Vol. 2 No. 3 (2025)
ONLINE ISSN :3007-309X
PRINT ISSN :3007-3081
Journal of Medical & Health Sciences Review

ASSESSMENT OF HAND HYGIENE COMPLIANCE AMONG HEALTHCARE WORKERS IN INTENSIVE CARE UNITS OF NISHTAR HOSPITAL, MULTAN: AN OBSERVATIONAL STUDY

Shehla Bano[1], Asghar Javaid[2], Zunaira Aziz[3], Qamar-un-Nisa[4]

[1]College of Nursing, Nishtar Medical University, Multan, Email: shehlabano561@gmail.com
[2]Chairperson, Pathology Department, Nishtar Medical University, Multan,
Email: asgharmicro@hotmail.com
[3]PhD Scholar, School of Nursing, Agha Khan University, Karachi,
Email: zunairasadaf26@gmail.com
[4]Dean/Principal, College of Nursing, Nishtar Medical University, Multan
Email: qamarunnisa1122@gmail.com

ARTICLE INFO:

Keywords:
Hand Hygiene Compliance, Healthcare-associated Infection

Corresponding Author:
Shehla Bano,
College of Nursing, Nishtar Medical University, Multan,
Email:
shehlabano561@gmail.com

Article History:
Published on 25 August 2025

ABSTRACT

Background: Hand hygiene remains the cornerstone of infection prevention, particularly in high-risk areas such as intensive care units (ICUs), where patients are more vulnerable to healthcare-associated infections (HAIs). Despite established WHO guidelines, hand hygiene compliance among healthcare workers continues to be suboptimal in many settings.
Objective: This study aimed to assess the level of hand hygiene compliance among healthcare workers in the ICU of a Nishtar Hospital, Multan.
Methods: A prospective observational study was conducted over 6 months, from March 2024 to August 2024, including one month for piloting in the ICU of Nishtar Hospital, Multan. All 49 doctors and nurses from the ICU were included through universal sampling. Hand hygiene was covertly observed by a trained observer who had no direct contact with patients using the WHO's "Five Moments for Hand Hygiene" through a CDC-standardized checklist.
Results: The overall hand hygiene compliance varied across shifts. The morning shift showed the highest compliance with a mean score of 4.49 ± 0.98, followed by the night shift at 3.67 ± 1.05, and the evening shift at 2.67 ± 0.97. The range of compliance scores was 3.00–4.00 across all shifts. The 33rd and 66th percentiles for each shift were as follows: Morning shift: P33 = 5.00, P66 = 5.00, Evening shift: P33 = 2.00, P66 = 3.00, Night shift: P33 = 3.00, P66 = 4.00. These findings indicate higher compliance in the morning shift, possibly due to increased staff availability and supervision. Lower

adherence in the evening and night shifts may be associated with fatigue, reduced staffing, or limited monitoring.
Conclusion; Hand hygiene compliance among ICU healthcare workers demonstrated significant variation across shifts and remained below optimal standards, especially in evening and night hours. Continuous surveillance, targeted shift-based interventions, and reinforcement strategies are essential to improve adherence and reduce infection risks in critical care settings.

INTRODUCTION

Healthcare-associated infections (HAIs) continue to pose a significant threat to patient safety worldwide, particularly in critical care settings where patients are highly susceptible due to invasive procedures, compromised immunity, and prolonged hospital stays(Blot et al., 2022). Among various infection control measures, hand hygiene remains the most effective and low-cost strategy to prevent the transmission of pathogens within healthcare environments(Bajunaid et al., 2024). Despite this, compliance with hand hygiene protocols remains a persistent challenge across many institutions, especially in resource-constrained settings(Biswal et al., 2022).

Hand hygiene refers to the standardized practice of cleansing hands using soap and water or alcohol-based formulations to remove pathogenic microorganisms and prevent their transmission. The right protocol is to wash your hands with water and detergent by rubbing according to the hand washing 7 steps for at least 20 seconds, and then let them air dry(Gunalan et al., 2021). Every organization follows the "5 Moments for Hand Hygiene" procedure from the Organizations of Health(WHO,2023), a common infection prevention practice in healthcare settings, which is a standard protocol (Lawson, Cameron, &Vaganay-Miller, 2021)(Mastrogianni et al., 2023).

The World Health Organization (WHO) emphasizes the importance of hand hygiene as the cornerstone of patient safety and has established comprehensive guidelines to standardize hand hygiene practices(CDC, 2023). These guidelines outline "Five Moments for Hand Hygiene," which serve as a global framework to reduce infection transmission(Centeleghe et al., 2024). However, multiple studies have shown that adherence to these guidelines varies greatly depending on factors such as shift timing, workload, staff category, availability of hand hygiene supplies, and organizational culture(Dhandapani et al., 2023).

In intensive care units (ICUs), where patients are often supported by mechanical ventilation and central lines, lapses in hand hygiene can lead to severe complications such as ventilator-associated pneumonia (VAP), bloodstream infections, and extended hospital stays(Fernandes et al., 2024). Understanding compliance levels among healthcare workers is essential for designing targeted interventions that strengthen infection prevention efforts(From-Hansen et al., 2024).

This study was conducted in the ICU of a Nishtar Hospital, Multan, to observe and evaluate hand hygiene compliance among healthcare workers during different work shifts. By identifying patterns and potential gaps in adherence, the findings aim to support the development of evidence-based strategies to enhance hand hygiene practices, ultimately improving patient outcomes and safety in high-dependency clinical settings.

LITERATURE REVIEW

Hospital-acquired infection is a serious problem that raises morbidity, mortality, and medical expenses (Klompas et al., 2022). It poses a threat to patient safety, prolonging hospital stays, and increasing healthcare costs **(**Mergulhão et al., 2024).

Numerous risk factors have been identified in the development of VAP, including prolonged mechanical ventilation, poor oral hygiene, inadequate infection control practices, and invasive procedures. Among these, hand hygiene stands out as a simple yet highly effective preventive measure (Murugesan et al., 2022). This study aims to assess the adherence of healthcare workers to hand hygiene protocols in ICU settings. Understanding international trends and findings provides a strong foundation for interpreting local data and developing evidence-based strategies tailored to the needs of Nishtar Hospital Multan. This literature review explored existing evidence, knowledge gaps, and the rationale for conducting a prospective study on the surveillance and impact of healthcare worker hand hygiene on VAP rates in ICU settings in Nishtar Hospital, Multan.

HH compliance remains one of the most effective and low-cost strategies to prevent HAIs, including ventilator-associated pneumonia (VAP). Despite global consensus on its importance, studies reveal wide variability in compliance rates across regions, healthcare settings, and professional roles. The World Health Organization (WHO) introduced the "My 5 Moments for Hand Hygiene" framework in 2009, which serves as a universal guideline (Allegranzi et al., 2022). However, adherence to this framework differs significantly between developed and developing countries.

In high-income countries, hand hygiene compliance tends to be higher compliance range of 57%-88%, due to structured training programs, automated reminders, regular audits, and accountability systems (Gebremicael et al., 2024). For instance, an analysis of 97 healthcare facilities across 28 countries found that most achieved advanced hand hygiene promotion levels, with compliance rates generally above 70%. A decade after its launch, the Hand Hygiene Excellence Award (HHEA) remains an effective global program for improving hand hygiene practices and a reduction in infection rates in Switzerland (Tartari et al., 2024).

In contrast, studies in low- and middle-income countries report lower compliance, often attributed to limited access to hand hygiene supplies, understaffing, and insufficient training (Toney-Butler et al., 2025). Furthermore, a comparison between professional categories shows that physicians often have lower compliance rates than nurses, despite both groups acknowledging the importance of hand hygiene (Khalish and Gautama, 2025). Nurses are generally more consistent, likely due to their frequent and direct patient contact and involvement in routine care.

