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Enhancing Intravenous Injection Safety Through a PDCA cycle approach: Quality Improvement Initiative in a Tertiary Care Cardiac Hospital

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ABSTRACT

Background:
IV injection is a routine nursing task in hospitals but carries preventable risks like hospital-acquired infections, medication errors, and needle-stick injuries for staff. Global guidelines from WHO, CDC, and ISMP are clear, yet consistent adherence in busy wards remains difficult. We tested if a structured Plan-Do-Check-Act (PDCA) quality improvement approach could improve nurses' compliance with IV injection safety practices and indirectly benefit infection control.

methods:
This pre- and post-intervention observational study was done in adult critical care, non-critical wards, and paediatric units of our tertiary cardiac hospital. A standardized checklist based on WHO, CDC, and ISMP guidelines audited 19 IV injection safety indicators. 337 baseline observations were compared with post-intervention and focused PDCA follow-up audits. Descriptive statistics, Chi-square, and Fisher's Exact tests were used. Monthly CLABSI rates were monitored.

Results:
PDCA implementation led to significant improvement ($p \leq 0.05$) in all 16 changeable indicators. Largest gains occurred in injection site antisepsis, infectious waste segregation, multi-dose vial handling, syringe labelling, and hand hygiene. Baseline 100% compliant indicators stayed stable (ceiling effect). A clear downward trend in CLABSI rates post-intervention suggested better infection control.

Conclusions:
The PDCA approach significantly boosted adherence to IV injection safety practices with sustained results. It is a practical, low-cost, and scalable method to strengthen nursing habits, enhance patient safety, and support continuous quality improvement in busy clinical settings.

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Introduction

Intravenous (IV) therapy is something nurses do every day in hospitals — it's how we quickly give patients medications, fluids, blood products, or even nutrition when they can't eat normally. It's such a routine procedure that we sometimes forget how risky it can be if things aren't done right. When safety steps get skipped, patients can end up with bloodstream infections, central line-associated bloodstream infections (CLABSI), wrong medications, or even blood-borne diseases like hepatitis B or C. Healthcare workers also face the danger of needle-stick injuries (1-3).

From what we've seen and what global reports say, unsafe injection practices are still one of the biggest preventable causes of healthcare-associated infections (HAIs). The World Health Organization and CDC have pointed this out time and again (2,3). Simple things like not washing hands properly, skipping the "scrub the hub" step, not keeping an aseptic non-touch technique, or poorly disinfecting vial tops can let bacteria get into the IV line (4). International guidelines are very clear: use hand hygiene every time, stick to sterile single-use equipment, label medications correctly, and dispose of waste safely (1,2,5). But in real life — especially in places like India and other low- and middle-income countries — there's still a big gap. We see problems with not explaining things to patients, forgetting to label syringes, not giving enough time for antiseptic to work, or mixing up waste bags (6). These issues usually come down to heavy workloads, training that isn't consistent, little supervision, and no regular feedback to improve.

Medication errors during IV preparation are another serious worry. In busy wards, it's easy to pick the wrong drug, give the wrong dose, forget to label a syringe, or miss documenting something — and these mistakes harm patients more often than we like to admit (7). The Institute for Safe Medication Practices keeps stressing that syringe labelling and handling high-alert drugs need strict rules and consistency (8).

That's why quality improvement methods like the Plan-Do-Check-Act (PDCA) cycle make so much sense. PDCA, which came from W. Edwards Deming (9), is basically a simple loop: spot the problem, try a fix, check if it worked, and then make the good changes permanent. It's been used successfully in hospitals to improve infection control and medication safety (10,11). Still, we don't have much evidence on using PDCA specifically for IV injection safety in a specialized setting like a tertiary cardiac hospital.

So, we decided to run this quality improvement project in our cardiac hospital. The goal was to see if a structured PDCA approach could actually help nurses follow IV injection safety practices better — and whether it would have any positive knock-on effect on infection indicators like CLABSI rates.

