Quality Improvement Initiative to Reduce Intravenous Line-related Infiltration and Phlebitis Incidence in Pediatric Emergency Room

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Abstract

Aim and objective: To reduce the incidence of infiltration and phlebitis by 50% over 2 months among children admitted to the emergency room (ER) of a tertiary care hospital.

Materials and methods: The study was conducted in the pediatric ER of a tertiary care hospital in North India. All children aged >28 days, receiving intravenous (IV) medication and/or fluids, were enrolled between June (2017) and September (2017). Existing practices of IV line insertion and maintenance were observed and recorded. The visual infusion phlebitis score and infiltration assessment scale used to grade the extent of the two. The intervention classified as "IV line insertion and maintenance bundle" included the introduction of low-cost mobile sterile compartment trays, audit and feedback, organizational change and introduction of infection control nurse. These interventions were implemented in sequential Plan-Do-Study-Act (PDSA) cycles. Reduction in the "incidence of phlebitis and infiltration" were the outcome measures while "scores on checklist of IV line insertion and IV line maintenance and administration of drugs" were the process measures.

Result: The process measures, for IV line insertion, maintenance and administration of drugs through IV line, revealed an increase in scores on the checklist. There was a significant decrease in the incidence of infiltration and phlebitis from 82.9% and 96.1% to 45% and 55%, respectively, after implementation of all PDSA cycles.

Conclusion: Multifaceted QI IV line insertion and maintenance bundle reduced the incidence of infiltration and phlebitis. These interventions when integrated into daily work bundles along with continuous education and motivation helped in sustaining the goal and attaining long-term success.

Keywords: Infiltration, Pediatric emergency, Phlebitis, Quality improvement.

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Introduction

Intravenous (IV) cannulation is a commonly performed procedure in sick children admitted to an emergency room (ER). Most common IV line-related complications include infiltration and phlebitis.[1,2] Local swelling, redness, warmth, cording, and leakage of nonvesicant solution into the surrounding tissue leads to adverse outcomes.[2] The incidence of phlebitis reported among patients receiving IV therapy is around 27–70%.[3] A study conducted by White SA from Indiana revealed the highest (90%) incidence of phlebitis.[4] Another study conducted by Kaur et al. from India, at the outpatient department of an emergency, reported phlebitis to the tune of 56.5% and a significant association between phlebitis and duration of the cannula *in situ*.[5] IV line-related infections are associated with the increased economic burden (ranging from US$ 4888 to 11691), morbidity, duration of hospital stay (range 5–21 days), and mortality (7–46%).[6-8] Globally it has been found that each bloodstream infection (BSI) costs the hospital approximately $6000 and increases the length of hospital stay by an additional week.[9] In India, children with hospital-acquired BSIs spend 3.6 times more than those who do not acquire such infections.[10]

The causes of IV cannula induced phlebitis include cannulation by inexperienced staff, inappropriate disinfection of the site before insertion, multiple insertion attempts, administration of drugs and IV fluids with low pH (antibiotics like beta-lactams and vancomycin, potassium chloride, hypertonic glucose, lipids, and amino acids) and using high flow rates.[11-13] A baseline survey to identify the incidence of phlebitis and infiltration conducted in our pediatric emergency unit revealed a high infiltration rate (82.9%) and phlebitis (96.1%). The barriers and facilitators related to IV line insertion and maintenance identified from a previous study were real eye-openers and were also used to shape the bundle.[14]

Available Knowledge and Rationale

Extensive literature review was done with more focus on MEDLINE, Scopus, Embase, and Cochrane databases before the intervention bundle was developed.[14-21] The evidence revealed that many interventions help reduce infection/phlebitis, including hand hygiene.[15-24] The use of the aseptic nontouch technique (ANTT) is one of the critical strategies to reduce infection in hospital setup.[20,21,25] Other commonly used strategies to improve practices include quality improvement (QI) initiatives, audit/assessment and feedback to healthcare personnel (HCP), education of patient and

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HCPs, organizational changes, and reminder systems using a variety of methods.[15-21,26-29] QI methods are the most effective way to identify and implement evidence-based interventions and improve care quality by employing Plan-Do-Study-Act (PDSA) cycles.[28] In order to reduce higher rates of infiltration and phlebitis associated with IV lines, we conducted this QI study using a multifaceted *"IV line insertion and maintenance bundle"* adapted from the available literature and baseline data collected in our unit.