In addition, another study conducted in Austria, A single-center observational study (2013–2017) assessed hand hygiene compliance across 12 ICUs using direct observation and feedback. Out of 10,315 observed moments, compliance improved from 75.1% to 88.6%, with an annual increase of ~4.5%. Nurses showed the highest compliance (80.2%–90.9%), followed by physicians (61.2%–77.1%) and others (61.3%–82.4%) (Hoffmann et al., 2020). So, Surveillance of hand hygiene adherence is critical to ensuring compliance with protocols. Some other methods, such as direct observation, automated hand hygiene monitoring systems, and patient participation, have been employed to monitor hand hygiene adherence (Juliana et al., 2023)

For instance, a study conducted in the Netherlands, University Medical Centre Groningen by Hilt and his colleagues in 2025 demonstrated a significant reduction in HAI incidence following the introduction of a hand hygiene improvement program, with compliance rising from 43% to 71% over 12 months (Hilt et al., 2025).

Similarly, research in Greece by Mastrogianni et al. (2023) also confirmed that adherence to

hand hygiene protocols, alongside ventilator care bundles, led to a measurable decline in VAP rates. A systematic review study included 38 studies, which concluded that 22 studies found an over 36% VAP decline, and in ten of them, the decrease was over 65%. Four of these studies indicated zero or nearly zero after-intervention VAP rates. The studies adopted Ventilator bundle care with the highest VAP reduction combined with adequate endotracheal tube cuff pressure, hand hygiene, oral care, and subglottic suctioning. Multifaceted techniques can lead to VAP reduction to a great extent (Mastrogianni et al., 2023).

Objective

- To assess healthcare workers' adherence to hand hygiene protocols through direct observation.

Research question

- How does direct observation assess healthcare worker adherence to hand hygiene protocols in ICU settings?
- **Operational definition**
- **Handwashing**

Hand washing refers to the act of cleaning hands with soap and water for at least 20 seconds, using the World Health Organization (WHO)- recommended technique. It includes wetting hands, applying soap, rubbing all hand surfaces, rinsing, and drying with a clean towel. Compliance is assessed through direct observation using a standardized checklist, with hand washing considered adequate when performed correctly during the recommended moments of patient care.

- **Surveillance**

Surveillance refers to the structured and continuous process of directly observing healthcare workers in ICU settings to monitor their adherence to hand hygiene protocols. It is conducted using a standardized checklist during routine patient care, specifically to track behaviors related to the prevention of ventilator-associated pneumonia (VAP).

Compliance

It is defined as the healthcare worker adhering to the recommended hand hygiene protocols. It includes the frequency and consistency of handwashing or hand rubbing, as well as following the correct techniques and timing.

- **Hand hygiene**

Hand hygiene refers to the method used by healthcare workers to clean their hands either by hand washing with soap and water or by using an alcohol-based hand rub, following WHO-recommended guidelineswith proper hand hygiene considered when performed correctly at the five key moments of patient care.

METHODOLOGY

Study Design

This study employed a prospective observational design to assess hand hygiene compliance among healthcare workers in the Intensive Care Unit (ICU) of a tertiary care hospital, Nishtar Hospital Multan. The design was non-experimental and aimed to observe hand hygiene behavior in its natural setting without any interventions.

Study Setting and Duration

The study was conducted in the ICU of Nishtar Hospital, Multan, a public tertiary care teaching hospital in South Punjab, Pakistan. Data collection took place over six months, fromMarch 2024 to August 2024, ensuring adequate representation from all working shifts.

Study Population

The population included all doctors and nurses healthcare workers assigned to ICU duties who had direct contact with patients during the study period. Administrative staff and non-clinical personnel were excluded.

Sampling Technique and Sample Size

A non-probability convenience sampling method was used to select participants for observation based on their presence and involvement in patient care during data collection. a universal sampling technique

was employed for healthcare professionals (HCPs), as the total population of eligible doctors and nurses providing direct care to ventilated patients in the ICU, 49 HCPs consented and met the inclusion criteria.

Data Collection procedure

Data were collected using the WHO Hand Hygiene Observation Form, a standardized and validated instrument that records.

Covert Observation

Covert observations were conducted by two trained infection control nurses, who were already part of the hospital's infection control team, nursing students, and a researcher. Their routine presence in the ICU allowed them to observe HH practices without disclosing the purpose or timing of data collection, thus minimizing the Hawthorne effect. These observers conducted non-participant, structured observations using the CDC Hand Hygiene Checklist(CDC, 2023), focusing on the WHO's 5 Moments for Hand Hygiene (before touching a patient, before aseptic procedures, after body fluid exposure, after touching a patient, and after touching patient surroundings).

The observers did not follow or single out any HCP individually. Instead, they integrated into daily ICU rounds or positioned themselves at nurse stations or near patient bedsides, where care was being provided. They noted HH actions in real-time using a checklist without drawing attention. Observation was indirect and non-intrusive; no physical intervention or verbal instruction was made.

Both doctors and nurses were observed across all three shifts (morning, evening, and night) to capture a representative pattern of practice. Each HCP was observed during 5 to 6 patient care interactions per shift, with a typical ICU HCP performing 8–12 patient interactions per shift, depending on workload (Kesecioglu et al., 2024). A total of 49 HCPs were observed, following the universal sampling approach. The observations were conducted by trained personnel discreetly to minimize the Hawthorne effect, where individuals alter their behavior due to awareness of being observed.

Data Collection Tool

It was comprised of two parts: demographic profile, direct observation monitoring tool standard checklist prepared by the CDC.

Demographic Profile

It consisted of demographic questions concerning the age of the patient, gender, healthcare worker age, gender, educational status, experience level, position of healthcare workers, and average stay of the patient.

Direct observation monitoring tool standard checklist prepared by the CDC

The CDC has provided a standardized checklist for direct observation and monitoring of HH compliance(CDC, 2023). This tool is designed to assess and document healthcare worker adherence to hand hygiene protocols. The checklist includes the following key components

- **Date and Time:** Record the date and time of the observation.

Healthcare Worker Information: Capture the name by employee ID, and role/position of the healthcare worker being observed as an optional.

Patient Information: Note the room/bed number for the patient.

Moment of Observation: Specify whether the observation is conducted before or after direct patient contact.

Hand Hygiene Action Check the appropriate box to indicate whether handwashing or hand rubbing is performed.

Technique Detail the specific steps of the hand hygiene technique, including wetting hands, applying soap/sanitizer, rubbing hands thoroughly, rinsing (if applicable), and drying.

Hand hygiene compliance in 3 shifts. Hand hygiene protocols are complied with by

healthcare workers in the morning, evening, and night shift .

- **Compliance:** Indicate whether the healthcare worker complied with hand hygiene protocols in a dichotomous yes or no answer.
- **Additional Observations/Comments:** Provide any relevant observations or comments related to the hand hygiene practice observed.
- **Observer Information:** Capture the name and signature of the person conducting the observation.

This direct observation monitoring tool checklist, based on CDC guidelines, allows for consistent and standardized assessment of healthcare worker hand hygiene compliance. It provides a structured format to document observations, ensuring accurate data collection for assessing the HH protocol's impact on VAP rates in ICU settings

Ethical Considerations

Prior to data collection, ethical approval was obtained from the Institutional Ethical Review Board (IERB) of Nishtar Medical University, Multan. All observations were conducted anonymously. No personal identifiers or sensitive data were recorded, ensuring full confidentiality and ethical compliance.

Results

A Demographics of the participants

This section analyzes the demographic profile of healthcare workers in the ICU at Nishtar Hospital Multan, including their age, gender, educational qualifications, years of experience, professional roles, and the duration of patient stay under their care. These variables were assessed by the researcher in relation to their adherence to hand hygiene protocol compliance.

