

Leveraging Technology to Improve the Surveillance of Intravenous Infiltrations

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Abstract

Problem & Purpose: Peripheral intravenous (PIV) catheters have a high failure rate, with infiltrations accounting for 24% of all failures. Hospitals largely rely on voluntary incident reports (VIR) to track these events, leading to poor organizational surveillance. A Mid-Atlantic Metropolitan hospital relied on VIR to track PIV infiltration events. In a four-week period, zero PIV infiltration VIR were submitted, creating concern for the reliability of VIR as a surveillance tool and the underreporting of these events by nursing. This quality improvement (QI) project aimed to capture the true frequency of PIV infiltration through a new surveillance process and to identify perceived barriers to incident reporting among nurses. **Methods:** An electronic health record (EHR) based report was developed, utilizing data mining in the EHR to identify PIV infiltrations. Data was collected on the aggregate number of infiltrations identified in each system and compared weekly over 14 weeks. Additionally, an online survey was distributed to inpatient nurses to assess perceived barriers to infiltration reporting. These results were used to tailor an educational module presented to nurses from each nursing unit. **Results:** The EHR report identified significantly more PIV infiltrations than the VIR system ($p < 0.001$). The EHR identified 353 infiltrations, compared to 3 identified through VIR. The percent infiltrations reported in the VIR system was 6% or less each week. The nursing survey identified knowledge deficits, staffing challenges, and time constraints as common barriers to VIR of PIV infiltrations. **Conclusions:** Implementing an EHR report to identify PIV infiltrations is a feasible intervention and provides more accurate surveillance than VIR. Despite nurse knowledge of VIR and the utility of reporting infiltrates, VIR alone is not a reliable surveillance tool. Use of the EHR report as a new surveillance method for PIV infiltrations should be continued. More efforts

should be made to increase nurse engagement in VIR, and hospital policies should clearly identify reporting criteria for PIV complications.

Keywords: peripheral intravenous infiltrations, PIV, EHR report, voluntary incident reporting, quality improvement

Leveraging Technology to Improve Surveillance of Intravenous Infiltrations

Peripheral intravenous (PIV) infiltrations are an underreported, under surveilled, but frequent patient safety event affecting adult patients admitted to the hospital. Despite being the most frequently used invasive medical device in the inpatient setting, PIVs have an overall failure rate of 35-50%, leading to premature removal of the catheter (Helm et al., 2019). With as many as 90% of adult patients having at least one PIV during an inpatient hospital admission, PIV failure is a significant risk to patient safety (Chen et al., 2021; Helm et al., 2019).

Infiltration, a common cause of catheter failure, has the potential to cause severe tissue damage, delay treatment, increase hospital costs, and can lead to litigation (Gibien et al., 2022). Infiltration occurs when an intravenous (IV) solution leaks into the soft tissue, rather than remaining in the blood vessels (Helm et al., 2019). Extravasation occurs by the same mechanism but involves a vesicant solution, thus infiltration will be used to encompass both terms.

Infiltration, along with other PIV complications, are often perceived as being insignificant, inevitable, and a “natural consequence of intravenous therapy” (Fabian, 2020). Infiltrations have not gained the attention of healthcare agencies and accrediting bodies in the way that patient falls, or central line infections have. Organizations generally rely on voluntary incident reporting (VIR) systems to track occurrences of PIV failure; and while VIR has its utility, it is estimated to capture only 20% of patient safety events in the United States healthcare system (Levinson, 2012; Weber et al., 2018). Consequently, rates of infiltration vary widely in the literature and organizational rates are often unknown or inaccurate (Tewfik, 2020). And though PIV infiltrations are widely an underreported metric, it is considered as a standard of practice by the Infusion Nurses Society (INS) that all organizations review and evaluate all PIV complications resulting in patient harm (Gorski et al., 2021).

A Mid-Atlantic metropolitan acute care hospital was reliant on voluntary nurse reporting through an electronic VIR system for surveillance, or the continuous and systematic collection and analysis of PIV infiltration occurrences. The organizational incidence rate of PIV infiltration was unknown; however, occurrences were known to be underreported (M. Klein, personal communication, February 7, 2022; K. Friedel, personal communication, March 11, 2022). A review of the VIR system over a four-week period in Summer 2022 revealed that there had been zero reports of PIV infiltrations submitted. However, data mining in the EHR revealed 39 PIV infiltrations, an infiltration involving heparin, an infiltration with a +4 severity grade, and an infiltration rate of 26%, creating concern for the reliability of VIR as a surveillance tool and the underreporting of these events by nursing. Therefore, this quality improvement (QI) project aimed to capture the true frequency of PIV infiltration through a new surveillance process and to identify perceived barriers to incident reporting among nurses.