Aim and Objective

To reduce the incidence of infiltration and phlebitis by 50% over 2 months among children admitted to the ER of a tertiary care hospital.

Materials and Methods

The study was conducted in the standalone pediatric emergency unit of a tertiary care teaching and referral 300 bedded children's hospital with all diagnostic, curative, and rehabilitative facilities under one roof. The pediatric emergency unit is 22 bedded with annual visit and admission average of 25,000 and 12,000, respectively. During the study year (2016–2017), 11,695 children were admitted and treated in the emergency unit. Ethical clearance was taken from the (INT/IEC/2017/217 dated 17/03/17) Institute's Ethics Committee. Children aged >28 days, receiving IV medication and/or fluids admitted in ER, and their HCPs were enrolled in the study. Phlebitis, defined as the veins' intima's inflammation, was assessed by VIP score[29] (visual infusion phlebitis score) and graded as 0,1, 2, 3, 4,5. Infiltration**, defined as** inadvertent leakage of a nonvesicant solution from its intended vascular pathway (vein) into the surrounding tissue during IV drug administration, was assessed using the infiltration assessment scale and graded 0, 1, 2, 3, 4.[26] All phlebitis and infiltration cases were identified and reported according to the different stages of the VIP score and infiltration assessment scale by the staff nurses. The study was conducted in three phases: preassessment, development of bundle, and implementation and adherence phase, and four different PDSA cycles. Although it is recommended to use sterile-additional packs to keep alcohol swabs and syringes, the observations made during the preassessment phase revealed that these sterile-additional packs' availability was limited. As there was no tray to keep the articles, the residents had to carry articles on their hands or in the pocket of lab coats; however, only a few could use sterile-additional packs and majority did not create any sterile field to carry the articles. Those who used sterile-additional packs kept both sterile and unsterile articles together except very few. The remaining others kept all the articles, such as a cannula, syringe, spirit swabs, and sampling vials, on the patient's bed before the procedure. During drug preparation and administration, by nurses although the trolley was cleaned with an alcohol swab before keeping the articles on the trolley, there was no demarcation for clean and sterile articles. When the medications were administered bed to bed, the articles, including pediatric drip sets, syringes, and drug vials, were kept directly on each bed's cardiac table. Every time the hand rub was not used before and during the procedure. Even after sampling, the vials and syringes were left on the patient's bed. The root cause of the lack of sterile IV line insertion and maintenance is depicted in Figure 1. The preassessment score on the IV line