Table 4.1; Healthcare Workers age group

Age		
Age group	**Frequency**	**Percentage**
20—25	06	12%
26—40	34	69%
41—55	9	18%
Total	49	100.0%

The table describes the age distribution of the 49 healthcare workers included in this observational study (accounting for a 15% attrition from the original sample size of 42), the majority (67.3%) were between 26 and 40 years of age. This indicates that a substantial portion of the ICU workforce comprises individuals in their peak professional years. A smaller proportion (12.2%) fell within the 20–25 age range, suggesting limited representation of younger, possibly less experienced staff. In contrast, 20.4% of participants were aged 41–55, reflecting a noteworthy segment of more seasoned professionals within the ICU setting.

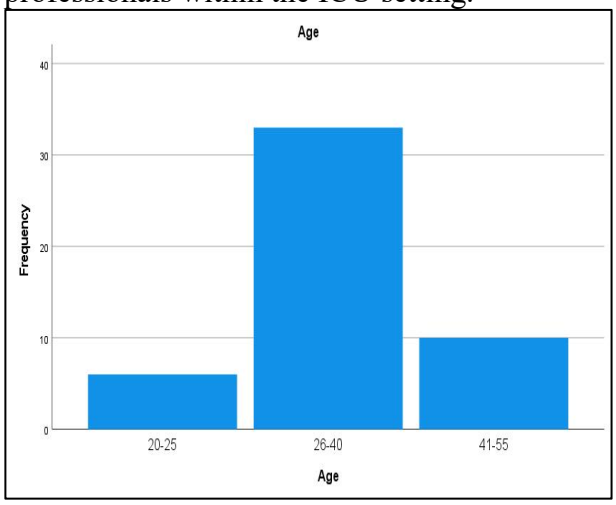


Figure 4.1:Healthcare workers'age.

Table 4.2Gender of professionals

Gender	Frequency	Percentage
Male	11	22.4%
Female	38	77.55%
Total	49	100.0%

Table 4.2 indicates that among the 49 participants in this observational study, 79.6% were female and 20.4% were male. The findings highlight that the ICU workforce was predominantly composed of women, with men representing a smaller proportion.

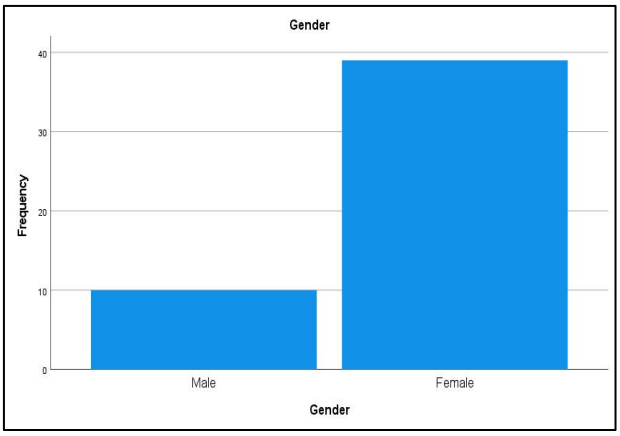


Figure 4.2.

Table 4.3Education

Education	Healthcare worker	%
General nursing	08	16%
BSN /Post RN	21	42%
MsN	05	10%
MBBS	09	18%
PGR Resident	06	12%
Sum	49	100.%

In this study, the educational qualifications of 49 participants were assessed. The majority held a bachelor's degree (n = 21), followed by 8 participants with a 3-year general nursing diploma, 5 with a master's degree in nursing, 9 with an MBBS, and 6 postgraduate residents (PGRs). This diverse academic background reflects the range of professional training among ICU healthcare workers.

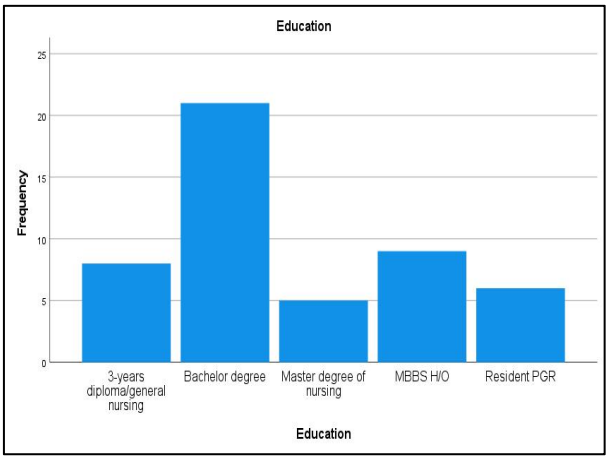


Figure 4.3

Table 4.4years of experience of HCW in ICU

Experience		
Range	Frequency	Percentage
1—5	9	18%
5—10	29	59%
11—15	10	20%
4.00	1	2.1%
Total	49	100.0%

Table 4.4 presents the analysis of the participants' years of professional experience. Among the 49 healthcare workers, the largest group consisted of 29 individuals, highlighting a substantial segment with a specific range of experience. This variation in experience levels is important, as it may impact both compliance with hand hygiene protocols and the associated rates of ventilator-associated pneumonia (VAP).

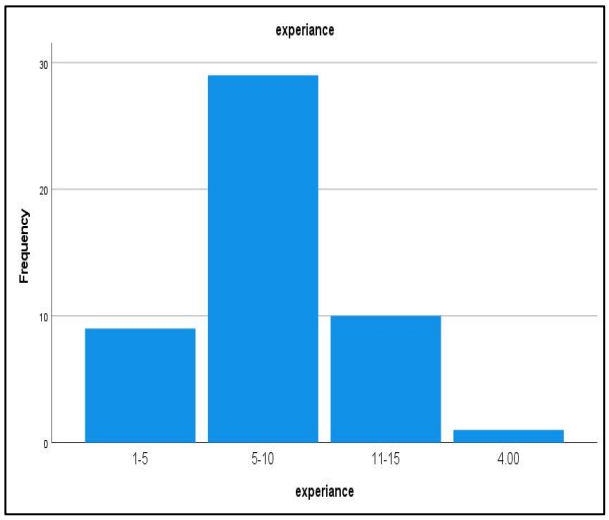


Figure 4.4

Table 4.5 stay of the patient

Stay	Frequency	%
1--5 Days	27.0	55
6—10	22.0	45
Total	49	100.0

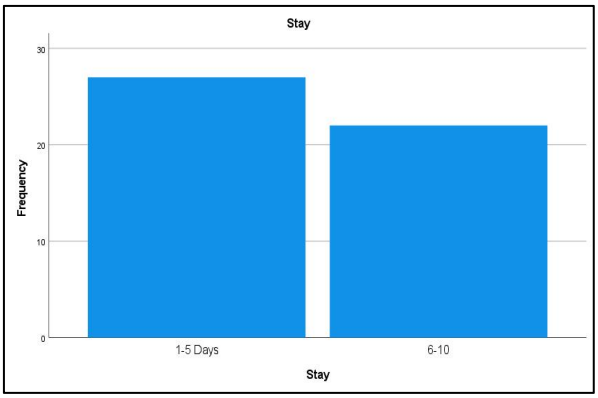


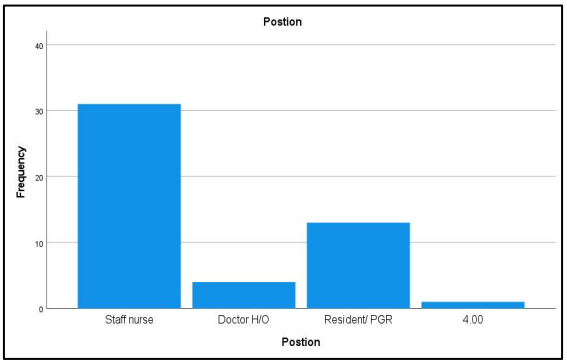
Figure 4.5

In this study exploring the impact of healthcare workers' hand hygiene protocols on VAP rates in ICU settings, the length of stay for 49 participants was assessed. A majority (55.1%) had shorter ICU stays between 1 to 5 days, whereas 44.9% experienced longer stays ranging from 6 to 10 days.

