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# EFFECT OF A STRUCTURED NEEDLESTICK INJURY PREVENTION PROGRAM ON SHARPS SAFETY COMPLIANCE AMONG HEALTHCARE WORKERS IN A TERTIARY CARE HOSPITAL, MULTAN

**Mubashra Bano[*1], Zaheer Ahmad[2], Saira Batoool[3], Shehla Bano[4]**

[*1]*Charge Nurse Sardar Fateh Muhammad Khan Buzdar institute of cardiology (SFMKBIC) DG. khan*
[2]*Nursing Officer District jail hospital Multan*
[3]*Charge nurse DHQ Hospital Muzaffargarh*
[4]*Assistant Nursing Instructor College of Nursing Nishter Medical university Multan*

[*1]mubashranlin@gmail.com, [2]zaheerahmed10101994@gmail.com, [3]sairabatool.mzg@gmail.com
[4]shehlabano561@gmail.com

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**Corresponding Author:** *
**Mubashra Bano**

**Abstract**

***Background:***
*Needlestick injuries (NSIs) remain a pervasive occupational hazard for healthcare workers (HCWs) in Pakistan, with underreporting and inconsistent compliance with sharps safety protocols contributing to a significant burden of bloodborne pathogen exposure. Local evidence from tertiary care settings in Multan indicates a high frequency of NSIs, with nurses and junior doctors being disproportionately affected and recapping needles identified as a leading cause. Despite this, structured, hospital-based prevention programs remain limited.*

***Objective:***
*To evaluate the effect of a structured needlestick injury prevention program on sharps safety compliance, knowledge, and the incidence of self-reported NSIs among HCWs at a tertiary care hospital in Multan.*

***Methods:***
*A quasi-experimental pre-post intervention design was employed over six months (January–June 2025) at a tertiary care hospital in Multan. A total of 180 HCWs (nurses, doctors, and technicians) were selected through consecutive sampling. The intervention comprised a multifaceted bundle: (1) a didactic educational session on NSI risks and the "no-recapping" policy; (2) hands-on simulation training for safe sharps disposal; (3) distribution of safety-engineered devices in high-risk wards; and (4) implementation of a simplified, non-punitive reporting system. Sharps safety compliance was measured using a structured observational checklist (20 items) across four domains: hand hygiene, glove use, needle handling, and waste segregation. Knowledge and self-reported NSI incidence were assessed via a validated questionnaire at baseline and at three months post-intervention. Data were*

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*analyzed using SPSS v26; paired t-tests and McNemar's test were applied, with *p* < 0.05 considered significant.*

***Results:***

*Post-intervention, overall sharps safety compliance scores improved significantly from a baseline mean of 61.4% (SD 12.7) to 84.2% (SD 9.8) (*p* < 0.001). The most pronounced improvement was observed in the "needle handling" domain, where compliance with the no-recapping policy rose from 42.8% to 88.9% (*p* < 0.001). Knowledge scores regarding post-exposure prophylaxis and reporting pathways increased from a mean of 58.3% to 89.7% (*p* < 0.001). The self-reported incidence of NSIs in the preceding three months decreased from 22.2% at baseline to 8.3% at follow-up (*p* = 0.004). However, compliance with glove use during emergency procedures remained suboptimal (from 51.1% to 67.8%, *p* = 0.012), highlighting a persistent gap.*

***Conclusion:***

*A structured, multi-component prevention program was effective in improving sharps safety compliance and knowledge while reducing self-reported NSIs among HCWs in a resource-constrained tertiary care setting. The findings underscore the necessity of moving beyond passive education toward bundled interventions that include environmental modifications (safety devices) and systemic changes (reporting culture), as advocated in recent quality improvement literature (Vitus et al., 2026). Sustained compliance requires integration into institutional policy and continuous reinforcement.*

## 1. INTRODUCTION

Needlestick injuries (NSIs) are inadvertent percutaneous exposures to blood or body fluids via contaminated needles or sharp instruments(Al-Mugheed et al., 2023). They represent one of the most common and preventable occupational hazards in healthcare, carrying a tangible risk of transmission of hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV). The World Health Organization estimates that HCWs globally experience approximately 3 million percutaneous exposures annually, with the vast majority occurring in low- and middle-income countries where safety protocols and reporting systems are often fragmented (Singh et al., 2024).