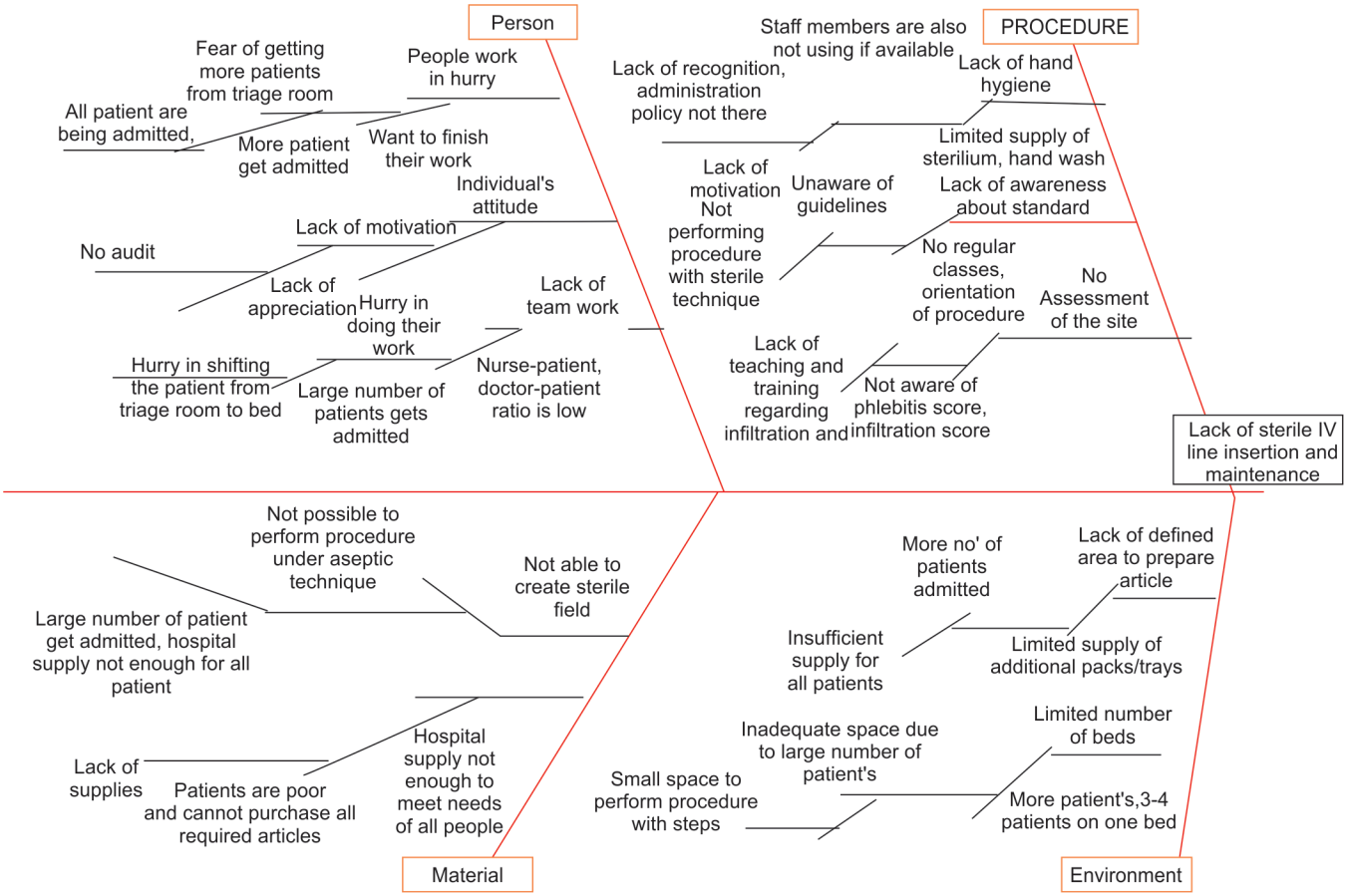


Fig. 1: Root cause analysis

insertion checklist ranged between 8.69 and 43.47% and of drug administration ranged between 20.58 and 41.17%. IV line insertion and maintenance bundles were developed for aseptic IV line insertion and its maintenance based on the best available evidence, problems identified, and suggested innovations and remedial measures. Reduction in the *"incidence of phlebitis and infiltration"* was **outcome measures** while *"scores on checklist of IV line insertion and IV line maintenance and administration of drugs"* were **process measures.** The opinion of HCPs was the **balancing measure.**

IV Line Insertion and Maintenance Bundle

Articles needed for aseptic insertion, including injection and cannulation trays, tourniquets, Tegaderm, hand rub, and gloves, were made available to the treating team. The bundle innovated using a low-cost stainless steel tray (Fig. 2), costing (INR 120-160) to prepare and arrange things needed to insert IV cannula and administer IV medications. This tray provided a compact and easy mobile sterile field after it was scrubbed with 70% alcohol or 2% chlorhexidine.[21,26] After adequate hand hygiene with soap and water or alcohol gel, the tray was cleaned with alcohol wipes, first inside, then outside, and the bottom; this practice was based on ANTT practices.[25] This low-cost innovation solved residents and nurses' problems by providing them a mobile sterile surface to segregate the sterile and unsterile articles in different trays' compartments. The sterile articles were no longer kept on the beds or patients/trollies.

The evidence-based practices specific interventions were incorporated in the maintenance bundle included (i) use of low-cost trays, use of ANTT and appropriate material to secure the cannula[25,30]; (ii) site assessment using VIP score,[29] and infiltration assessment scale,[26] and documentation of the same in each shift[31]; (iii) removal of IV line if signs of phlebitis, infiltration, and blockage were present; (iv) IV line change only if clinically indicated rather than routinely after 72 hours.[32] Other recommended interventions such as audit and feedback, organizational change, the introduction of infection control nurses, sending reminders, and QI team formulations were also used in sequential PDSAs.[15-21,27] The details of the PDSA are given in Table 1.