Available Knowledge

INS highlights QI activities as being a standard of practice for infusion therapy nursing. All organizations should assess gaps in practice, identify and eliminate barriers to change (Gorski et al., 2021). It is strongly recommended that organizations use accurate surveillance methods to identify all PIV complications that result in patient harm. Surveillance methods should allow for organizations to monitor internal rates of occurrence and allow for internal benchmarking and external comparison. Gorski et al. (2022) recommend that surveillance data and QI results be shared internally and externally (see Appendix A).

Weber et al. (2018) recognized that their reliance on VIR to capture PIV infiltrations within their organization lead to a “false impression” that PIV infiltrations were not a frequent nor significant cause of patient harm. After the implementation of an EHR-based data collection

tool, the number of PIV infiltrations increased by 82% and the monthly rate of severe PIV infiltrations increased by 32%. These increases were attributed to accurate surveillance with the EHR-based tool, rather than a true increase in occurrences.

Additionally, Miller et al. (2017) found that an automated EHR-based tool was a better way to measure adverse events (AE) that took place during a clinical trial, as compared to voluntary event reporting. Miller et al. (2017) found that 33 AE reports were submitted voluntarily, compared to 695 AEs identified with the automated EHR-based tool. Compared to manual chart review, the EMR-based tool had a specificity greater than 98% for all AEs examined in the study, compared to 0% to 21.1% for voluntary event reporting.

Though there is not a large body of evidence in the literature to support the use of an EHR-based surveillance method to identify PIV complications or other patient safety events, the literature provides high quality evidence defining the scope of this problem, as well as demonstrating the clinical impact of data mining in the EHR, compared to VIR to provide surveillance for PIV infiltrations and other adverse outcomes (see Appendix B). Therefore, the purpose of this QI initiative is to implement the use of an automated EHR-based tool to improve the surveillance of PIV infiltrations in the organization and to identify barriers to voluntary incident reporting among nurses.

Rationale

The Framework of Complex Innovation Implementation can be used as a guide for the implementation of this practice change (see Appendix C). The framework hypothesizes that implementation is a function of collective effort of all members and the continuous support and resources provided by those in leadership roles (Helfrish et al., 2007). It is then conceptualized that success will come from the collective effort, rather than from the effort of an individual. In

this practice setting, the organizational climate includes nursing administration, nurse managers, educators, and bedside nurses. The innovation will need to be initially championed by leadership and adopted by staff nurses. With continued support by those in leadership positions, and the collective effort of nurses at all levels, this innovation may be successfully integrated.

Methods

Context

The initial surveillance method for PIV infiltrations was fully reliant on a nurse reporting the infiltrations in the VIR system. After an infiltration occurred, a nurse would need to enter into the VIR system and complete a “Medication and I.V. Incident” form (see Figure 1). As the nurse would be prompted to include details of the incident, the event being reported would be specified as an infiltration. Once completed in its entirety and submitted, notification of the report would be sent to the involved unit’s nurse manager, pharmacy, and the Quality Director for the Nursing Division (QD) for review and follow-up. This method did not allow for infiltrations that were not reported in the VIR system to be accounted for, nor did it provide any information on the frequency or rate of PIV infiltrations in the organization.

Nurses were expected to document assessments on the EHR “PIV Assessment” flowsheet at least every 4 hours. When a PIV infiltration was identified, the nurse was expected to document a site assessment, to include a severity grade, and then document the removal of the PIV as a “Line, Drain, and Airway” (LDA), with “infiltration” being selected as the reason for removal. Documentation of an infiltration in the EHR did not trigger a report in the VIR system and the EHR data was not used for PIV infiltration surveillance. Additionally, there was no institutional policy detailing expectations for reporting infiltrations in the VIR system.