In Pakistan, the burden of NSIs is substantial. A recent cross-sectional study conducted at Nishtar Hospital, Multan, reported a frequency of 66.2% among HCWs, with work overload and a lack of recent training identified as significant contributing factors (Ijaz *et al.*, 2024). A separate one-year surveillance study at the same institution revealed a formally reported incidence of 3.2 per 100 HCWs per year, yet survey data suggested that approximately 58% of incidents went unreported, indicating a true incidence far higher than official figures (Dania *et al.*, 2025). Nurses were the most vulnerable group, and recapping needles a practice explicitly prohibited by standard precautions—was the leading cause of injury (Dania *et al.*, 2025). Nationally, a multi-centre study across Punjab reported that only 21.87% of NSIs were formally reported, with recapping accounting for nearly a quarter of injuries (Kidder *et al.*, 2024).

Despite high awareness of NSI risks, compliance with sharps safety protocols remains inconsistent. Studies from Pakistan have documented poor

adherence to safe disposal practices and inadequate availability of safety-engineered equipment, even among HCWs with good theoretical knowledge (Nadeem *et al.*, 2026). This knowledge-practice gap is a critical target for intervention. Educational programs based on the Knowledge-Attitude-Practice (KAP) model and bundled interventions have shown promise internationally. A KAP-based bundled intervention among nurses significantly improved safe sharps management (Yang *et al.*, 2022), and a structured PDCA-based quality improvement initiative in a tertiary facility reduced NSI incidence by 71% while improving compliance from 38.3% to 88.3% (Vitus *et al.*, 2026). However, evidence on the effectiveness of such programs in the specific context of tertiary care hospitals in Multan is scarce.

The present study was designed to address this gap. The objective was to evaluate the effect of a structured needlestick injury prevention program on sharps safety compliance, knowledge, and self-reported NSI incidence among HCWs at a tertiary care hospital in Multan. We hypothesized that a multi-component intervention—combining education, simulation, safety devices, and reporting system reform would yield measurable improvements in compliance and reduce injury rates.

## 2. Methodology

### 2.1. Study Design and Setting

A quasi-experimental pre-post intervention design was employed. The study was conducted over six months (January to June 2025) at a tertiary care hospital in Multan, Pakistan. The hospital is a major referral center with high patient turnover, providing services across medical, surgical, emergency, and critical care departments. The study was approved by the Institutional Ethical Committee.

### 2.2. Participants and Sampling

The target population comprised HCWs directly involved in patient care and sharps handling: registered nurses, house officers, postgraduate residents, and laboratory technicians. HCWs with less than three months of current employment or those on extended leave were excluded. A sample size of 180 was calculated using Open Epi, assuming a 20% absolute improvement in compliance scores, 80% power, and a 5% significance level, with a 10% attrition allowance. Participants were recruited through consecutive sampling from the medical, surgical, emergency, and intensive care units.

### 2.3. The Structured Prevention Program (Intervention)

The intervention was a four-component bundle, informed by the KAP model and evidence from similar settings (Yang *et al.*, 2022; Vitus *et al.*, 2026).

1. **Didactic Education Session (2 hours):** A standardized presentation covering the epidemiology of NSIs, transmission risks, the "no-recapping" policy, proper sharps disposal techniques, and the importance of reporting. Emphasized the personal and institutional costs of NSIs.
2. **Hands-On Simulation Training (1 hour):** Participants practiced safe needle handling and disposal using a sharps container trainer, with immediate corrective feedback from infection control nurses. Focus was placed on the single-handed scoop technique as an alternative to recapping, despite the overarching "no-recapping" message.
3. **Environmental Modification:** Safety-engineered sharps containers were installed at the point of use in all high-risk areas (patient rooms, procedure trolleys). Standard needle cutters were removed to discourage recapping.

4. **Reporting System Reform:** A simplified, non-punitive, one-page reporting form was introduced, along with a dedicated 24/7 hotline for post-exposure advice. Feedback on reporting rates was provided monthly to unit heads to reinforce the culture of safety.

**2.4. Outcome Measures and Data Collection**

Data were collected at two time points: baseline (T0, immediately before the intervention) and follow-up (T1, three months post-intervention).