Figs 2A to D: (A and B) Drug administration and IV line insertion trays. (C and D) Use of 70% alcohol to clean the trays

Table 1: Details of PDSA

PDSA-1	*PDSA-2*	*PDSA-3*	*PDSA-4*
A quality improvement team (QI team 1) (investigator, nurse educator, administrator of unit, senior resident, and few nurses to keep the record) was formed. This team educated and sensitized 2–3 HCP's at a time by presenting the preassessment findings (pictures of prevalent practices, barriers, and facilitators related IV line insertion and maintenance) The feedback of existing challenges was given and aseptic IV line insertion and maintenance were taught via powerpoint presentations, videos, and demonstrations (skin preparation, fixing of the cannula, administration of medication, and maintenance of IV line using trays) and repeat demonstrations were taken. The checklists for these procedures were displayed in pediatric emergency at strategic places, pamphlets were provided, posters were placed in the unit, and reminders were circulated on focus groups created on social media platform (whatsapp). The use of infiltration and phlebitis assessment scales were taught to HCP's and the same were displayed in the pediatric emergency as well as in the duty rooms. The nursing personnel and investigator documented the scores in each shift.	QI team 2 was formed at the end of the first PDSA and implemented in the second PDSA cycle. The team 2 was constituted by co-opting 10–11 HCP working in the pediatric emergency. It consisted of an administrator, educator, leader, and executive and monitoring team. The function of each member of team 2 was explained to them and was also displayed in the unit for further clarification of roles. During this PDSA, the complete control was maintained by this team of ER unit.	During this PDSA, infection control nurse was introduced. Her main role was to conduct a sensitization program each month along with team leaders for all new residents and nurses. She observed the practice bundle for compliance and sent reminders to HCPs to make them adhere to the bundle. This process ensured that all people working in the unit were sensitized to the interventions.	The motivation and positive reinforcement of the HCP toward adherence to the bundle were done by the leader and other team members in the fourth PDSA cycle. The incentives for good practices were recognized and appreciated by displaying the names of HCP who were exemplary in their work on unit's notice board, giving appreciation cards and acknowledging good work in combined audits.

Each PDSA cycle described in Table 1 was conducted for 1 or 2 weeks; within 5 to 6 weeks, the bundle's compliance increased in the weekly audits. The incorporation of positive change within the unit was a sign of sustainable improvement. HCP fully accepted the bundle. There was a minimum cost of trays, but no extra staff was involved in implementing the bundle.

Results

The clinical and demographic characteristics of the study subjects are presented in Tables 2 and 3.

From June to September 2017, 185 children and 46 HCP were enrolled in the study. The majority of the children were boys both in the preassessment phase and all PDSAs. Among the HCPs, two-thirds (71.7%) were nurses and one-fourth (28.3%) were doctors. The majority (76%) of the HCP's were between 20 years and 30 years, with the mean ± SD age being 29.1 ± 6.1 years. Nearly half of the nurses (47%) were graduates (B.Sc Nursing), and one-third (26.1%) of the doctors were MD Pediatrics trainees.

Infiltration and Phlebitis in Preassessment and over 4 PDSA

The preassessment findings revealed that the scores on the checklist of IV line insertion and drug administration ranged between 8.69 to 43.47% and 20.58 to 41.17%, respectively. Also, the infiltration and phlebitis incidences were found to be 82.96 and 96.09%, respectively.

The analysis was done through control charts, line graphs, and bar graphs over a period of time to determine the reduction in the incidence of phlebitis and infiltration ***(the outcome measures)***. Incidence of infiltration (Table 4, Fig. 3A) and phlebitis (Table 4, Fig. 3B) at 24, 24–48, 48–72, and 72–96 hours is depicted in the form of table and line graphs. In preassessment, one-fourth (25.9%) of the children developed infiltration within 24 hours than a few (5%) in PDSA 3. None of the children developed infiltration within 24 hours in PDSA 2 and PDSA 4. Less than half (41.9%) of the children within 24–48 hours and only 5% developed infiltration in PDSA 3. Almost half (51.4%) of the children developed phlebitis between 24 hours and 48 hours, and only 10% of children developed phlebitis in PDSA 4 between 24 hours and 48 hours. There was an improvement in outcome measures, reduction in the incidence of infiltration and phlebitis; infiltration scores from 82.96 to 45% (Table 5) and phlebitis scores from 96.09 to 55% (Table 5).

There was an increase in overall scores for the ***process measures*** procedure of IV line insertion (20.54–88.99%) (Fig. 4A) and administration of drugs through an IV line (50.16–68.40) (Fig. 4B).

