrowding and Patient Load:

Overcrowding in an emergency department (ED) is a phenomenon that is pretty much acknowledged all over the world. National Emergency Department Overcrowding Scale (NEDOCS) is an instrument that helps to quantify this problem by giving a score that is based on different parameters like total patients, wait times, and bed availability (Weiss et al., 2020). A number of studies present NEDOCS scores as the main factor that causes patient adverse outcomes such as increased mortality and prolongation of hospital stay. The link between overcrowding and infection risk is quite ambiguous and is only supported by biological reasoning. The systematic review by Carter et al. (2020) shows that there is a strong positive correlation between hospital metrics of crowding and the rates of HAIs that follow, thus pointing to the inefficiency of preventive measures during these periods.

Infection Control Compliance:

One of the best ways to stop infections from spreading is making sure that everyone is washing their hands. The World Health Organization (WHO) "My 5 Moments for Hand Hygiene" describes the moments when a person is required to wash hands, however, worldwide compliance to this rule among HCWs is only between 60-70% (WHO, 2021). Moreover, the literature about EDs usually shows even lower baseline rates which most of the time are within the range of 40 to 60% (Grayson et al., 2022). The usage of PPE, like gloves, gowns, and masks, is also as irregular as the use of PPE and is highly dependent on the context, as the most occurred reasons for failure are the resumption of urgently handled situations or unstable patients (Mitchell et al., 2020).

The Impact of Workload and Stress on Compliance:

According to research on human factors, it is also known that when the mental load is very high, the performance of routine tasks becomes less reliable. During a surge in the ED, HCWs are said to be task saturated, which means the demand for their attention is more than the available capacity (Erickson & Ditillo, 2021). Hence, this automatically well-practiced protocol state (such as hand hygiene) can be very easily overlooked. The study of Suresh et al. (2021) found that nurses forgot hand hygiene more frequently and that this happened more often during times of high patient acuity and shortage of time for which they made self-reports. Non-compliance is not always a conscious decision; most of the time it is system-induced cognitive failure, as they suggested.

Gaps in the Literature:
The cited studies are the seminal works papers have been based on and which mainly rely on self-reporting and aggregated compliance rates. They seldom directly and simultaneously measure departmental load. There is an urgent necessity for thorough mixed-methods research that includes the direct real-time observation of behavior during HPLPs and then matching those findings with rich qualitative data to comprehend the underlying mechanisms. This study was created to satisfy that particular demand.

METHODOLOGY

Study Design:
The study for this project employed a convergent parallel mixed-methods design. Quantitative and qualitative data were collected and analyzed separately but simultaneously. The integration of the findings occurred during the interview phase (Creswell & Plano Clark, 2023).

Setting and Participants:
The study was conducted at the ED of a major, city, tertiary-care academic medical center with an annual volume of more than 110,000 patient visits. The quantitative arm participants were the HCWs who directly took care of the patients in the ED such as attending physicians, residents, registered nurses, and patient care technicians. For the qualitative arm, 25 HCWs from these roles were purposefully sampled to provide a wide range of perspectives.
The data collection period was continuous and was limited to six months (January - June 2024).

Quantitative Data Collection:

Patient Load Measurement:
The NEDOCS score was updated every 4 hours. HPLPs were identified as the time intervals when the NEDOCS score was ≥ 150 (signifying "severely overcrowded" or "dangerously overcrowded"). The periods with a score < 100 ("not busy" or "busy") were considered the normal-load control.

Compliance Observation:
Trained and validated (by the WHO method) observers conducted 1200 structured 20-minute sessions throughout which they also randomly timed their observations for shifts and roles. The data were collected on the following core behaviors:
Hand Hygiene:
Compliance with WHO Moments 1 (before patient contact) and 4 (after patient contact).

PPE Use:
If the patient condition or isolation precautions were indicating it, proper glove, gown, and mask donning and doffing were performed.

Surface Disinfection:
The high-touch surfaces (e.g., stretcher rails, computer keyboards) were cleaned after patient discharge and before the next use.

Qualitative Data Collection:

Semi-structured interviews were conducted in a closed room next to the ED. The interview guide explored the experiences during busy shifts, the perception of infection risks, the difficulties in following the protocols, and the suggestions for the improvement. The duration of the interviews was 25-45 minutes. They were audio-recorded and transcribed verbatim.