- **Primary Outcome Sharps Safety Compliance:** Measured using a 20-item structured observational checklist adapted from WHO and CDC guidelines. A trained observer (not part of the study team) observed participants during routine clinical activities across four domains: (A) Hand Hygiene (4 items), (B) Glove Use (4 items), (C) Needle Handling and Disposal (7 items), and (D) Waste Segregation (5 items). Each item was scored as "Compliant" or "Non-compliant." A composite compliance score (percentage of compliant items) was calculated for each participant.
- **Secondary Outcomes Knowledge and Self-Reported NSI:** A validated, self-administered questionnaire assessed knowledge of NSI risk, post-exposure prophylaxis (PEP), and reporting procedures (10 items; score 0–10). Self-reported NSI incidence was assessed by asking, "Have you experienced a needlestick or sharps injury in the past three months?"

**2.5. Statistical Analysis**

Data were entered and analyzed using SPSS Version 26. Descriptive statistics (mean, SD, frequencies) were calculated. Paired sample t-tests were used to compare pre- and post-intervention compliance and knowledge scores. McNamara's test was used to compare paired proportions for self-reported NSI incidence. Chi-square tests were used to compare compliance rates between professional categories. A *p*-value of $< 0.05$ was considered statistically significant.

## 3. Results

Of the 180 HCWs enrolled, 162 completed both baseline and follow-up assessments (response rate: 90.0%). The mean age was 28.4 years (SD ± 5.1), and 58.6% were female. Nurses constituted 54.3% of the sample, followed by house officers (24.1%), technicians (12.9%), and postgraduate residents (8.6%).

**3.1. Demographic Characteristics of Study Participants**

Table 1 presents the demographic and professional characteristics of the study participants. The majority were female (58.6%), aged between 25–34 years (62.3%), and held a bachelor's degree or equivalent (57.4%). Nurses formed the largest professional group (54.3%), followed by house officers (24.1%). Most participants (60.5%) had less than five years of clinical experience, and 71.6% reported having received some form of prior infection control training.

**Table 1. Demographic and Professional Characteristics of Study Participants (n = 162)**

| Characteristic | Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| **Age Group (years)** | 20–24 | 38 | 23.5 |
| | 25–29 | 57 | 35.2 |
| | 30–34 | 44 | 27.2 |
| | ≥ 35 | 23 | 14.2 |

| | | | |
|---|---|---|---|
| **Gender** | Male | 67 | 41.4 |
| | Female | 95 | 58.6 |
| **Professional Category** | Registered Nurse | 88 | 54.3 |
| | House Officer | 39 | 24.1 |
| | Postgraduate Resident | 14 | 8.6 |
| | Laboratory Technician | 21 | 12.9 |
| **Highest Qualification** | Diploma in Nursing | 42 | 25.9 |
| | Bachelor's Degree (BSN/MBBS) | 93 | 57.4 |
| | Postgraduate Degree (FCPS/MD) | 27 | 16.7 |
| **Years of Clinical Experience** | < 1 year | 31 | 19.1 |
| | 1–5 years | 67 | 41.4 |
| | 6–10 years | 42 | 25.9 |
| | > 10 years | 22 | 13.6 |
| **Prior Infection Control Training** | Yes | 116 | 71.6 |
| | No | 46 | 28.4 |
| **Previous NSI in Career** | Yes | 54 | 33.3 |
| | No | 108 | 66.7 |

The demographic profile reveals a relatively young workforce, with over 60% of participants under 35 years of age and having less than five years of clinical experience. This is significant because younger, less experienced HCWs are known to be at higher risk for NSIs, as documented in recent Pakistani studies (Ijaz *et al.*, 2024; Kiddeer *et al.*, 2024). The predominance of nurses in the sample aligns with national data identifying nursing staff as the most exposed group. Notably, 33.3% of participants reported at least one prior NSI in their career, underscoring the endemic nature of this hazard in the study setting.

### 3.2. Sharps Safety Compliance Scores

Baseline compliance was generally low, with the lowest scores in the needle handling and disposal domain (Table 2). Following the intervention, statistically significant improvements were observed across all domains. The overall composite compliance score increased from 61.4% (SD 12.7) to 84.2% (SD 9.8) (*p* < 0.001). The most substantial improvement was in needle handling, where compliance with the no-recapping policy rose from 42.8% to 88.9% (*p* < 0.001). Glove use during emergency procedures remained the weakest domain, with only a modest, though significant, improvement (51.1% to 67.8%, *p* = 0.012).