Table 3: Sociodemographic cum clinical profile of healthcare personnel of pediatric emergency (*N* = 46)

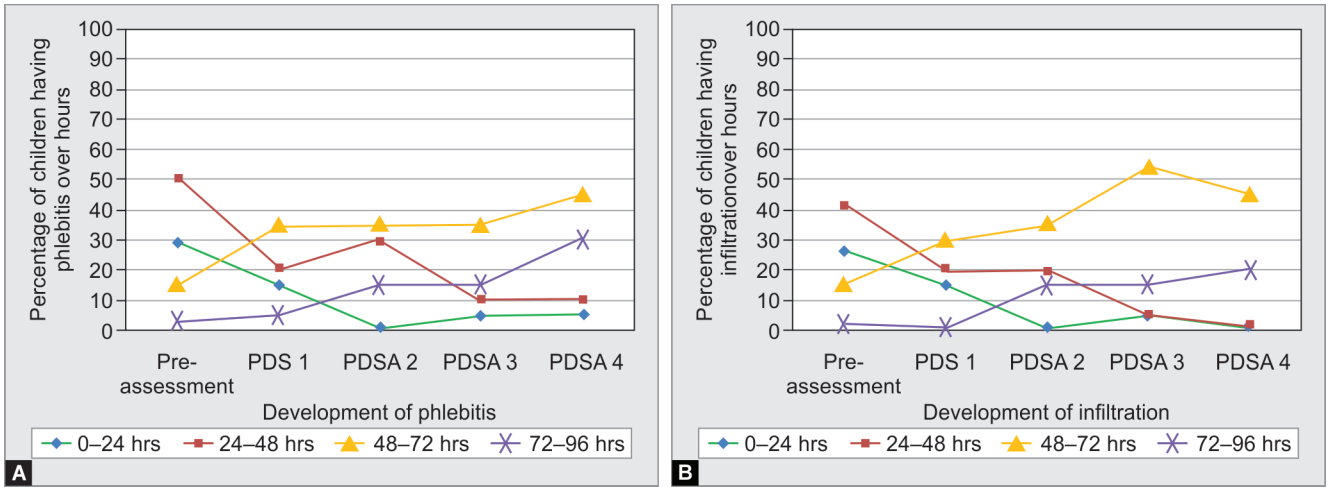
Observation	*Frequency n (%)*
Designation	
Physicians	13 (28.3)
Nurses	33 (71.7)
Age (years)	
20–30	35 (76)
30–40	7 (15.2)
40–50	4 (8.8)
Sex	
Male	15 (32.6)
Female	31 (67.4)
Professional qualification	
GNM	5 (10.9)
BSc Nursing	22 (47.8)
BSc (Post Basic)	6 (13.0)
MSc Nursing	1 (2.2)
MBBS and pursuing MD	12 (26.1)
Working experience in PGIMER	
0–5 years	32 (69.6)
5–10 years	7 (15.2)
>10 years	7 (15.2)
Working experience in pediatric emergency	
0–2 years	17 (37)
2–4 years	14 (30.4)
4–6 years	5 (10.9)
>6 years	10 (21.7)

Table 2: Clinical and demographic characteristics of study population (*N* = 185)

	Preassessment group	*PDSA cycles*			
Variables	*n = 105 (%)*	*PDSA 1 n = 20 (%)*	*PDSA 2 n = 20 (%)*	*PDSA 3 n = 20 (%)*	*PDSA 4 n = 20 (%)*
Age (years)					
Median (Q1–Q3)	4 (1–7.5)	7 (3.5–9.5)	4.5 (2–7)	4 (1.62–6)	3.5 (1.12–5)
Gender					
Male	66 (62.9)	10 (50)	15 (75)	13 (65)	19 (95)
Female	39 (37.1)	10 (50)	5 (25)	7 (35)	1 (5)
Drugs					
1 Antibiotics	14 (13.3)	3 (15)	8 (40)	2 (10)	8 (40)
2 Antibiotics	54 (51.4)	4 (20)	7 (35)	9 (45)	8 (40)
1 Antiepileptic	6 (5.71)	1 (5)	–	9 (45)	–
2 Antiepileptic	19 (18.09)	4 (20)	–	1 (5)	–
Antiviral and antibiotics	1 (0.95)	3 (15)	1 (5)	1 (5)	–
Antibiotics and antiepileptic	5 (4.76)	1 (5)	2 (5)	1 (5)	1 (5)
Other	6 (5.71)	4 (20)	1 (5)	2 (10)	2 (10)
Nil	–	–	1 (5)	2 (10)	1 (5)
IV fluids					
N/2 5% dextrose	72 (68.6)	14 (70)	9 (45)	12 (60)	8 (40)
Other fluids**	33 (31.3)	6 (30)	11 (55)	8 (40)	12 (60)