Intervention

The primary intervention in this project was the implementation of a new PIV infiltration surveillance method, utilizing data mining in the EHR to identify infiltrations through “PIV Assessment” and “LDA” flowsheet data. Led by the QI-PL, and in collaboration with nursing informatics, information technology and the QD, a EHR report was created to identify PIV infiltrations by capturing the number of PIVs removed as an LDA with the “infiltration” radio button selected as the reason for removal. The report provided data on the total number of PIV removals, the number of infiltrations, severity grading, and the number of infiltrations without a severity grade (see Figure 2). Patient identifiers were provided by the report, however, no patient identifiers were used in this project or accessed by the QI-PL.

Secondary interventions focused on surveying and educating bedside nurses to identify and address barriers to PIV infiltration VIR (see Appendix D). A brief online survey was distributed to nurses on three established nursing councils: the Practice, Quality and Education nursing councils. The survey used a combination of Likert-scale and open response questions to identify barriers to PIV infiltration incident reporting. The survey was completed on REDCap, a secure, HIPAA-compliant database, and was accessible to participants via a QR code that was distributed through email. To encourage participation, a small Amazon gift card, provided by the QI-PL, was raffled to participant’s who wished to provide their company email address.

Additionally, an educational module was presented to the nurses in attendance at the three nursing councils October meetings. The presentation aimed to increase nurse knowledge and engagement of PIV infiltration identification and reporting (see Appendix E). The module included a brief online post-test accessible via QR code. The quiz results were used to evaluate

the learning objectives intended for the presentation. Data from the post-test was collected directly into REDCap and was anonymous.

Implementation Strategies and Tactics

Initial implementation strategies and tactics included obtaining the buy-in of nursing administrators and nursing informatics, beginning by proving that the clinical issue existed. With VIR being the only method of surveying occurrences of PIV infiltrations, initially, there was no objective data demonstrating the issue. The data could not be obtained on a large scale without the EHR report, therefore, evidence from the literature review, first-person observations, and the lack of PIV infiltration VIR in a one-month period was used to convey the need for the EHR report. The buy-in from the QD and nursing informatics was integral in moving the project forward as they were largely responsible for developing, testing, and running the report.

Additionally, direct communication with bedside nurses throughout the hospital was another tactic utilized. This was achieved by the QI-PL attending nursing council meetings, communicating with nurse managers and educators, and distributing educational materials. The nursing councils consisted of nurse representatives from all of the nursing units in the hospital. They were encouraged to bring the information and learning materials from the council meetings to their units. Additionally, the councils had the opportunity to learn about the EHR report, view preliminary data, and discuss potential ways to utilize the report specific to their units. This helped to increase awareness and interest in the QI project.

Measures

Structure, process, and outcome measures used to assess the progress of the implementation included: the presence of a functional and accurate EHR report, the percent of infiltrations reported in the VIR system, and the number of PIV infiltrations identified (Appendix

F). The measures were evaluated with the aggregate weekly data collected from the EHR report and the VIR system. The structure outcome was the EHR report and its accessibility and functionality. This outcome was measured through the completion and utility of the report.

The outcome measure for this QI project was the total number of PIV infiltrations identified. Prior to implementation, the total number of PIV infiltrations was measured with manual review of the VIR system. During implementation, the EHR report was used as the primary measurement tool. The EHR report was chosen after it had been tested and was demonstrated to be more sensitive at identifying infiltrations than the VIR system. Data on the number of infiltration reports in the VIR system each week was collected and compared weekly to the EHR report. This data was used to calculate the percent of PIV infiltrations reported in the VIR system, a process outcome measure for this project. This measure was calculated for each week interval with the number of VIR reports as the numerator and the number of infiltrations identified by the EHR as the denominator and represented as a percentage.

Study of the Intervention

Project implementation took place over a 14-week period in Fall 2022 and included six adult medical-surgical units in a single Mid-Atlantic Metropolitan hospital. All PIV removals documented in the EHR, and all PIV infiltrations reported in the VIR system were included. PIVs without a documented removal in the EHR and PIV infiltrations not reported in the VIR system were excluded from the project.

The data collection process involved the QI-PL and the QD. The EHR report was run in one-week intervals by the QD to collect data on the number of PIV removals and PIV infiltrations identified in the EHR. She would also manually review all “Medication and I.V. Incident” reports submitted in the VIR for the same one-week interval to identify reports of PIV

infiltrations. The aggregate, de-identified data from each electronic system was then sent the QI-PL for collection in REDCap.