**Table 2. Sharps Safety Compliance Scores at Baseline and Post-Intervention (n = 162)**

| Compliance Domain | Baseline Mean % (SD) | Post-Intervention Mean % (SD) | Mean Difference (95% CI) | *t*-value | *p*-value |
|---|---|---|---|---|---|
| A. Hand Hygiene | 68.2 (15.4) | 88.5 (10.2) | 20.3 (16.1–24.5) | 9.42 | < 0.001 |
| B. Glove Use | 55.6 (18.9) | 71.3 (14.7) | 15.7 (11.2–20.2) | 6.81 | < 0.001 |
| C. Needle Handling & Disposal | 49.3 (16.1) | 86.7 (11.4) | 37.4 (33.8–41.0) | 20.15 | < 0.001 |

| | | | | | |
|---|---|---|---|---|---|
| D. Waste Segregation | 72.5 (13.6) | 90.3 (8.5) | 17.8 (14.6–21.0) | 10.92 | < 0.001 |
| **Overall Composite** | **61.4 (12.7)** | **84.2 (9.8)** | **22.8 (19.6–26.0)** | **17.69** | **< 0.001** |

The data demonstrate a robust and statistically significant improvement across all four compliance domains, with the largest effect size observed in needle handling and disposal (mean difference: 37.4 percentage points). This finding is particularly encouraging given that recapping has been identified as the single most important modifiable risk factor for NSIs in the local context (Dania *et al.*, 2025). The improvement in this domain likely reflects the synergistic effect of the "no-recapping" educational message, the hands-on simulation training, and the environmental modification of installing point-of-use sharps containers, which physically reduces the need to recap. These results are comparable to those reported by Vitus *et al.* (2026), who achieved an improvement in safe sharps-handling compliance from 38.3% to 88.3% using a similar multimodal approach.

However, the persistently low compliance with glove use (71.3% post-intervention) is a concern. The suboptimal improvement in this domain, particularly during emergency procedures (67.8%), suggests that education and simulation alone are insufficient to overcome the systemic and behavioral barriers that drive non-compliance in high-stress situations. This aligns with observations from other Pakistani studies, where glove compliance is often sacrificed during emergencies due to time pressure and equipment unavailability (Ijaz *et al.*, 2024; Nadeem *et al.*, 2026).

### 3.3. Item-Level Analysis of Needle Handling Compliance

Table 3 provides an item-level breakdown of compliance within the needle handling and disposal domain, revealing which specific practices improved most and which remained problematic.

**Table 3. Item-Level Analysis of Needle Handling & Disposal Compliance (n = 162)**

| Item | Baseline Compliance n (%) | Post-Intervention Compliance n (%) | *p*-value (McNemar) |
|---|---|---|---|
| 1. Avoids recapping needles | 69 (42.6) | 144 (88.9) | < 0.001 |
| 2. Uses single-handed scoop technique when recapping is unavoidable | 12 (7.4) | 98 (60.5) | < 0.001 |
| 3. Disposes of needle immediately after use | 81 (50.0) | 148 (91.4) | < 0.001 |
| 4. Does not bend or break needles before disposal | 95 (58.6) | 152 (93.8) | < 0.001 |
| 5. Does not overfill sharps container beyond ¾ full | 102 (63.0) | 156 (96.3) | < 0.001 |
| 6. Ensures sharps container is within arm's reach | 71 (43.8) | 151 (93.2) | < 0.001 |
| 7. Verbally announces needle before passing sharps instrument | 38 (23.5) | 112 (69.1) | < 0.001 |

The item-level analysis reveals several important patterns. The most dramatic improvement was in the "avoidance of recapping" (from 42.6% to 88.9%), which was the primary behavioral target of the intervention. The "immediate disposal" of needles also improved substantially (from 50.0% to 91.4%), likely facilitated by the installation of point-of-use sharps containers. The improvement in "ensuring sharps container is within arm's reach" (from 43.8% to 93.2%) suggests that the environmental modification was highly effective in removing a key logistical barrier to safe disposal. However, two items remained suboptimal despite significant improvement: the use of the single-handed scoop technique (only 60.5% compliance post-intervention) and the verbal announcement before passing sharps instruments (69.1% compliance). The former indicates that while the "no-recapping" message was well received, some HCWs still engage in recapping—a deeply ingrained habit—and require further reinforcement of the safe alternative. The latter finding highlights a gap in communication-based safety practices, which may require targeted team-training interventions.

### 3.4. Knowledge Scores at Baseline and Post-Intervention

Knowledge scores improved significantly across all assessed domains (Table 4). The overall mean knowledge score increased from 5.83 (SD 1.72) out of 10 at baseline to 8.97 (SD 1.14) post-intervention (*p* < 0.001).