Table 4: Percentage of infiltration and phlebitis within 24, 24–48, 48–72, 72–96 hours

	Preassessment n = 105	*PDSA 1 n = 20*	*PDSA 2 n = 20*	*PDSA 3 n = 20*	*PDSA 4 n = 20*
Time of infiltration development					
0–24 hrs	25.9	15	0	5	0
24–48 hrs	41.86	20	20	5	0
48–72 hrs	15.2	30	35	55	45
72–96 hrs	1.9	0	15	15	20
Total	84.86	65	60	80	65
Time of phlebitis development					
0–24 hrs	29.45	15	0	5	0
24–48 hrs	51.41	20	30	10	10
48–72 hrs	15.23	35	35	35	45
72–96 hrs	2.85	5	15	15	30
	98.98	75	80	65	85

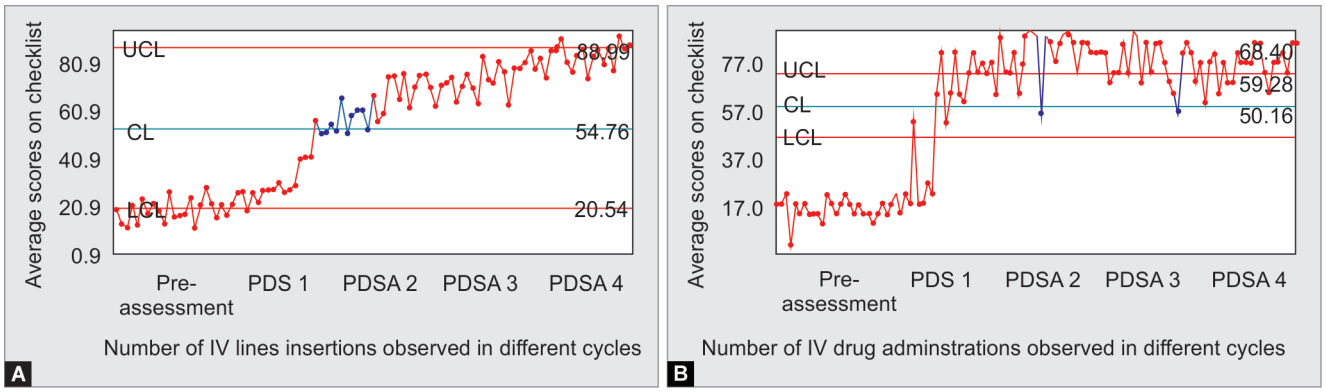


Figs 3A and B: (A) Line graph depicting incidence of infiltration within 24, 24–48, 48–72, 72–96 hours; (B) Line graph depicting incidence of infiltration in 24, 24–48, 48–72, 72–96 hours