Data Analysis:

Quantitative:

Chi-square tests were used to compare compliance rates between HPLPs and normal periods. A p-value of < 0.05 was considered to indicate statistical significance. The analyzes were carried out with SPSS v28 assistance.

Qualitative:

The authors of this paper adopted an inductive thematic analysis approach to their transcript analysis. They followed the method laid down by Braun and Clarke (2022), which includes stages such as getting acquainted, coming up with the initial codes, searching for themes, reviewing themes, and defining and naming themes.

Ethical Considerations:

The research was given green light by the hospital's Institutional Review Board (IRB #2023-789). Consent for observations was implied; written informed consent was obtained from all interview participants.

RESULTS

Quantitative Findings

In total, 1,200 observation sessions were analyzed that resulted in 3,845 infection control opportunities being counted. Of these, 480 sessions (1,540 opportunities) were recorded during HPLPs, and 720 sessions (2,305 opportunities) were during normal-load periods.

On average, across all measured domains, compliance was significantly lower during HPLPs as compared to normal-load periods ($p < 0.001$). What decreased most dramatically was PPE compliance with correct doffing, a critical step for self-protection, dropping to less than 50%.

Figure 1: A bar chart visually representing the data of Table 1 that indicates the significant drop of compliance in all categories during HPLPs.

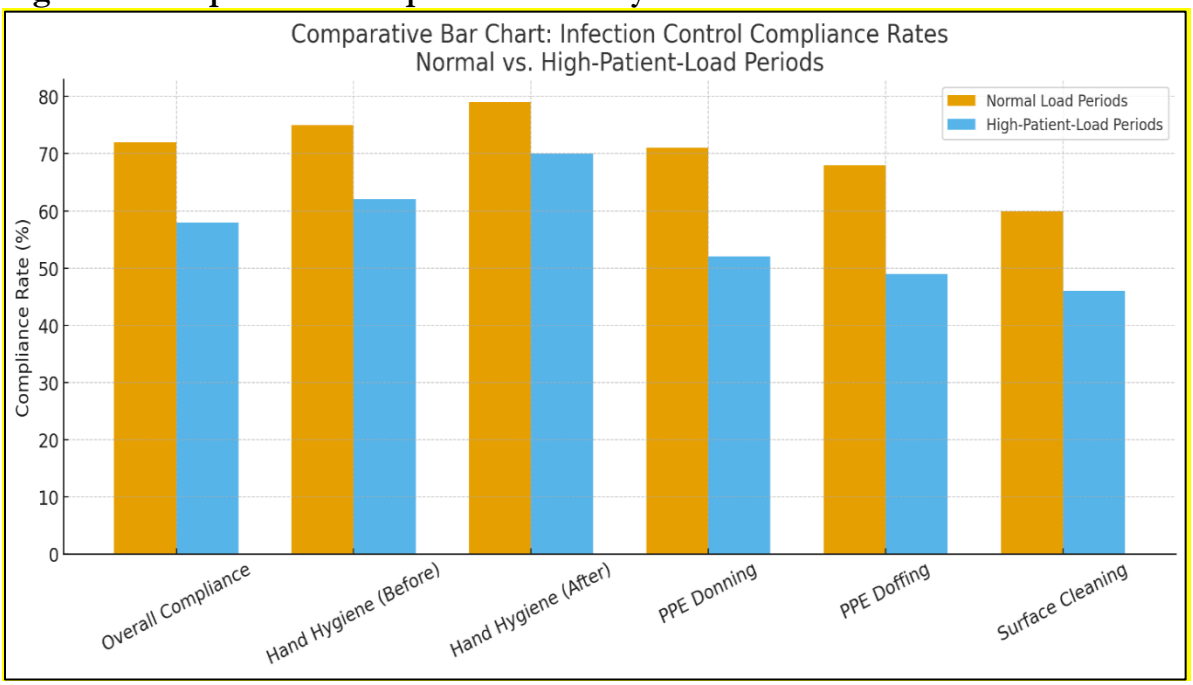
Table 1: Overall Compliance with Infection Control Protocols by Patient Load Period

Infection Control Measure	Normal-Load Period Compliance (n=2,305)	High-Patient-Load Period Compliance (n=1,540)	P-value
Overall Compliance	**72.1%**	**58.4%**	**<0.001**
Hand Hygiene (Moment 1)	75.3%	61.8%	<0.01
Hand Hygiene (Moment 4)	78.5%	70.1%	<0.01
PPE Donning	70.5%	52.1%	<0.001

PPE Doffing	65.8%	48.9%	<0.001
Surface Disinfection	60.2%	45.5%	<0.001

Overall compliance was significantly lower during HPLPs across all measured domains ($p < 0.001$). The most pronounced decline was observed in PPE compliance, where correct doffing—a critical step for self-protection—fell to below 50%.