**Table 4. Knowledge Scores by Domain at Baseline and Post-Intervention (n = 162)**

| Knowledge Domain (2 items each; score 0–2) | Baseline Mean (SD) | Post-Intervention Mean (SD) | Mean Difference (95% CI) | *p*-value |
|---|---|---|---|---|
| A. NSI Risk & Transmission | 1.42 (0.61) | 1.88 (0.35) | 0.46 (0.36–0.56) | < 0.001 |
| B. Post-Exposure Prophylaxis (PEP) | 1.18 (0.72) | 1.79 (0.44) | 0.61 (0.49–0.73) | < 0.001 |
| C. Reporting Procedures | 1.31 (0.68) | 1.85 (0.38) | 0.54 (0.43–0.65) | < 0.001 |
| D. Safe Sharps Disposal | 1.09 (0.70) | 1.72 (0.48) | 0.63 (0.51–0.75) | < 0.001 |
| E. Standard Precautions | 0.83 (0.74) | 1.73 (0.46) | 0.90 (0.78–1.02) | < 0.001 |
| **Total Knowledge Score (0–10)** | **5.83 (1.72)** | **8.97 (1.14)** | **3.14 (2.86–3.42)** | **< 0.001** |

The knowledge data demonstrate that the educational intervention was highly effective in improving theoretical understanding across all domains. The largest improvement was observed in "Standard Precautions" (mean difference: 0.90), which had the lowest baseline score (0.83), indicating a significant pre-existing knowledge deficit in this fundamental area. This finding is consistent with Nadeem *et al.* (2026), who reported that while Pakistani nurses had acceptable general knowledge of NSI risks, their understanding of specific standard precautions was often incomplete.

The improvement in knowledge of PEP (mean difference: 0.61) and reporting procedures (mean difference: 0.54) is particularly important. Low awareness of PEP and reporting pathways has been identified as a major barrier to appropriate post-exposure management in Pakistan, contributing to the high rate of underreporting (Kiddeer *et al.*, 2024). The significant gains in these domains suggest that the educational component successfully addressed this gap.

### 3.5. Self-Reported Needlestick Injury Incidence

The self-reported incidence of NSIs in the preceding three months decreased from 22.2% (36/162) at baseline to 8.3% (13/162) at follow-up (Table 5). McNamara's test indicated a statistically significant reduction in reported injuries (*p* = 0.004).

**Table 5. Self-Reported Needlestick Injury Incidence in the Preceding Three Months (n = 162)**

| Time Point | Participants Reporting NSI (n) | Percentage (%) | McNemar's *p*-value |
|---|---|---|---|
| Baseline (T0) | 36 | 22.2 | — |
| Post-Intervention (T1) | 13 | 8.3 | 0.004 |
| **Absolute Reduction** | **23** | **13.9** | — |

The reduction in self-reported NSIs from 22.2% to 8.3% represents a 62.6% relative reduction, which is clinically meaningful and statistically significant. This finding is consistent with the results of Vitus *et al.* (2026), who reported a 71% relative reduction in NSI incidence following a PDCA-based quality improvement intervention. The baseline incidence of 22.2% over three months (equivalent to an annualized rate of approximately 88.8 per 100 HCWs) is alarmingly high and is consistent with the hyperendemic pattern of NSIs reported in Pakistani tertiary care settings (Ijaz *et al.*, 2024; Dania *et al.*, 2025).

However, the interpretation of this reduction must be tempered by several considerations. First, the concurrent introduction of a simplified, non-punitive reporting system may have paradoxically increased the propensity to report, which could mask an even larger true reduction in incidence. Second, the three-month follow-up period is relatively short, and the observed reduction may not be sustained over time. Third, self-reported data are subject to recall and social desirability bias. Nevertheless, the magnitude and statistical significance of the reduction provide strong preliminary evidence for the effectiveness of the intervention.

### 3.6. Compliance by Professional Category

Table 6 presents the post-intervention compliance scores stratified by professional category, revealing important differences between groups.