Table 4.6Position of HCW

Designations	Participants	%
Nurses	31.0	63%
House officersDoctors	4.0	8%
Resident & PGR	13.0	26%
Other	1.0	2%
Sum	49.0	100.0%

Table 4.6 shows that the majority of participants (63.3%) were staff nurses, emphasizing their key role in providing direct patient care in the ICU. Doctors in training, including house officers and postgraduate residents (PGRs), made up 8.2% and 26.5% of the sample, respectively. One participant (2.0%) held a different role within the healthcare team.



Section 2

Table No 4.11 Hand hygiene compliance in a shift for 48 hr

Shifts	Starting Shift	Ending shift
Morning	8 AM	2 PM
Evening	2 PM	8 PM
Night	8 PM	8 AM

Morning		
R	**Frequency**	**Percentage**
21---40	4	8.2%
41---60	4	8.2%
61---80	3	6.1%
81---100	38	77.6%
Total	49	100.0%

R* range F* frequency %* percentage

Table 4.11 shows that during the morning shift, 77.6% of healthcare workers demonstrated high hand hygiene compliance (81–100%). Smaller proportions showed moderate compliance: 6.1% (61–80%), 8.2% (41–60%), and 8.2% (21–40%). Overall, the majority adhered well to hand hygiene protocols.

Table No 4.12; Morning shift Hand Hygiene Observations Over 48 hours.

Patient no	HH Opportunities	HH Observations	Compliance rate
1	26	15	58%
2	30	18	60%
3	28	16	57%
4	22	13	59%
5	35	19	54%
6	27	16	59%
7	32	17	53%
8	26	15	58%
9	29	18	62%
10	24	13	54%
11	23	14	61%
12	31	17	55%
13	27	16	59%
14	33	18	55%
15	28	15	54%
16	36	21	58%

17	25	14	56%
18	30	18	60%
19	28	16	57%
20	22	13	59%
21	35	20	57%
22	27	15	56%
23	32	19	59%
24	26	14	54%
25	29	17	59%
26	24	14	58%
27	23	13	57%
28	31	19	61%
29	27	16	59%
30	33	18	55%
31	28	15	54%
32	36	21	58%
33	25	14	56%
34	30	17	57%
35	28	15	54%
36	22	13	59%
37	35	19	54%
38	27	16	59%
39	32	18	56%
40	26	15	58%
41	29	18	62%
42	24	13	54%
43	23	14	61%
44	31	18	58%
45	27	16	59%
46	33	18	55%
47	28	15	54%
48	36	21	58%
49	26	15	58%
Total	1394	800	57.4%

Hand hygiene compliance for 49 healthcare workers is illustrated in table 4.12 with a total hand hygiene compliance of 57.5% A total of 1394 contacts were made with about 800 hand hygiene observations. Compliance rates for individuals varied between 56% and 60%, from a total of 49 healthcare workers reporting, mostly (33 out of 49) reporting compliance of either 57% or 59%. Four healthcare workers had a level of compliance of less than 57%, and twelve more significant degrees of compliance (>58%).

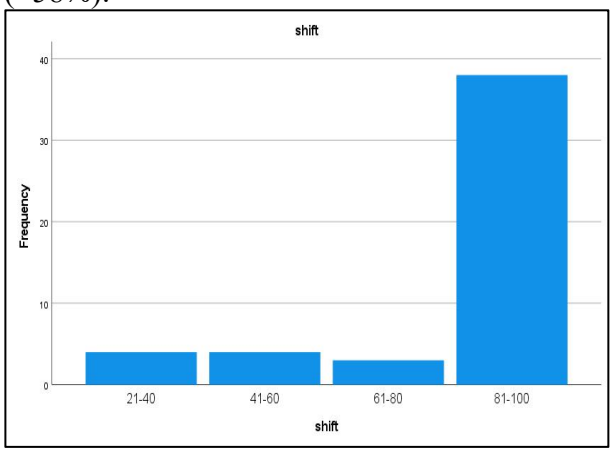


Figure 4.12

Table no 4.13 Evening shift Hand Hygiene Observation over 48 hrs

Shift No 2 (Evening)		
	Frequency	Percent
1---20	5	10.2%
21---40	17	34.7%
41---60	17	34.7%
61---80	9	18.4%
81---100	1	2.0%
	49	0.0

During the evening shift, hand hygiene compliance among healthcare workers showed varied patterns. The largest groups (34.7%) fell within the 21–40% and 41–60% compliance ranges, reflecting moderate adherence. Additionally, 18.4% demonstrated good compliance (61–80%), while 10.2% showed low compliance (1–20%). Only 2% achieved high compliance (81–100%). Overall, compliance during the evening shift was moderate.

Evening shift Hand Hygiene Observations Over 48 hours.

Patient ID	HH Opportunities	HH Observations	Compliance rate
1	25	13	52%
2	30	15	50%
3	28	14	51%
4	22	11	50%
5	15	10	67%

6	27	14	52%
7	32	16	50%
8	26	13	50%
9	29	15	52%
10	24	12	50%
11	23	12	52%
12	31	16	52%
13	27	14	52%
14	33	17	51%
15	28	14	50%
16	36	18	50%
17	25	13	52%
18	30	15	50%
19	28	14	51%
20	22	11	50%
21	25	12	49%
22	27	14	52%
23	32	16	50%
24	26	13	50%
25	22	12	52%
26	24	12	50%
27	23	12	52%
28	31	16	52%
29	27	14	52%
30	33	17	51%
31	28	14	50%
32	36	18	50%
33	25	13	52%
34	30	15	50%
35	28	14	50%
36	22	11	50%
37	35	18	51%
38	27	14	52%
39	32	16	50%
40	26	13	50%
41	29	15	52%
42	24	12	50%
43	23	12	52%
44	31	16	52%
45	27	14	52%
46	33	17	51%
47	28	14	50%
48	36	18	50%
49	25	13	52%
Total	1160	512	45%

Table 4.14, titled "Hand Hygiene Observations During Patient Contact in the Evening Shift Over 2 Days," presents compliance data for healthcare workers. Observations were recorded for 49 patients, with a total of 512 hand hygiene opportunities. The overall compliance rate during the evening shift was 45%, indicating a noticeable decline in adherence compared to the morning shift.

Table No 4.14 Hand hygiene observation in the(Night Shift) over 48 hours

Night shift		
R	Frequency	Percent
1---20	1	2.0
21---40	7	14.3
41---60	13	26.5
61---80	16	32.7
81---100	12	24.5
	49	100.0

Table 4.14 summarizes hand hygiene observation levels among healthcare workers during patient contact in the night shift for 49 patients. The observations are grouped into five compliance ranges. The lowest compliance (1–20%) was recorded for only 1 patient (2.0%). Moderate compliance levels were seen in 7 patients (14.3%) within the 21–40% range and 13 patients (26.5%) in the 41–60% range. The highest frequency was observed in the 61–80% range, with 16 patients (32.7%). Additionally, 12 patients (24.5%) showed excellent compliance in the 81–100% range. These findings reflect varying levels of adherence during the night shift, with a substantial portion demonstrating moderate to high compliance.