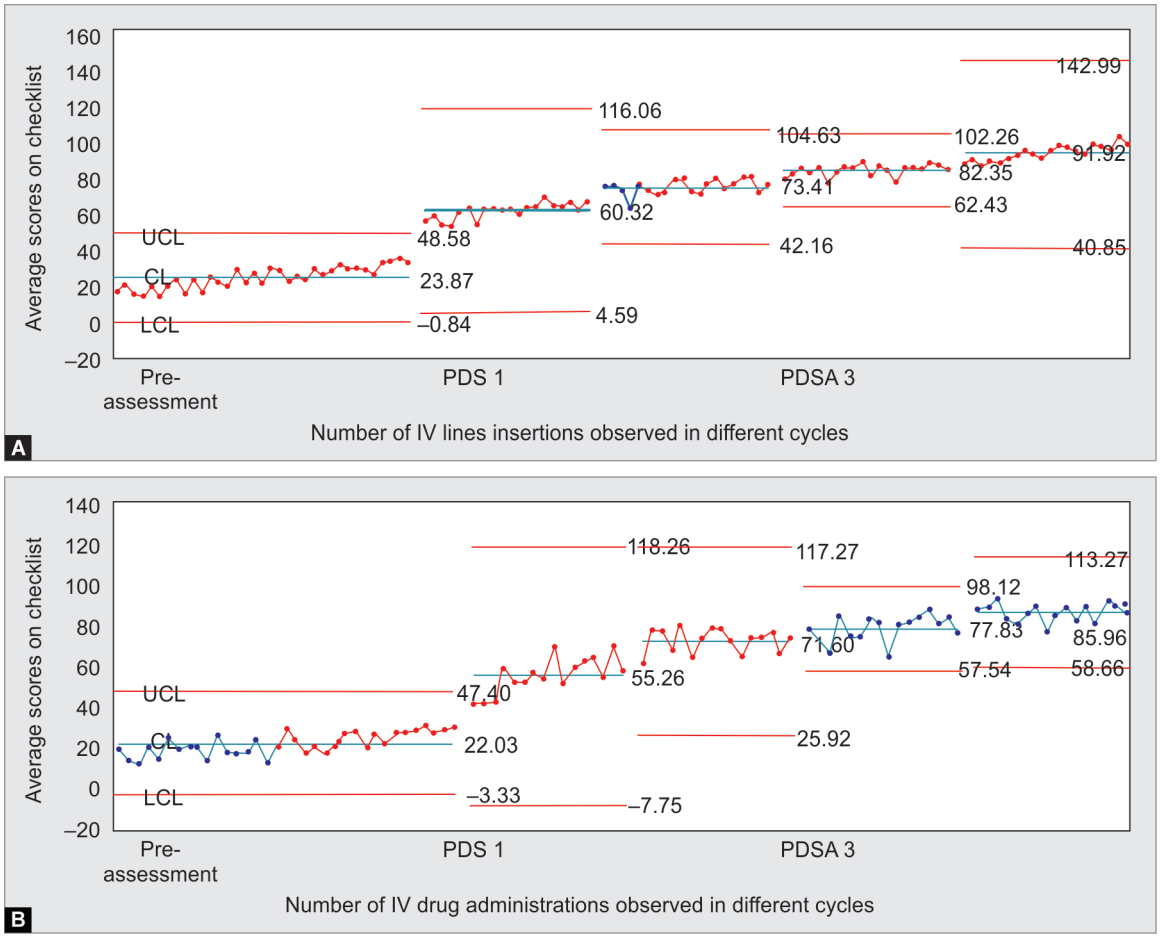
Table 5: Incidence of the development of infiltration and phlebitis in preassessment and different PDSA cycles

Phases	*Incidence of the development of infiltration over a period of time*		*Incidence of the development of phlebitis over a period of time*	
	0–48 hrs	*0–72 hrs*	*0–48 hrs*	*0–72 hrs*
Preassessment phase (105)	67.5	82.96	80.86	96.09
PDSA 1 (20)	35	65	35	70
PDSA 2 (20)	20	55	30	65
PDSA 3 (20)	10	65	15	50
PDSA 4 (20)	0	45	10	55

The control chart of IV line insertion and maintenance shows a shift at the end of preassessment and in the PDSA cycles. There was a complete shift after PDSA 1 due to sensitization and interventions. There are two runs above the upper control limit, possibly due to the inclusion of lower preassessment scores. When improvement took place, the scores improved, and 2 data points shifted above the upper control limit. Over time, the process became stable in the subsequent PDSAs, which was evident in individual control charts provided in Figure 5. The ***balancing measure*** revealed that the opinion of HCPs changed from "not willing, finding difficult to the used tray and ANTT in an emergency, there is lack of supplies" to "good practice, became a normal routine, teamwork helped a lot,



Figs 4A and B: (A) Consolidated charts for score on IV line insertion checklist; (B) Consolidated charts for score on IV drug administration checklist



Figs 5A and B: (A) Average control charts of percent scores for IV line insertion checklist; (B) Average control charts of percent scores for score on IV drug administration checklist

this reduces chances of infection, try can be carried easily to bedside, the tray is low cost and easy to clean and use" over the 6 weeks.

Discussion

Peripheral IV line insertion in children is common in sick children in the pediatric ER. Nurses and physicians are responsible for the insertion and maintenance of the peripheral IV line and the prevention of complications related to its use. The prevention of infection remains the most significant ER challenge[17] due to overcrowding, low nurse-patient ratio, and limited resources, especially in developing nations.[33] Also, challenges are unique to every emergency setup that has to be effectively addressed. The challenges in our setup are that HCP is unable to follow all steps of proper aseptic practices and adhere stringently to them in an emergency setting[34] where the pressure of getting things done fast within a specified time for acutely sick children is high. This task multiplies manifold when the unit is extremely crowded. In the preassessment phase, the strategy followed was mainly audit and feedback, considering its low to moderate efficacy in improving

the practices.[17,35,36] To prevent behavior modification by HCPs, a covert nonparticipatory assessment of existing practices related to aseptic techniques (using the checklist on IV line insertion and drug administration) and assessing the site for infiltration signs and phlebitis was done. We found a high incidence of infiltration and phlebitis in the preassessment phase, similar to that reported previously by White SA from Indiana.[4]