Methods

This quasi-experimental, pre- and post-intervention observational study evaluated 337 nursing staff using the Plan-Do-Check-Act (PDCA) cycle as a quality improvement framework. The study highlights the application of structured PDCA cycles to assess staff performance and operational

enhancements. The study took place in the adult critical care units, adult non-critical care wards, and paediatric units of a tertiary cardiac care hospital in India. We focused on nursing staff who were directly involved in preparing and administering IV medications. Inclusion criteria covered any IV injection procedures performed by nursing staff in the selected wards. Exclusion criteria included procedures done in the cardiac catheterization laboratory or operating theatres, as well as nursing staff working in administrative or non-clinical roles. For data collection, we developed a structured observational checklist with 19 IV injection safety indicators based on WHO, CDC, and ISMP guidelines. During audits, each indicator was recorded as compliant (Yes), non-compliant (No), or not applicable (NA). Since this was an institutional quality improvement initiative, no patient identifiers were collected, and staff confidentiality was fully maintained.

The PDCA intervention worked like this: In the Plan phase, baseline audits helped us identify key gaps, especially in injection site antisepsis, syringe labelling, multi-dose vial management, and waste segregation, so we created a targeted intervention plan. In the Do phase, we carried out structured training sessions, bedside demonstrations, visual reminders in work areas, real-time feedback, and reinforcement of standard operating procedures. In the Check phase, we repeated audits using the same checklist after the main intervention and ran a focused PDCA cycle to address any remaining gaps. In the Act phase, successful practices were integrated into routine nursing protocols, with ongoing monitoring to make sure the improvements lasted.

Statistical analysis

Statistical analysis was performed using SPSS version 26.0, with statistical significance set at a two-tailed p-value of <0.05. Categorical compliance indicators were expressed as percentages, and differences between audit phases (pre-intervention versus post-intervention, and post-audit versus focused PDCA) were evaluated using the Chi-square test for large samples or Fisher's exact test for cells with small expected frequencies (n<5). Absolute improvement was calculated to measure compliance trajectory over time, while indicators that maintained 100% compliance across phases were flagged as experiencing a ceiling effect. Central Line-Associated Bloodstream Infection (CLABSI) clinical outcomes were tracked and reported as a rate range per 1,000 central line days.

Ethical approval

This data was collected for quality improvement purposes; therefore, Ethics Committee approval as per our institutional protocol was not require.

Results

The pre-intervention audit was conducted from September to December 2024, while the post-intervention audit ran from January to April 2025. presents the compliance percentages for 19 IV injection safety indicators before and after the PDCA intervention. Following the implementation, all 16 indicators that could be statistically compared showed significant improvement ($p \leq 0.05$). The three indicators that were already at 100% compliance in the baseline phase remained unchanged due to a ceiling effect. The most notable gains were seen in patients being informed before injection, which increased from 64.1% to 93.3% (a 29.2% absolute improvement), injection site cleaning (scrub the hub) from 69.7% to 92.3%, yellow bag waste segregation from 77.2% to 100%, and syringe labelling for procedures involving two or more injections from 69.5% to 89.6%. Hand hygiene before injection improved from 83.1% to 97.9%, and both dating/discarding of multi-dose vials and their centralized storage reached 100%. Single-use needles, syringes, single-dose vials, and IV tubing/connectors maintained 100% compliance throughout. Overall, post-intervention compliance exceeded 95% for most indicators, with several achieving 100%, reflecting strong uptake of the standardized safety practices. CLABSI rates also showed a declining trend

in the post-intervention period (pre-intervention range: 1.83–3.55 per 1,000 central line days; post-intervention range: 1.49–2.42). In the focused PDCA sustained compliance audit, most indicators stayed stable at or near 100%. Additional significant improvements were observed in scrub the hub (from 92.3% to 96.1%, p = 0.048) and syringe labelling for ≥2 injections (from 89.6% to 97.1%, p = 0.005), while use of injection trays showed a borderline gain (from 94.7% to 97.3%, p = 0.071).