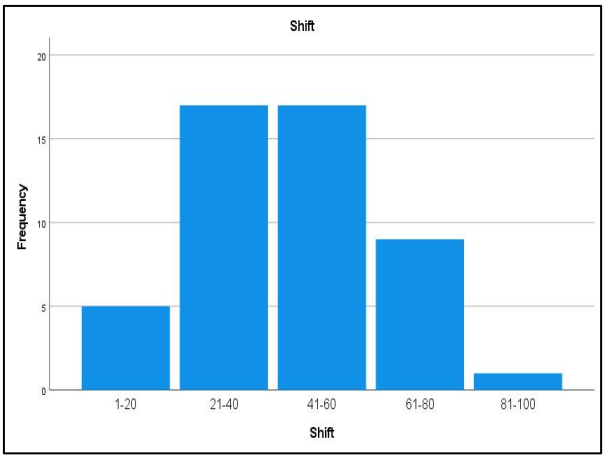


Figure 4.14

Night shift Hand Hygiene Observations Over 48 hours.

ID	HH Opportunities	HH Observations	Compliance rate
1	25	19	76%
2	30	18	60%
3	28	17	61%
4	22	13	59%
5	35	20	57%
6	27	16	59%
7	32	18	56%
8	26	15	58%
9	29	17	59%
10	24	14	58%
11	23	13	57%
12	31	18	58%
13	27	16	59%
14	33	19	58%
15	28	16	57%
16	36	21	58%
17	25	14	56%
18	30	17	57%
19	28	16	57%
20	22	13	59%
21	35	20	57%
22	27	16	59%
23	32	18	56%
24	26	15	58%
25	29	17	59%
26	24	14	58%
27	23	13	57%
28	31	18	58%
29	27	16	59%
30	33	19	58%
31	28	16	57%
32	36	21	58%
33	25	14	56%
34	30	17	57%
35	28	16	57%
36	22	13	59%
37	35	20	57%
38	27	16	59%
39	32	18	56%
40	26	15	58%
41	29	17	59%
42	24	14	58%
43	23	13	57%
44	31	18	58%
45	27	16	59%
46	33	19	58%
47	28	16	57%
48	36	21	58%
49	25	14	56%
Total	1130	690	61%

Table 4.14 highlights hand hygiene compliance during patient contact in the night shift over two days. An overall compliance rate of 49% was recorded, with individual rates ranging from 55% to 62% across 49 patients. Most patients (36 out of 49) exhibited moderate compliance levels within the 45% to 62% range. Additionally, 13 patients showed relatively higher adherence, with rates between 49% and 61%. These results emphasize the need to strengthen hand hygiene training and awareness, especially during night shifts, to enhance patient safety and infection control practices.

Table No 4.15 Hand Hygiene Compliance Rate in Critical Moments

Time Duration	Compliant observation	Totalobservation	Percentage
Before procedure	780	1844	42%
After the Procedure	1216	1844	66%

Table 4.17 presents a comparison of hand hygiene compliance before and after medical procedures. Compliance prior to procedures was recorded at 38% (784 out of 1,842 observations), while post-procedure compliance increased to 62% (1,218 out of 1,842 observations). This indicates a notable improvement in hand hygiene adherence following medical interventions.

Table No 4.16 Hand hygiene compliance rates B/W different methods

Products	F	%
Soap	10--20	15--25%
Waterless gel	30--50	45--60%
Alcohol rub	40--60	60--70%

Table 4.16 presents a comparison of hand hygiene compliance rates among three different methods: soap (10–20%), waterless hand gel (30–50%), and alcohol-based rub (40–60%). The findings indicate that compliance was lowest with soap, while higher adherence rates were observed with waterless gel and alcohol rub. This suggests that alcohol-based and waterless gel methods are more convenient and effective in encouraging consistent hand hygiene practices among healthcare workers.

4.2 Section BDescriptive Statistics

Table 4.17Comparison of every 3 shifts over 48 hrs

Statistics			
	M. shift	E. Shift	N. Shift
Number	49	49	49
Mean X	4.4898	2.6735	3.6735
S.D	0.98155	0.96583	1.04857
RANGE	3.00	4.00	4.00
P33	5.0000	2.0000	3.0000
P66	5.0000	3.0000	4.0000

Hand Hygiene Compliance Each Shift of 49 Healthcare Workers During morning shifts, mean compliance rates were highest (4.49), followed by night (3.67) and evening shifts (2.67)—indicating a drop in rates as the day progressed. The standard deviations were 0.98, 0.97, and 1.05 for morning, evening, and night shift compliance, respectively, suggesting more variability of night shift compliance. In the evening and night shifts, compliance ranges were corresponding to 4.00, and in the morning were 3.00. Percentiles fell from morning to evening (33rd 5.00 vs. 2.00), but recovered slightly overnight (3.00). Interventions need to be targeted, especially for evening shifts; therefore, sign-up compliance needs to be improved.

Table no 4.18 Direct Observation by Standardized Checklist by CDC

Items	Yes	No
1	94	55
2	90	49
3	140	42
4	119	98
5	113	92
6	123	89
7	69	45
8	63	39
9	75	54
10	95	67
11	80	74
12	102	45
13	67	23

The table provides a summary of hand hygiene practices and compliance among healthcare providers (HCPs) across multiple scenarios. ITEM 1 shows 94 compliant and 55 non-compliant observations. The highest compliance was recorded before performing aseptic tasks (140 instances), followed by after patient contact (119) and after contact

with the patient's surroundings (123). Additional compliance was observed after glove removal (69) and when moving between tasks (63). Hand hygiene education was provided to 75 HCPs upon hiring, with 95 demonstrating post-training competency. The facility conducted audits to monitor adherence (80 instances) and compliance with ITEM 3 (102 observations). Policies also emphasized the preference for alcohol-based hand rubs over soap and water (67 instances).

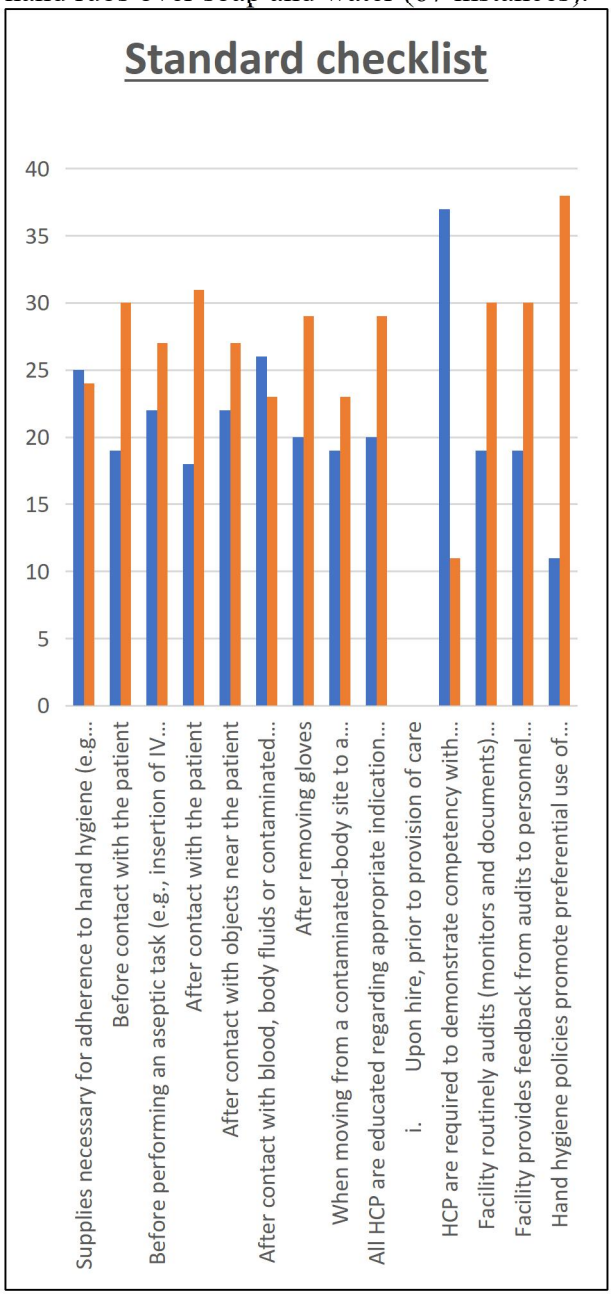


Figure 4.18

Table No. 4.19 Standardized checklist of hand hygiene compliance

Item	Number	X± S.D	Mean(X)	Stand Deviation
Item 1	49	.984±1.99	01.48	.50
2	49	1.11±2.10	1.61	0.49
3	49	1.04±2.05	1.55	0.50
4	49	1.14±2.11	1.63	0.48
5	49	1.04±2.05	1.55	0.50
6	49	0.96±1.97	1.46	0.50
7	49	1.095±2.08	1.59	0.49
8	49	1.11±2.10	1.61	0.49
9	49	1.095±2.08	1.59	0.49
10	49	0.810±1.67	1.24	0.43
11	49	1.07±2.07	1.57	0.5
12	49	1.11±2.10	1.61	0.49
13	49	1.35±2.19	1.77	0.42
14	49	0.81±1.71	1.26	0.44