Survey and post-quiz data was entered directly into REDCap by nurse participants using the survey capabilities provided by REDCap. Participants were able to access each form with QR codes that were distributed through email. Participants had the option of providing their work email address on the survey form, otherwise, the collected data was anonymous.

Analytics

Data collected during the implementation phase of this QI project was analyzed using run charts and a two-tailed t-test. Two run charts were created, one looking at the total number of PIV infiltrations identified each week, and one displaying the percent of infiltrations reported in the VIR system. Once all data was collected and plotted, the median for each data set was marked on each run chart. The data points were then compared to the median value and analyzed to determine the outcome of the project.

A two-tailed t-test was calculated with GraphPad by Dotmatics and used to determine whether a significant difference in the weekly average number of PIV infiltrations identified during the implementation period was observed. The implementation data was compared to the baseline data. A significant change would be demonstrated by a $p < 0.05$ and then used to support that the EHR-based report was a more accurate surveillance method for PIV infiltrations occurring in the organization.

Ethical Considerations

This QI project was reviewed by both the University of Maryland, Baltimore, and the hospitals institutional review boards. The project was determined to be non-human subject research. Furthermore, patient privacy and confidentiality were ensured in the data collection

process. All data was collected from the EHR and VIR system by the QD and was de-identified prior to being shared with the QI-PL. The de-identified data was sent to the QI-PL via email on the hospitals secure and confidential email platform. Additionally, all data was collected in a HIPAA compliant, secure, online data collection software. Only the QI-PL and faculty advisor had access to the collected data.

Results

The EHR report identified a total of 3,377 PIV removals during the 14-week implementation period. Of the total documented removals, 10.5% (n=353) had infiltration as the documented reason for removal and 49% (n=1,651) of all removals had no documented reason for removal (see Figure H1). The average number of PIV infiltrations identified each week was 25 (SD= 7). The VIR system had 3 PIV infiltrations reports submitted during the implementation period, with a weekly average of 0.38 (SD=0.74). The number of infiltrations identified by the EHR reports was significantly greater than the number identified through the VIR system ($p<0.001$) (see figure 3). The percent of infiltrations reported in the VIR system each week ranged from 0% to 6%, with 12 of the 14 weeks having zero. No shifts, runs, or trends were seen on the run chart (figure 4). The goal of seeing 20% of infiltrations reported in the VIR was not met at any point throughout the implementation phase.

A total of 33 nurses participated in the nursing survey (see Appendix G). The majority of the participating nurses worked in maternal-child health, perioperative, and medical-surgical service lines. Most nurses 69.7% (n= 23) either disagreed or strongly disagreed that PIV infiltrations were common complications for patients on their nursing units. While 87.9% (n=29) of participants agreed or strongly agreed that PIV infiltration can cause serious patient injury and 66.6% (n= 22) agreed that reporting PIV infiltrations could lead to improved patient outcomes,

only 9.1% (n= 3) of nurses agreed that they consistently report PIV infiltrations in the VIR. The most frequently stated barriers to PIV infiltration reporting among nurses were time constraints, staffing challenges, and knowledge deficits on reporting practices.

A total of 28 nurses completed the post-quiz after the education was presented (see Appendix H). Two questions had high variability in the selected answers. Question three, which focused grading the severity of PIV infiltrations injuries was answered incorrectly by 85.7% (n= 24) of participants. Question four, which focused on reportable patient safety incidents was answered incorrectly by 21.4% (n= 6) of participants. The other four questions were answered correctly by the majority of participants with each question having less than two incorrect answers.

Discussion

The EHR report provides significantly better surveillance data than VIR for PIV infiltrations. A significant increase in the number of PIV infiltrations identified each week was seen throughout the implementation phase. This QI project did not implement changes at the patient-care level or affect the way nurses were managing PIVs. Therefore, the increase in occurrences can be attributed to improved surveillance, rather than a true increase in PIV infiltrations occurring on the medical-surgical units.