No clinically meaningful decline occurred in any key safety practice, confirming that the PDCA approach helped maintain the improvements over time, particularly in areas that depend on daily behaviour and consistency (Table 1).

Table 1: Compliance with IV Injection Safety Practices Before and After PDCA Intervention

Indicator	Pre-Audit Yes (%)	Post-Audit Yes (%)	Absolute Improvement (%)	Statistical Test	p-value	Significance
Correct patient identification	96.7	100	3.3	Fisher's exact	<0.001	Significant
Patient informed before injection	64.1	93.3	29.2	Chi-square	<0.001	Significant
Hand hygiene before injection	83.1	97.9	14.8	Chi-square	<0.001	Significant
Clean medication preparation area	97.3	99.1	1.8	Fisher's exact	0.02	Significant
Use of injection tray	88.7	94.7	6	Chi-square	<0.001	Significant
Injection site cleaned (scrub the hub)	69.7	92.3	22.6	Chi-square	<0.001	Significant
Single-use needles & syringes	100	100	0	Not applicable	1	No change
Syringe labelling (≥2 injections)*	69.5	89.6	20.1	Chi-square	<0.001	Significant
Rubber septum disinfected	91.2	99.4	8.2	Fisher's exact	<0.001	Significant
Single-dose vials used for one patient	100	100	0	Not applicable	1	No change
IV tubing & connectors single-patient use	100	100	0	Not applicable	1	No change
Multi-dose vials dated & discarded*	90.3	100	9.7	Fisher's exact	<0.001	Significant
Multi-dose vials stored centrally*	95.7	100	4.3	Fisher's exact	<0.001	Significant

Sharps disposed correctly	97.3	100	2.7	Fisher's exact	0.01	Significant
Proper documentation	98.2	100	1.8	Fisher's exact	0.04	Significant
Safe needle recapping	94.4	100	5.6	Fisher's exact	<0.001	Significant
Yellow bag waste segregation	77.2	100	22.8	Chi-square	<0.001	Significant
Red bag waste segregation	84.6	99.7	15.1	Chi-square	<0.001	Significant
Blue bag waste segregation	93.8	100	6.2	Fisher's exact	<0.001	Significant

***** Pre Intervention Audit duration (4 months)– September- December 2024
***** Post Intervention Audit duration (4 months)- January-April 2025

presents A declining trend in CLABSI rates was observed following the intervention (Table 2).

Focused PDCA cycles ensured sustained compliance with IV injection safety practices, with significant gains in high-risk, behaviour-dependent indicators and no clinically relevant decline across safety domains (Table 3).

Table 2: CLABSI Rates Before and After Intervention

Period	CLABSI Rate (per 1,000 central line days)
Pre-intervention	1.83 – 3.55
Post-intervention	1.49 – 2.42

Table 3: Sustained Compliance Audit: Post-Audit Vs Focused PDCA

Indicator	Post-Audit Compliance (%)	Focused PDCA Compliance (%)	Absolute Improvement (%)	*p*-value	Interpretation
Correct patient identification	100	100	0	NA	Ceiling effect
Patient informed about procedure	93.3	94.9	1.6	0.312	Not significant
Hand hygiene before medication	97.9	99.1	1.2	0.339	Not significant

Medication preparation area clean	99.1	100	0.9	0.157	Not significant
Use of injection tray	94.7	97.3	2.6	0.071	Borderline
Injection site cleaned (scrub the hub)	92.3	96.1	3.8	0.048	Significant
Single-patient needle/syringe use	100	100	0	NA	Ceiling effect
Syringe labeled for ≥2 injections	89.6	97.1	7.5	0.005	Highly significant
Rubber septum disinfected	99.4	99.7	0.3	0.564	Not significant
Single-dose vial use	100	100	0	NA	Ceiling effect
Tubing/connectors single-patient use	100	100	0	NA	Ceiling effect
MDV dated & discarded	100	100	0	NA	Ceiling effect
MDV stored centrally	100	100	0	NA	Ceiling effect
Sharps in puncture-proof container	100	100	0	NA	Ceiling effect
Proper documentation	100	99.7	−0.3	0.317	Not significant
Scoop method for recapping	100	99.4	−0.6	0.156	Not significant
Yellow bag disposal	100	100	0	NA	Ceiling effect
Red bag disposal	99.7	99.7	0	NA	Stable
Blue bag disposal	100	100	0	NA	Ceiling effect