Table 4.20 summarizes hand hygiene practices among healthcare personnel (HCPs) based on responses from 49 participants. Item 1 recorded a mean score of 1.49 (SD = 0.51), while Item 2 and Item 3 reported mean scores of 1.61 (SD = 0.49) and 1.55 (SD = 0.50), respectively. Compliance after patient contact showed a slightly higher mean of 1.63 (SD = 0.49). For Item 5, the mean scores were 1.55 (SD = 0.50) and 1.59 (SD = 0.50), while hand hygiene during transitions from contaminated to clean body sites had a mean of 1.61 (SD = 0.49). Item 6 showed a lower mean of 1.47 (SD = 0.50).

Regarding education and training, HCPs received hand hygiene education upon hire (mean = 1.59, SD = 0.50) and annually (mean = 1.27, SD = 0.45). Competency assessments following training yielded a mean of 1.24 (SD = 0.43). Routine audits of compliance were reported with a mean of 1.57

(SD = 0.50), while feedback on adherence scored 1.61 (SD = 0.49).

DISCUSSION

Sociodemographic Characteristics

This study was conducted at Nishtar Hospital Multan, involving 49 ICU patients receiving mechanical ventilation for over 48 hours, alongside 49 healthcare workers (HCWs), including nurses and doctors responsible for their care. The research assessed adherence to the CDC's "Five Moments of Hand Hygiene" in this high-risk setting (CDC, 2023).

Most HCWs (67.3%) were aged 26–40, with smaller groups aged 41–55 (20.4%) and 20–25 (12.2%) **(Table 4.1**). Females dominated the workforce (79.6%), reflecting nursing's gender skew in many ICUs**(table 4.2)** similar to trends noted by Ahmed et al., 2023 and the majority of the patients are aged 24-29 (51.0%), followed by 18-23 (36.7%), and the smallest group is 30-35 (12.2%). This indicates that most patients are young adults, particularly in their mid-to-late twenties, that also in different studies(Ahmed et al., 2023).

In terms of education**(Table 4.3),** 42.9% held a Bachelor's degree, 16.3% had a 3-year diploma/general nursing, 10.2% had a Master's degree in nursing, 18.4% were medical doctors (MBBS H/O), and 12.2% were residents (PGR). This demographic profile suggests a youthful, predominantly female, and highly educated group, indicating a potentially receptive audience for hand hygiene training and VAP prevention initiatives which coincides with a study(Aziz et al., 2020).

The participants' experience levels varied **(table 4.4)**, with 59.2% having 5-10 years of experience, 20.4% having 11-15 years, 18.4% having 1-5 years, and 2.0% having 4 years of experience. This indicates a workforce with a significant amount of experience, which is beneficial for adherence to hand hygiene protocols and VAP prevention measures coincided with other research study(Musu et al., 2017). The study's participants included 63.3% staff nurses, 26.5% residents (PGR), and 8.2% doctors (H/O). This distribution highlights a predominantly nursing-focused sample, essential for evaluating hand hygiene practices and VAP prevention efforts in ICU settings (Mastrogianni et al., 2023). The majority of participants, comprising 55.1%(5 days) in ICU consistent with other study showing 8.77 (+ 6.85) days(Biswal et al., 2022).

5.2 Critical five Moments of hand hygiene

This study helped to emphasize that all 5 moments of HH, as per WHO, have equal importance and contribution to reduce HAIs, especially Ventilator-associated pneumonia(VAP). Moreover, these poor results encourage the HCW to follow all the HH moments and HH steps (Allegranzi et al., 2022). Hand practices are reported to be very poor in low- and middle-income countries; this may be due to multiple reasons like limited availability of resources, lack of awareness and motivation among HCWs, and overburdened work.

A total of 3684 opportunities of patient contact were observed, of which 2001 were hand hygiene compliance**(Table 4.17).** The study's data regarding HH compliance is categorized. Before procedures, there were 723 compliant observations out of 1,891 total opportunities, resulting in a compliance rate of 38% but one study shows the significant percentage of hand hygiene compliance in before the procedure Moment of HH is 86%, in which a global compliance with the five moments of HH of the participants was 64.5%. Before touching a patient, the adherence was 86,9%(Grau et al., 2024). Moreover, these poor results encourage the HCW to follow all the HH moments and HH steps(Allegranzi et al., 2022) Hand practices are reported to be very poor in low- and middle-income countries; this may be due to multiple reasons like limited availability of resources, lack of

awareness and motivation among HCWs, and overburdened work.

In contrast, after procedures, there were 1,168 compliant observations out of the same 1,891 opportunities, resulting in a higher compliance rate of 62%. The hand washing frequency reported in my study is 51% to 54% but the literature has a wide range from 60% to 61.4% reported by (Lambe et al., 2019) to 73.17% by (Mouajou et al., 2022) and conversely reported in the study 75.1% to 88.6% (Hoffmann et al., 2020).

This indicates a significant improvement in hand hygiene adherence post-procedure compared to pre-procedure, highlighting the need for increased emphasis on hand hygiene before medical interventions to enhance overall compliance and reduce infection risks. A recent multi-centric study from India has reported hand hygiene after the procedure of 59.7% and before procedure hand hygiene of 27.3%; the compliance from the northern zone was 19.9% (our institute also lies in northern India)(Anguraj et al., 2021).

The moment-specific compliance of all the 5 moments of Hand hygiene, as per WHO, was observed and evaluated separately. After moments (after body fluid exposure and after touching the patient) have significantly higher compliance (CP4 71% and CP5 76%) than before moments CP2 (38%) and CP3 (62%). The higher compliance in after moments has also been reported in multiple studies (Krishnamoorthi et al., 2023).

Conversely, another study reported a generally low level of healthcare workers' adherence to hand hygiene across the five critical moments. Interestingly, it found that compliance was significantly higher *after* patient contact than *before* performing a procedure. Specifically, hand hygiene compliance *before* a procedure was as low as 2.4% (95% CI: 0.9–5.3), whereas compliance *after* a procedure was slightly higher at 3.3% (95% CI: 1.2–7.9). These findings highlight a critical gap in preventive hand hygiene practices, particularly in moments where transmission risk is highest. This discrepancy underscores the need for targeted interventions and training programs to reinforce the importance of hand hygiene *before* patient contact or aseptic procedures, as these moments are crucial in preventing healthcare-associated infections, including VAP(Kolola and Gezahegn, 2017, Haenen et al., 2024).

The results of this study revealed notable differences in healthcare workers' adherence to hand hygiene protocols across shifts. Morning shift health workers exhibited the highest compliance, **table (4.14)** with 77.6% of observations suggesting strong adherence at the start of the day. In contrast, the evening shift showed lower adherence, with only 2.0% in the highest range indicating potential fatigue or reduced supervision. The night shift data was more dispersed, with adherence ranging from 2.0% in the lowest category to 32.7% reflecting varied compliance coinciding with another study showing consistent result (Bajunaid et al., 2024). These findings highlight the need for targeted interventions to improve hand hygiene practices, particularly during evening and night shifts, to enhance overall adherence and patient safety (Daba et al., 2024)(Lambe et al., 2019).