No runs, shifts, or trends were observed on the run-chart for the primary outcome measure assessed throughout implementation (refer to figure 3). This is likely imparted to implemented intervention being at a data collection level, rather than the intervention being made at the patient-care level. No changes were made to the way nurses initiate PIVs or manage patients receiving infusion therapy. An astronomical point was observed during week 10, with a total of 35 PIV infiltrations being identified. In reviewing data from this week, 35 out of 217 PIV

removals were indicated to be due to infiltrations, a rate of 16%. This is the highest weekly rate of infiltration seen during the implementation phase. Additionally, 92 out of the 217 (42%) removals had no reason for removal documented. Week 10 saw the lowest rate of PIV removals without a documented reason. This week did not correlate with any known project-related interventions, and there is no data to support or indicate to what this astronomical point can be attributed.

The number of reports in the VIR system on PIV infiltrations did not see a significant change throughout the project. The survey distributed to nurses supports that nurses are aware of the VIR system, are comfortable using it, and understand the utility of VIR. Additionally, the survey demonstrates that the majority of nurses agree the VIR has the potential to improve patient outcomes regarding PIV infiltrations. Despite this, however, the majority of nurses said that they do not regularly report PIV infiltrations. The data from the survey and from the number of PIV infiltrations reported in the VIR system throughout the 14-week implementation phase supports that VIR is not an effective or accurate surveillance method for PIV infiltrations despite nurse awareness of the VIR system and utility for VIR.

The findings from this QI project are consistent with findings in the literature. Similar to Weber et al. (2018), a significant increase in the number of PIV infiltrations identified was seen after implementing an EHR report. The EHR report was found to be a more sensitive surveillance tool than the VIR, which is consistent with the findings of Miller et al. (2017). And while this project has a limited view of VIR in the organization, the lack of PIV infiltration reports in the VIR system is consistent with the Department of Health and Human Services' findings that an estimated 86% of safety incidents in hospitals go unreported in VIR systems (Levinson 2012).

Limitations

Data mining is only as accurate as the data available in the EHR; therefore, one limitation of this study is the reliance on accurate nurse documentation. It was observed that 49% of PIV removals did not have a documented reason for removal in the EHR. This limits the accuracy of PIV infiltration rates and identification of all occurrences of PIV infiltrations. Another limitation to this study is the limited number of nurses on the six medical-surgical units in which education was directly presented. Surveying and education were directed to nurses on the established nursing councils, rather than aimed directly at all medical-surgical nurses.

Conclusion

Data mining in the EHR is a more effective surveillance tool at identifying occurrences of PIV infiltration than VIR. This project team succeeded at developing, testing, and implementing the use of a EHR report to improve PIV infiltration surveillance. Sustainability of this practice change will be achieved with updates to the EHR to improve the accuracy of nurse documentation, subsequently improving the surveillance data provided by the EHR report. The report will continue to be used regularly and will be made accessible to other parties interested in reviewing PIV infiltration data. This new surveillance method provides the organization a way to measure this patient safety event and can pave way for clinically focused QI aimed at decreasing PIV infiltration rates and other measures that may benefit from EHR surveillance.

While this project focuses on PIV infiltrations specifically, this QI project contributes to the body of evidence supporting the use of data mining in the EHR as a surveillance method of patient safety events. The organization should look at other patient safety events and consider how an EHR report could improve data surveillance, such as with skin breakdown, treatment delays, or medication errors. As a major focus of healthcare in the United States, organizations

need to be proactive and innovative at measuring patient safety in healthcare settings. While VIR reporting and retrospective chart review were once considered to be sufficient, widespread integration of EHR in healthcare settings has allowed for improvements in the patient safety realm (AHRQ, Van & Mossburg, 2022). The EHR should be leveraged as a tool to allow for cost effective, efficient, accurate, and proactive surveillance of patient safety events.

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Figure 1. Initial process map for PIV infiltration surveillance