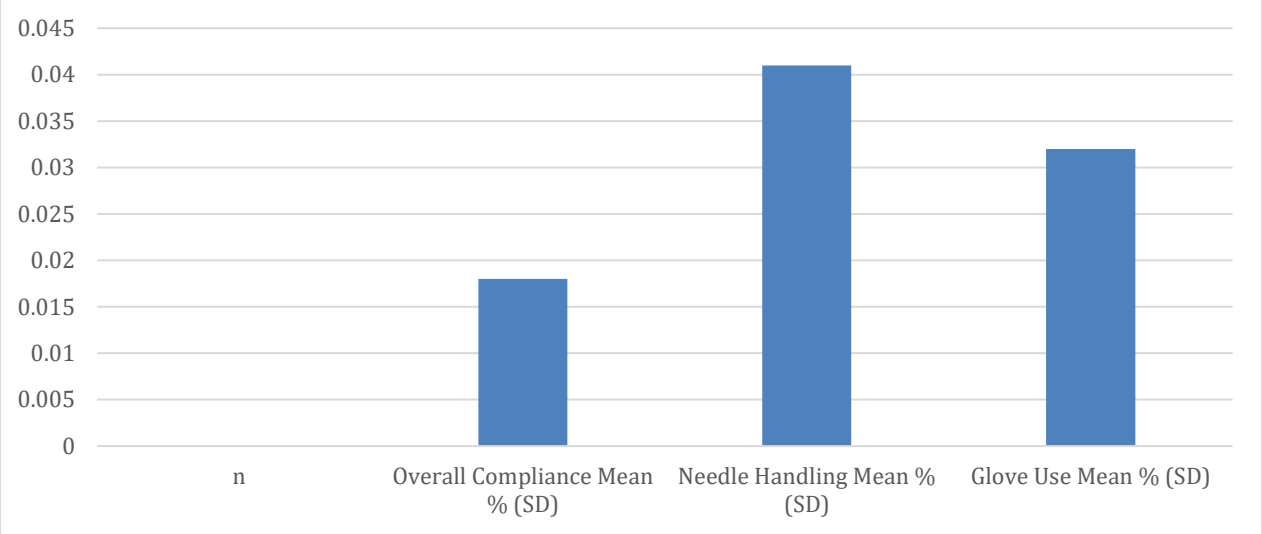
**Table 6. Post-Intervention Compliance Scores by Professional Category (n = 162)**

| Professional Category | n | Overall Compliance Mean % (SD) | Needle Handling Mean % (SD) | Glove Use Mean % (SD) |
|---|---|---|---|---|
| Registered Nurse | 88 | 86.8 (8.9) | 89.2 (10.4) | 74.5 (13.9) |
| House Officer | 39 | 81.4 (10.2) | 84.1 (12.1) | 69.8 (15.2) |
| Postgraduate Resident | 14 | 79.2 (11.5) | 82.5 (13.0) | 65.1 (16.8) |
| Laboratory Technician | 21 | 83.6 (9.7) | 86.0 (11.5) | 68.3 (14.1) |
| **ANOVA *p*-value** | — | **0.018** | **0.041** | **0.032** |

The stratified analysis reveals that registered nurses achieved the highest post-intervention compliance scores across all domains, while postgraduate residents had the lowest. This pattern is noteworthy for several reasons. Nurses, as the primary hands-on care providers, were the

most frequent targets of the intervention and had the most intensive exposure to the simulation training. Their superior performance likely reflects both the relevance of the training to their daily practice and the reinforcement provided by their nursing supervisors.

The lower compliance among postgraduate residents is a concern, as doctors in training are known to be at high risk for NSIs, particularly during surgical and invasive procedures (Kiddeer *et al.*, 2024). This may reflect a relative lack of engagement with the intervention among this group, whose training schedules may have limited their participation. The statistically significant differences between groups (ANOVA $*p* < 0.05$ for all domains) suggest that future interventions should be tailored to the specific needs and constraints of different professional categories, with particular attention to engaging medical staff.