Strengths and limitations

This study's strengths lie in its use of real-time, direct observation within a high-risk ICU setting, employing the WHO Hand Hygiene Observation Tool to ensure standardized and internationally recognized data collection. The inclusion of all three work shifts allowed for a comprehensive understanding of adherence patterns across time. However, the study has certain limitations. Despite efforts to observe covertly, the potential influence of the Hawthorne effect cannot be entirely ruled out. Additionally, being a single-center study with

a relatively small sample size, the generalizability of the findings is limited.

Implications

The findings of this study have important implications for clinical practice and infection control policy. The variation in hand hygiene compliance across shifts highlights the need for shift-specific strategies, such as reinforcing hand hygiene practices during evening and night shifts through targeted training and supervisory support. Continuous monitoring using standardized tools like the WHO checklist can help sustain compliance and identify gaps in real-time. Furthermore, ensuring easy access to hand hygiene resources at the point of care, addressing workload issues, and fostering a culture of safety and accountability among healthcare workers can significantly improve adherence. These measures can contribute to a reduction in healthcare-associated infections and improve overall patient safety in intensive care settings.

CONCLUSION

This observational study focused on the surveillance and impact of healthcare workers' hand hygiene protocols in the ICU setting. This study showed that HH compliance with HCWs was found to be low. Indications that are high risk to the patient have lower compliance. This suggests that the need for an HH compliance improvement strategy is evident. Implementing WHO's multimodal strategy is crucial to improving HH compliance of HCWs. Access to HH resources should be emphasized as an integral part of the HH improvement strategy. The findings underscore the critical role of hand hygiene practices in preventing VAP and highlight several areas for improvement in adherence and protocol implementation.

- **Low Compliance with Basic Hand Hygiene**

The study found encouraging levels of compliance with hand hygiene before (mean=2.24, SD=0.78) and after patient contact (mean=2.73, SD=0.57). This indicates a strong commitment to fundamental infection control measures among healthcare personnel.

REFERENCE

AHMED, F., IQBAL, J., AHMED, K., HUSSAIN, F., JABBAR, H. & ARIFF, S. 2023. Ventilator Associated Pneunomia in Neonatal Intensive Care Unit: Occurrence and Risk Factors. *Pakistan Journal of Medical and Health Sciences,* 17**,** 436-438.

ALLEGRANZI, B., KILPATRICK, C., SAX, H. & PITTET, D. 2022. 'My Five Moments': understanding a user-centred approach to hand hygiene improvement within a broader implementation strategy. *BMJ Quality & Safety,* 31**,** 259-262.

ANGURAJ, S., KETAN, P., SIVARADJY, M., SHANMUGAM, L., JAMIR, I., CHERIAN, A. & SANKAR SASTRY, A. 2021. The effect of hand hygiene audit in COVID intensive care units in a tertiary care hospital in South India. *American Journal of Infection Control,* 49**,** 1247-1251.

AZIZ, Z., KAUSAR, S., ZAHID, S., FAROOQI, S., AZIZ, Z. & AHMAD, R. A. 2020. Knowledge and practice of ventilator care bundle for preventing ventilator associated pneumonia by ICU nurses of tertiary care hospitals of Lahore. *Anaesthesia, Pain & Intensive Care,* 24.

BAJUNAID, R. M., SAEED, A., BOSTAJI, M. & FARSI, N. J. 2024. Hand hygiene compliance and improvement interventions in the Eastern Mediterranean Region: a systematic review and meta-analysis. *Infect Prev Pract,* 6**,** 100363.

BISWAL, M., KAUR, K., JAIN, K. & DAYAL, S. K. 2022. Ventilator-associated Events Surveillance in a Trauma Intensive Care Unit: A

Prospective Study of Incidence, Predictive Values, Sensitivity, Specificity, Accuracy, and Concordance with Ventilator-associated Pneumonia. *Indian Journal of Critical Care Medicine,* 26**,** 582-588.

BLOT, S., RUPPÉ, E., HARBARTH, S., ASEHNOUNE, K., POULAKOU, G., LUYT, C. E., RELLO, J., KLOMPAS, M., DEPUYDT, P., ECKMANN, C., MARTIN-LOECHES, I., POVOA, P., BOUADMA, L., TIMSIT, J. F. & ZAHAR, J. R. 2022. Healthcare-associated infections in adult intensive care unit patients: Changes in epidemiology, diagnosis, prevention and contributions of new technologies. *Intensive Crit Care Nurs,* 70**,** 103227.

CDC 2023. clean hands count for safe healthcare. *patient safety*.

CENTELEGHE, I., NORVILLE, P., MAILLARD, J.-Y. & HUGHES, L. 2024. Infection prevention control in practice: a survey of healthcare professionals' knowledge and experiences. *Infection Prevention in Practice,* 6**,** 100357.

DABA, C., ATAMO, A., DEBELA, S. A. & GEBREHIWOT, M. 2024. Observational assessment of hand hygiene compliance among healthcare workers in public hospitals of Northeastern Ethiopia. *International Journal of Environmental Health Research,* 34**,** 792-802.

DHANDAPANI, S., RAJSHEKAR, D., PRIYADARSHI, K., KRISHNAMOORTHI, S., SUNDARAMURTHY, R., MADIGUBBA, H., SASTRY, A. S., SASTRY, D. A. S., PRIYADARSHI, D. K., RAJSHEKAR, D. D., KRISHNAMOORTHI, D. S., SUNDARAMURTHY, D. R., MADIGUBBA, D. H., SARUMATHI, CHERIAN, D. A., KB, D. C., JOE, D. G., K, D. R., NAGARAJAN, D. A., MANE, D. M. S., P, D. P. L., BILLORIA, D. A., ANTONY, D. T., RENUKA, D. M. K., JIGISHA, D. K. S., KORANI, D. A., JAN, D. A., BERRY, D. R., CHAURASIA, D. D., DUBEY, D. S., DAVE, D. L., SHARMA, D. A., LALWANI, D. J., MIRZA, D. S., PRASAD, D. A., GUPTA, D. P., PANDA, D. P. K., SINHA, D. S., SAHOO, D. B., SINGH, D. V., SAHU, D. S., SAHU, D. R., R, D. S., JAYAPRADA, D. R., RAMAKRISHNA, D. N., MAMTABHATT, N, D. M. P., CP, D. F., K, D. V., SULTAN, D. A., KHAN, D. F., CHAKRAVARTY, D. A., HAZARIKA, D. R., BHUYAN, D. B., LEELA, D. K. V., GOPINATHAN, D. A., SRIRAMAJAYAM, D. L., RIZWANA, D. M. M., AKUDE, D. R. A., WAJID, D. M., NAAZ, D. S., KARUMANCHI, D. D., DEVI, D. A. R., CHAKRAPANI, D. K., GUPTA, D. P., JAGIASI, D. B., BANERJEE, D. J., TOLPADI, D. A. G., MANE, D. A. K., TADI, D. L. J., NARANG, D. R., CHAVAN, D. S. K. D., GAIKWAD, D. U. N., MIRZA, D. M., KHANDAIT, D. M., SHARMA, D. M., P, D. K., SIDDIQ, D. A., UMA, D. P., YARLAGADDA, D. P., SUMANA, D. P., SHAIK, D. N., CHANDRAKESAN, D. S. D., SERALATHAN, D. S. E., E, D. A., J, V., JAYAKAR, D. D. S., PADALA, D. B., SUREKA, D. R. K., SANNITHI, D. K., SINGH, D. T. A., KOTTAPALLI, D. P., XESS, D. A. B., SETH, D. R. K., PATTANAIK, D. R. B., SAHOO, D. N. P., BEHERA, D. B., MAHAPATRA, D. A., GUPTA, D. V., CHAUDHARY, D. P., et al. 2023. Comparison of hand hygiene compliance among healthcare workers

in Intensive care units and wards of COVID-19: A large scale multicentric study in India. *American Journal of Infection Control,* 51**,** 304-312.