The incidence of phlebitis and infiltration scores reduced significantly after the introduction of the bundle. The present study introduced the low-cost trays, which provided a quick and easy mobile sterile surface, which was one example of a simple organizational change and effective utilization of resources. No such intervention has been tried in other studies to the best of our knowledge, especially in resource-limited settings. Before the intervention, we found that only 20% were following hand hygiene practices, and none were adhering to strict aseptic techniques for IV line insertion and maintenance. Postintervention, the score of hand hygiene improved to 80%, and that of the aseptic technique was increased by 2–5 times. Hoot et al. also reported that after implementing the low resource interventions such as educational presentations, teachings in groups, posters with diagrams, and text messages on hand hygiene, improved practices significantly.[33] The impact of continuous QI in clinical practice shows that evidence-based clinical application improves the outcome and reduces the cost of care.[37] It has been shown that the implementation of evidence-based practices raises the standard for the prevention of infection and patient safety in an emergency department.[17] Similarly, Hill reported that behavior and compliance of hand hygiene improved by QI projects.[38]

In the current study, the most critical barrier identified was the HCP's resistance to change. The reasons for this were many: apprehension about time and increased workload. They feared that implementing the bundle would be time-consuming and would overburden them as they were short-staffed. Apprehension about being observed and recorded was also a barrier to accepting the change. Their reluctance to use the compartment trays manifested in the form of hiding them and making several excuses for not using them. Initially, it was not easy to track the trays and other provided articles. HCP's verbal remarks were, *"we do not want to use the trays; we will hide them."* Acceptance gradually developed with continuous education, positive reinforcement, and motivation. Incentives to HCPs in the form of recognition and appreciation for good work, e.g., displaying HCP names with exemplary work on the unit's notice board, giving appreciation cards, and acknowledging good work in combined audits, were followed. Gradually HCPs accepted the change over time. Many authors have reported that incentives to HCP and positive reinforcement effectively enhance professional practices.[15-22,39,40]

The finding of the study showed that adherence to the bundle was better with each PDSA cycle. We observed that over 6 weeks, while this QI project was on infiltration and phlebitis, incidence reduced to 38% and 41.09%, respectively. Our findings are similar to another study conducted by Esteban et al., that identified challenges like hospital staff resistance to change, low nurse: patient ratio, and lack of resources and also reported that interventions provided over 3 weeks improved hand hygiene from 13.3 to 48.6%.[27]

The formation of Q1 teams further improves success, as was seen in our study. Weiner et al. also reported that hospital-level quality indicators with the QI team possessed higher values.[41] The infection control nurse, introduced in PDSA 3 ensured adherence to the bundle by using checklists, taking feedback of practices, and suggesting remedial measures. Similarly, in another study by Ceballos et al., a nurse leader was initiated to ensure the use of infection control practices using the CLABSI checklist. She ensured the bundle's use and provided specific feedback on intervention compliance, which led to improvement.[42] Motivation and improved adherence to bundle also improved with successive PDSA cycles and were best in PDSA 4. Alhassan et al. similarly reported that staff motivation and positive working conditions directly affect the standards in health facilities and patient safety.[43]

Summary

There was an improvement in outcome measures. The reduction in infiltration and phlebitis incidence was from 82.96 to 45% and phlebitis scores from 96.09 to 55%, respectively. The overall reduction of infiltration and phlebitis incidences was 38 and 41.09%, respectively.

Limitations

The study period was brief, and the long-term impact of the change model has not been studied. Further PDSA to limit the other relevant variables impacting phlebitis and infiltration, such as the use of more fluid, more drugs of different PH were not included due to the limited time frame.

Conclusion

Although we planned a 50% reduction for the primary outcome, we could only achieve 41.09 and 38% for phlebitis and infiltration, respectively. However, the extent of improvement seen reiterates that consistent regular efforts can improve it further. Regular feedback from team members and the motivation of the HCPs are helpful strategies. Also, the challenges of lack of resources can be overcome by low-cost local innovations. The aseptic IV line insertion and maintenance bundle need to be incorporated in the leading educational program and daily routine to achieve sustained benefits. It is replicable, and with practice, it will become a positive system change.

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