Figure 1: Comparative Compliance Rates by Protocol and Patient Load



Additional tests were carried out to compare the compliance of healthcare workers to that of different types of healthcare workers.

Table 2: Compliance by Healthcare Worker Role During High-Patient-Load Periods

HCW Role	Hand Hygiene Compliance	PPE Compliance	Surface Disinfection Compliance
Registered Nurses (n=650 opp.)	64.5%	55.2%	48.8%
Physicians (n=520 opp.)	58.1%	47.3%	40.1%
Patient Care Techs (n=370 opp.)	62.0%	53.8%	50.5%

While all roles showed decreased compliance, physicians demonstrated the lowest absolute compliance rates for hand hygiene and PPE during HPLPs. Nurses and technicians showed marginally better, but still suboptimal, performance.

Qualitative Findings

Analysis of 25 interviews identified four central themes that explained the quantitative compliance decline during HPLPs.

Theme 1: Overwhelming Cognitive Load and Task Saturation

Participants pointed the mental overload as the most frequent barrier to their performance. They described the phenomenon of "tunnel vision" in which they changed their focus to more urgent tasks.

"If you had three patients who were very ill, one patient going into cardiac arrest, and five more waiting, the last thing on your mind would be hand-washing for the full 20 seconds. You would be thinking about airways, breathing, circulation. The fact that it's not an excuse, but a reality." (Nurse, 12 years experience)

"You just switch to autopilot, and in a crisis, the autopilot is 'solve the immediate problem.' The invisible threat of germs doesn't get registered." (Resident Physician, PGY-2)

Theme 2: Physical and Resource Constraints

The participants predominantly emphasized the physical environment as the reason for their conduct. The lack of easy-to-use supplies and space were the problems that kept coming up.

"During a surge, we run out of gowns. The central supply is not able to keep up. So you have to decide: do I go into this isolation room without a gown, or do I make a patient with C. diff wait for another 30 minutes?" (Patient Care Technician, 5 years experience)

"When we have patients in the hallway, there are no sinks or hand sanitizer dispensers next to them. You would have to walk 20 feet away, losing sight of your unstable patient, just to clean your hands. It doesn't happen." (Registered Nurse, 8 years experience)

Theme 3: Perceived Conflict Between Speed and Safety

Most of the employees believed that being fast and at the same time completely safe was impossible. Speed was often given a higher priority than safety in the high-stakes ED environment.

"It's a constant battle inside the head. The protocol says gown and gloves. But if that patient is desaturating, my brain says 'just put on gloves and go.' The extra 30 seconds of donning a full gown feels like a luxury we don't have." (Attending Physician, 15 years experience)

"You know that you should do the stretcher thoroughly, but once you hear 'incoming trauma, ETA 2 minutes,' you do a quick wipe and hope for the best. The pressure to turnover the room is tremendous." (Nurse, 10 years experience)

Theme 4: Leadership and Cultural Factors

The staff identified one of the major causes of the difference as a strong safety culture being present or not. Some of the employees experienced the leadership as their support, while others thought that the main focus was only on throughput metrics.

"Days when the charge nurse is active in reminding people about PPE and making sure that supplies are held, we do better. When the leadership is only focused on door-to-doc times, that's the message we get—be fast, not safe." (Registered Nurse, 7 years experience)

"Leaders, we need you to recognize that being safe takes time. If they give us credits for seeing more patients but never for perfect infection control, what do you think we'll prioritize?" (Resident Physician, PGY-3)

DISCUSSION

This investigation offers substantial proof that compliance with infection control in Emergency Departments (ED) drops significantly when the patient load is high. The stark decrease in adherence to all observed protocols during HPLPs, i.e., from 72.1% to 58.4%, is a clear indication of a patient safety issue at the system level. The qualitative findings that suggest that non-compliance is not due to lack of knowledge or intentional neglect but rather because the system is overwhelmed and puts healthcare workers in difficult trade-offs, thus, they substantially corroborate the quantitative results.