FERNANDES, D., CARDOSO, S., MIRANDA, J., DUARTE, J. & SANTOS, M. F. 2024. Prediction of nosocomial infections associated with surgical interventions. *Procedia Computer Science,* 231**,** 433-438.

FROM-HANSEN, M., HANSEN, M. B., HANSEN, R., SINNERUP, K. M. & EMME, C. 2024. Empowering health care workers with personalized data-driven feedback to boost hand hygiene compliance. *American Journal of Infection Control,* 52**,** 21-28.

GEBREMICAEL, M. N., SKALETZ-ROROWSKI, A., POTTHOFF, A., LEMM, J., KASPER-SONNENBERG, M., AREFAINE, Z. G., TEMIZEL, S. & LEMM, F. 2024. Implementing a multimodal intervention using local resources to improve hand hygiene compliance in a comprehensive specialized hospital in Mekelle, Northern Ethiopia. *International Journal of Hygiene and Environmental Health,* 259**,** 114389.

GRAU, L., PERRUCHINO, G. & MESQUITA-RAMÍREZ, M. 2024. Compliance with the five moments for hand hygiene of healthcare workers in a pediatric hospital. A prospective observational study. *Medicina Clínica y Social,* 8**,** 166-172.

GUNALAN, A., SISTLA, S., SASTRY, A. S. & VENKATESWARAN, R. 2021. Concordance between the National Healthcare Safety Network (NHSN) Surveillance Criteria and Clinical Pulmonary Infection Score (CPIS) Criteria for Diagnosis of Ventilator-associated Pneumonia (VAP). *Indian J Crit Care Med,* 25**,** 296-298.

HAENEN, A., HUIS, A., TEERENSTRA, S., LIEFERS, J., BOS, N., VOSS, A., DE GREEFF, S. & HULSCHER, M. 2024. Effect and Process Evaluation of an Intervention to Improve Hand Hygiene Compliance in Long-Term Care Facilities. *Journal of the American Medical Directors Association,* 25**,** 591-598.

HILT, N., BERENDS, M. S., LOKATE, M., TENT, B. & VOSS, A. 2025. Compliance and Performance of Hand Hygiene in Dutch General Practice Offices Using Electronic Dispensers. *J Prim Care Community Health,* 16**,** 21501319251334218.

HOFFMANN, M., SENDLHOFER, G., GOMBOTZ, V., PREGARTNER, G., ZIERLER, R., SCHWARZ, C., TAX, C. & BRUNNER, G. 2020. Hand hygiene compliance in intensive care units: An observational study. *International Journal of Nursing Practice,* 26.

JULIANA, M., M.G SIANIPAR, I. & ADITYA WILLYANTO, N. 2023. ANALYSIS OF HAND HYGIENE PRACTICES AMONG HEALTH CARE WORKERS FOR PREVENTION OF NOSOCOMIAL INFECTION: A SYSTEMATIC REVIEW. *Journal of Advance Research in Medical & Health Science (ISSN: 2208-2425),* 9**,** 85-89.

KESECIOGLU, J., RUSINOVA, K., ALAMPI, D., ARABI, Y. M., BENBENISHTY, J., BENOIT, D., BOULANGER, C., CECCONI, M., COX, C., VAN DAM, M., VAN DIJK, D., DOWNAR, J., EFSTATHIOU, N., ENDACOTT, R., GALAZZI, A., VAN GELDER, F., GERRITSEN, R. T., GIRBES, A., HAWYRLUCK, L., HERRIDGE, M., HUDEC, J., KENTISH-BARNES, N., KERCKHOFFS, M., LATOUR, J. M.,

MALASKA, J., MARRA, A., MEDDICK-DYSON, S., MENTZELOPOULOS, S., MER, M., METAXA, V., MICHALSEN, A., MISHRA, R., MISTRALETTI, G., VAN MOL, M., MORENO, R., NELSON, J., SUÑER, A. O., PATTISON, N., PROKOPOVA, T., PUNTILLO, K., PUXTY, K., QAHTANI, S. A., RADBRUCH, L., RODRIGUEZ-RUIZ, E., SABAR, R., SCHALLER, S. J., SIDDIQUI, S., SPRUNG, C. L., UMBRELLO, M., VERGANO, M., ZAMBON, M., ZEGERS, M., DARMON, M. & AZOULAY, E. 2024. European Society of Intensive Care Medicine guidelines on end of life and palliative care in the intensive care unit. *Intensive Care Med,* 50**,** 1740-1766.

KHALISH, G. & GAUTAMA, M. S. N. 2025. Hand hygiene compliance among hospital visitors: A systematic review and meta-analysis of observational studies. *J Infect Prev***,** 17571774251324373.

KOLOLA, T. & GEZAHEGN, T. 2017. A twenty-four-hour observational study of hand hygiene compliance among health-care workers in Debre Berhan referral hospital, Ethiopia. *Antimicrobial Resistance & Infection Control,* 6.

KRISHNAMOORTHI, S., PRIYADARSHI, K., RAJSHEKAR, D., SUNDARAMURTHY, R., DHANDAPANI, S., MADIGUBBA, H. & SASTRY, A. S. 2023. Impact of conducting hand hygiene audit in COVID-19 care locations of India—A large scale national multicentric study – HHAC study. *Indian Journal of Medical Microbiology,* 43**,** 39-48.

LAMBE, K. A., LYDON, S., MADDEN, C., VELLINGA, A., HEHIR, A., WALSH, M. & O'CONNOR, P. 2019. Hand Hygiene Compliance in the ICU: A Systematic Review. *Crit Care Med,* 47**,** 1251-1257.

MASTROGIANNI, M., KATSOULAS, T., GALANIS, P., KOROMPELI, A. & MYRIANTHEFS, P. 2023. The Impact of Care Bundles on Ventilator-Associated Pneumonia (VAP) Prevention in Adult ICUs: A Systematic Review. *Antibiotics (Basel),* 12.

MOUAJOU, V., ADAMS, K., DELISLE, G. & QUACH, C. 2022. Hand hygiene compliance in the prevention of hospital-acquired infections: a systematic review. *J Hosp Infect,* 119**,** 33-48.

MURUGESAN, N., NATESAN, G. & FELIX, A. J. W. 2022. A Study to Assess the Compliance on Hand Hygiene during Bundle of Care Interventions among Healthcare Professionals Working in ICU of a Tertiary Care Hospital. *Indian J Crit Care Med,* 26**,** 1006-1010.

MUSU, M., LAI, A., MEREU, N. M., GALLETTA, M., CAMPAGNA, M., TIDORE, M., PIAZZA, M. F., SPADA, L., MASSIDDA, M. V., COLOMBO, S., MURA, P. & COPPOLA, R. C. 2017. Assessing hand hygiene compliance among healthcare workers in six Intensive Care Units. *J Prev Med Hyg,* 58**,** E231-e237.

TARTARI, E., GARLASCO, J., MEZERVILLE, M. H.-D., LING, M. L., MÁRQUEZ-VILLARREAL, H., SETO, W.-H., SIMON, A., HENNIG, T.-J. & PITTET, D. 2024. Ten years of hand hygiene excellence: a summary of outcomes, and a comparison of indicators, from award-winning hospitals worldwide. *Antimicrobial Resistance & Infection Control,* 13.

TONEY-BUTLER, T. J., GASNER, A. & CARVER, N. 2025. Hand Hygiene. *StatPearls*. Treasure Island (FL): StatPearls Publishing