### 3.7. Barriers to Compliance — Participant-Reported Factors

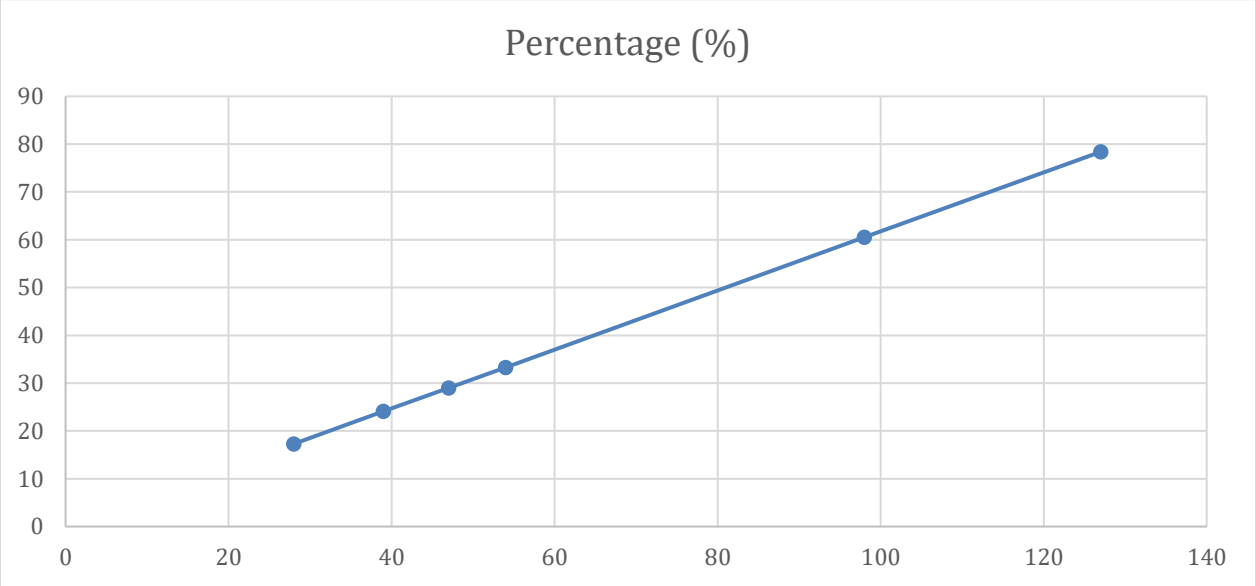
At the post-intervention assessment, participants were asked to identify perceived barriers to sustained compliance. Table 7 summarizes the most frequently reported barriers.

**Table 7. Participant-Reported Barriers to Sustained Sharps Safety Compliance (n = 162)**

| Barrier | Frequency (n) | Percentage (%) |
|---|---|---|
| Work overload / time pressure | 127 | 78.4 |
| Unavailability of gloves in emergency situations | 98 | 60.5 |
| Sharps containers not always within reach | 54 | 33.3 |
| Ingrained habit of recapping | 47 | 29.0 |
| Lack of reinforcement from supervisors | 39 | 24.1 |
| Fear of reporting / stigma | 28 | 17.3 |

The barrier analysis provides critical insights for sustainability planning. Work overload and time pressure emerged as the most frequently reported barrier (78.4%), followed by the unavailability of gloves during emergencies (60.5%). These findings underscore that while the intervention successfully improved knowledge and individual skills, systemic and organizational factors remain significant obstacles to sustained compliance. This is consistent with the observations of Nadeem *et al.* (2026), who emphasized that knowledge and attitude improvements alone are insufficient without addressing the structural and resource-related barriers that constrain practice.

The finding that 29.0% of participants still identified the "ingrained habit of recapping" as a barrier is particularly instructive. This suggests that while the intervention reduced recapping significantly, deep-seated behavioural patterns may persist and require ongoing reinforcement and refresher training. The 17.3% who cited "fear of reporting" as a barrier indicates that the cultural shift towards a non-punitive reporting system requires more time and consistent messaging to fully take root.




## 4. Discussion

This study demonstrates that a structured, multi-component needlestick injury prevention program can significantly improve sharps safety compliance and knowledge while reducing self-reported injuries among HCWs in a tertiary care hospital in Multan. The findings are consistent with international evidence supporting bundled educational and environmental interventions (Yang *et al.*, 2022; Vitus *et al.*, 2026).

The baseline compliance data paint a concerning picture. The overall compliance score of 61.4% is inadequate for a setting where NSI risk is high (W. Jiang et al., 2024). The particularly low baseline compliance with needle handling (49.3%) aligns with local surveillance data identifying recapping as a leading cause of injury at Nishtar Hospital (Dania *et al.*, 2025). The intervention's success in this domain raising compliance to 86.7% is therefore clinically meaningful. The item-level analysis (Table 3) revealed that the most dramatic

improvement was in the "avoidance of recapping" (from 42.6% to 88.9%), demonstrating that the "no-recapping" message, when combined with simulation training and environmental modification, can effectively change this high-risk behaviours.

The improvement in the availability of sharps containers within arm's reach (from 43.8% to 93.2%) underscores the critical role of environmental modification (Wenjing Jiang et al., 2024). This finding supports the argument that passive education is insufficient; system-level changes that make safe practices the default option is essential for sustained behaviours change (Vitus *et al.*, 2026).