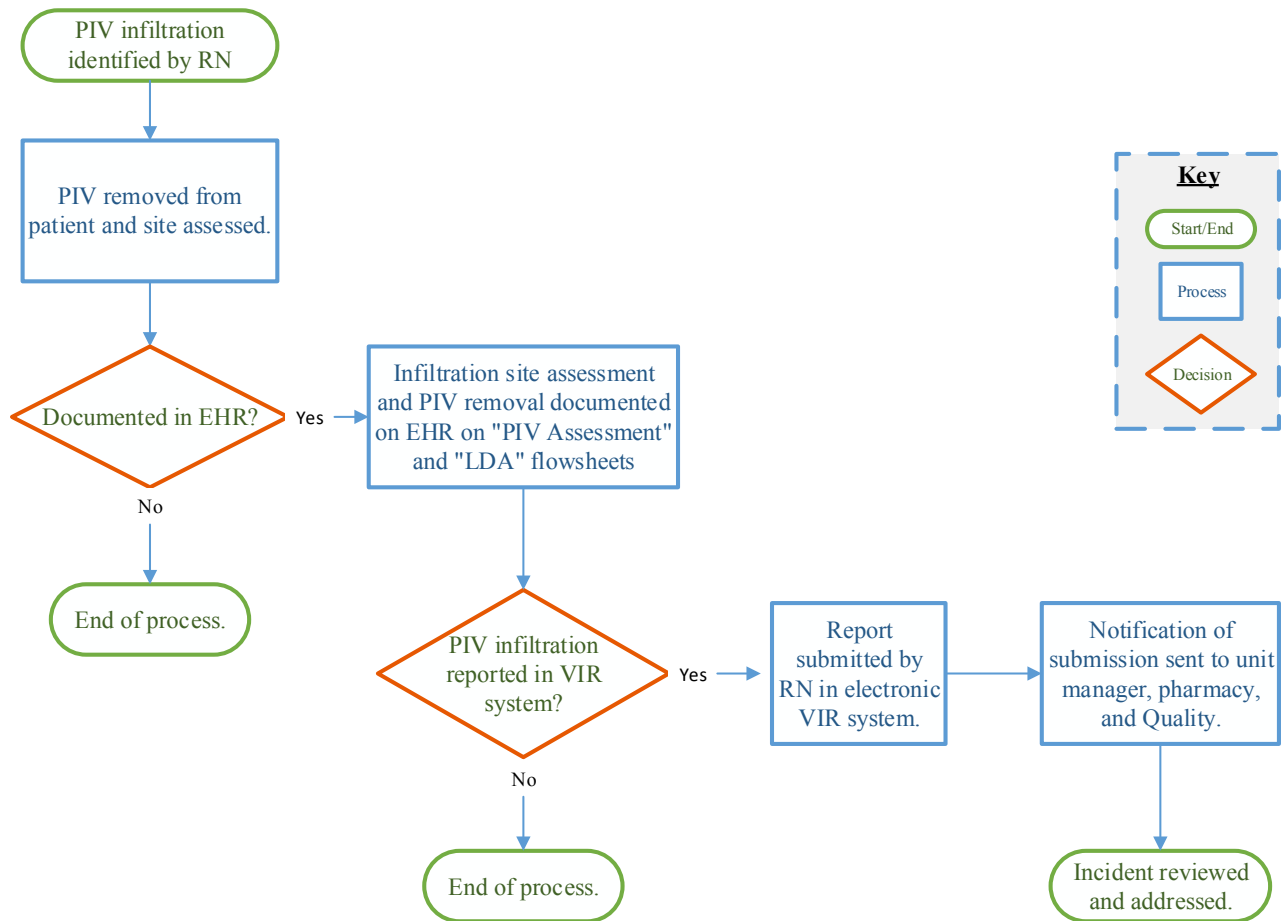


Figure 2. Desired process map for PIV infiltration reporting