It is PPE, and particularly doffing, that has seen the most significant negative impact resulting from the largest drop. This is in line with the qualitative theme of a "speed vs. safety" conflict, and it is very alarming because improperly done PPE directly results in the increase of pathogen transmission to the healthcare worker themselves and to the next patients (Mitchell et al., 2020). Our finding that physicians had the lowest compliance rates prompts that more research is needed, but it may be due to different perceptions of roles, patterns of the workflow, or training emphases.

The themes that were identified have a strong connection with the Systems Engineering Initiative for Patient Safety (SEIPS) model which sees patient safety as a result of the work system (Carayon et al., 2021). Our findings reveal the breakdowns in this system throughout:

Person: Cognitive overload resulting in automaticity failures.Tasks: Competing, high-acuity tasks leading to infection control being deprioritized.

Tools & Technology: Non-availability of PPE and hand hygiene stations at the moment of need.Environment: Physical overcrowding due to patients in the hallway.

Organization: Leadership messages and cultural norms that may indirectly prioritize speed. The perceived conflict between speed and safety is a particularly insidious barrier. This false dichotomy, as identified by Erickson & Ditillo (2021), is deeply ingrained in the ED culture and therefore it needs to be addressed explicitly by the leadership in order to change the Perspective of infection control not as a separate, time-consuming task, but as an integral The quantitative and qualitative data integration of our study indicated that re-education of individuals alone (for example, more posters) is not enough to address the problem. Building an infection control practice that is resistant to the pressures of High Patient Load Periods (HPLPs) requires a multi-pronged, systems-oriented approach.

Practice Recommendations

Engineering and Environmental Controls

Strategic Resource Placement: The setting up of the "PPE and Hand Hygiene Carts" or the wall-mounted stations in the areas of the hallways where there are no physical barriers to access should be done to dissolve the barrier of physical access.

Process Simplification: The use of the alcohol-based hand rub as the main (faster than soap/water) method should be supported, and "all-in-one" PPE kits should be provided for isolation rooms so as to facilitate the process of donning.

Cognitive and Workload Support:

Just-in-Time Cues: The use of a visual or auditory alert setting (e.g., simple lights, gentle reminders on digital badges) at room entrances that triggers the hand hygiene/PPE routine, thus, serving as a cognitive aid during the hectic time, can be realized.

Protected "Safety Time": Initiator nurses through the enabling of the "Safety Time" could be given the power to generate micro-pauses for their groups after high-intensity events (e.g., a code) in order to hand hygiene deliberately and to regroup.

Leadership and Cultural Changes:

Leadership Modeling and Messaging: ED leaders should at all times and in every way possible make it clear that infection control is as important as speed through their words and deeds. They should visibly practice and promote the protocols during rounds.

Positive Accountability: The shift audit and feedback change from a punitive to a supportive model should be the main feature. Units or teams that keep up high compliance during difficult periods should be rewarded. This study's qualitative stories should be shared in order to create empathy and a common understanding of the barriers.

Future Research Recommendations:

First, to identify the effects of certain interventions such as the use of PPE carts or cognitive aids, a randomized controlled trial design should be employed.

Second, to identify the specific factors that influence the differences in the inter-professional compliance (e.g., physicians vs. nurses).

Third, to conduct long-term studies to establish a connection between the specific compliance levels during HPLPs and patient-level HAI outcome data.

Limitations

This work is accompanied by several limitations. One is that it was a single-center study of a large academic center and the results may not be applicable to smaller or community EDs. Another limitation is that, although the observers were trained, the Hawthorne effect (where individuals change their behavior when they know they are being observed) might have caused the compliance rates to be overestimated. Nevertheless, this effect was probably similar in both HPLPs and normal periods. Thirdly, the qualitative sample, though providing deep insights, may not represent all viewpoints within the department. Lastly, this research focused on process compliance (behaviors) rather than direct patient outcomes (HAI rates); the link between the two, although strong, is indirect.

CONCLUSION

High patient load periods in the Emergency Department lead to a stressed system where infection control protocols that have been established are significantly more likely to be violated. The drop in adherence is not only an individual failure of healthcare workers but also a system's failure, which is overwhelmed by cognitive load,

resource constraints, and cultural pressures, thus, the healthcare workers do not have enough mental capacity to follow the infection control guidelines. The need to protect patients and staff from preventable infections at these high-risk times necessitates a move away from blaming and instead the creation of a more resilient ED environment that makes doing the safe thing the easy thing even under extreme pressure. The answers are found in a concerted effort that mixes human-centered design, supportive leadership, and an unwavering commitment to a culture of safety.

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