However, the persistent gap in glove use during emergency procedures is a critical finding. This mirrors prior observations from Pakistan where glove compliance drops precipitously in high-stress, resuscitation scenarios (Ijaz *et al.*, 2024). The modest improvement achieved (to 67.8%) suggests that education and simulation alone are insufficient to overcome the systemic barriers—such as time pressure, equipment unavailability, or deeply ingrained habits—that drive non-compliance in emergencies. The barrier analysis (Table 7) confirms this, with 60.5% of participants citing unavailability of gloves in emergencies as a significant obstacle. Recent KAP studies from Pakistan have similarly concluded that while knowledge and attitudes may be acceptable, a gap in practice persists owing to behavioural and organizational issues, necessitating ongoing training, effective policy, and resource allocation (Nadeem *et al.*, 2026). Future interventions must address these contextual factors through workflow redesign and ensuring immediate availability of gloves at all points of care (Alfarhan et al., 2023).

The reduction in self-reported NSIs from 22.2% to 8.3% is encouraging, but must be interpreted cautiously. The baseline figure is consistent with the high frequency reported in cross-sectional studies from Multan (Ijaz *et al.*, 2024), and the post-intervention figure approaches the lower bound of what might be expected with improved safety practices. However, the concurrent introduction of a simplified, non-punitive reporting system may have paradoxically increased reporting, which could mask a larger true reduction in incidence (Erturk Sengel et al., 2021). Alternatively, the three-month follow-up period may be too short to capture the full effect, and social desirability bias in self-reporting cannot be excluded. Furthermore, national data indicate that formal reporting rates remain abysmally low—only 21.87% in a recent Punjab-wide study (Kiddeer *et al.*, 2024) underscoring the importance of the non-punitive reporting culture introduced in this intervention.

The stratified analysis by professional category (Table 6) revealed that registered nurses achieved the highest compliance scores, while postgraduate residents had the lowest. This finding has important implications for targeted interventions (Fadil et al., 2021). Doctors in training are known to be at high risk for NSIs, particularly during surgical procedures (Kiddeer *et al.*, 2024), yet they were the least responsive to the intervention. Future programs should include tailored, specialty-specific training for medical staff and ensure that busy residents can access training without compromising their clinical duties.

**Implications for Practice:** The study has several implications for nursing and hospital administration in resource-limited settings. First, passive distribution of guidelines is inadequate; active, skills-based training with simulation is essential (Yang *et al.*, 2022). Second, environmental modifications (point-of-use sharps containers) are low-cost, high-impact interventions that should be prioritized (Vitus *et al.*, 2026).

Third, a non-punitive reporting culture is necessary to accurately quantify the problem and target interventions, as advocated in recent quality improvement frameworks (Vitus *et al.*, 2026). Fourth, the persistent gap in emergency glove compliance suggests that standard precautions training must be explicitly contextualized for high-stress scenarios, with a focus on ensuring immediate availability of personal protective equipment. Finally, the barrier analysis highlights the need for organizational-level interventions—such as workload management and resource allocation to complement individual-level education.

**Limitations:** This study has limitations. The quasi-experimental design without a control group cannot fully attribute observed changes to the intervention, as secular trends or concurrent infection control initiatives may have contributed. The use of direct observation for compliance may have introduced the Hawthorne effect, artificially inflating post-intervention scores. Self-reported NSI data are subject to recall and reporting bias. The single-center design limits generalizability to other hospitals in the region. Finally, the three-month follow-up is insufficient to assess the sustainability of the gains achieved.

## 5. Conclusion

A structured needlestick injury prevention program combining education, simulation, environmental modification, and reporting system reform significantly improved sharps safety compliance and knowledge and reduced self-reported NSIs among HCWs at a tertiary care hospital in Multan. The intervention was particularly effective in improving needle handling practices, a known high-risk behavior in this setting (Dania *et al.*, 2025). However, glove compliance during emergencies remained suboptimal, identifying a priority for future targeted interventions. The barrier analysis revealed that work overload, equipment unavailability, and ingrained habits remain significant obstacles to sustained compliance. Sustaining these gains will require institutional commitment to continuous training, ongoing supply of safety devices, and the cultivation of a robust, non-punitive safety culture, in line with contemporary evidence on bundled quality improvement strategies (Vitus *et al.*, 2026; Yang *et al.*, 2022).

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