Discussion

This study showed that a structured PDCA approach really worked in getting nurses to follow IV injection safety practices more consistently across different units. What we found lines up with what a lot of international research has been saying for years: when standard precautions aren't followed reliably, it opens the door to healthcare-associated infections (HAIs), medication mix-ups, and even needle-stick injuries for staff (12). The WHO and CDC have made it clear — unsafe injection practices are still a completely preventable source of harm for both patients and healthcare workers.

The biggest jumps in compliance came in the steps that are toughest to get right during busy shifts: scrubbing the hub properly, labelling syringes, hand hygiene before every injection, and sorting biomedical waste the right way. Past studies have pointed out these exact areas as common weak spots in high-pressure wards, and lapses here — especially poor hub disinfection and aseptic technique — directly raise the risk of bloodstream infections (13,14). Seeing such clear improvement after PDCA tells us that regular audits plus quick feedback can fix those everyday behavioural slips that creep in over time.

Syringe labelling stood out as one of the most meaningful changes. We know from the evidence that when labels are missing or unclear — especially when nurses are handling multiple IV drugs at once — the chance of giving the wrong drug or dose goes way up (15). The ISMP calls this a high-alert practice that needs strict rules and constant checking. The fact that we not only improved it but kept it high in the follow-up audit shows how powerful combining clear protocols with ongoing reinforcement can be.

The focused PDCA sustainability check was reassuring too. Most indicators that hit 100% after the main intervention stayed there, which means the changes actually stuck and became part of routine work. We've seen similar results in other PDCA projects on infection control — repeated feedback loops help build lasting habits and even shift the team culture over time (16).

Some areas didn't improve much more in the follow-up phase, but that's mainly because they were already very high at baseline — a classic "ceiling effect" that quality improvement experts talk about a lot (17). When something is already near-perfect, just holding steady is actually a win. We didn't run fancy stats to prove cause-and-effect, but the drop in CLABSI rates after the intervention was encouraging. It fits with what we know: better aseptic technique, proper hub scrubbing, and standardized practices really do cut down device-related infections (18). Of course infection rates have many factors, but the timing makes the connection feel plausible.

In the end, this project highlights how practical and scalable PDCA can be for improving injection safety in a busy cardiac hospital. Building in regular audit-feedback cycles seems like a realistic way to strengthen patient safety habits and cut preventable harm without needing huge resources. It's a simple framework that can make a real difference in high-risk settings like ours.

Limitation

This study has some limitations. First, the quasi-experimental design without a control group makes it difficult to fully rule out external factors that might have influenced the results. Second, observer bias (Hawthorne effect) could have played a role, as staff knew they were being watched during audits, which might have temporarily improved compliance. Finally, being a single-center study in one tertiary cardiac hospital, the findings may not apply broadly to other settings with different resources or patient populations.

Conclusion

This quality improvement study shows that a structured Plan–Do–Check–Act (PDCA) approach can bring real, measurable, and lasting improvements in how nurses handle IV injection safety. The biggest gains came in key high-risk areas like proper injection site antisepsis ("scrub the hub"), syringe labelling, and hand hygiene – steps that are essential for preventing infections and medication errors. The focused PDCA cycle was especially helpful in keeping these changes strong over time and stopping any backsliding. It highlights why ongoing monitoring, feedback, and small iterative tweaks work better than one-off training sessions. Overall, the results support PDCA as a simple, practical, and easy-to-replicate way to improve nursing practices, boost compliance with safety standards, and help create safer patient care with better infection control.

Acknowledgments
None

Conflict of Interest
None

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