and surveillance

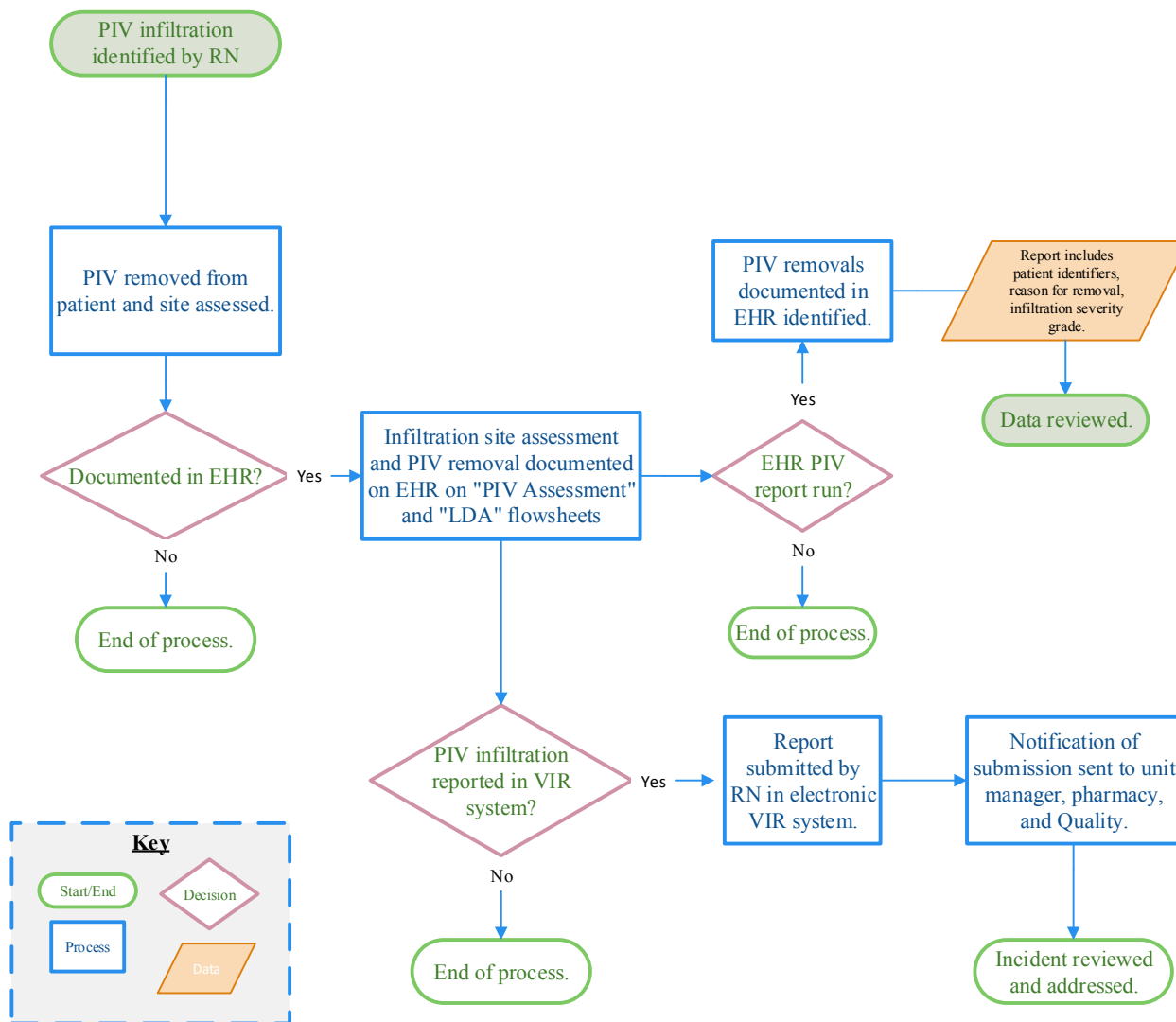
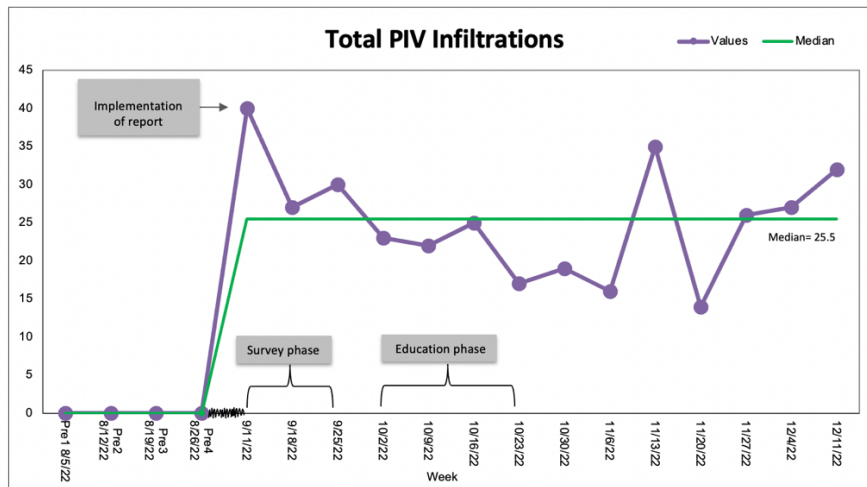
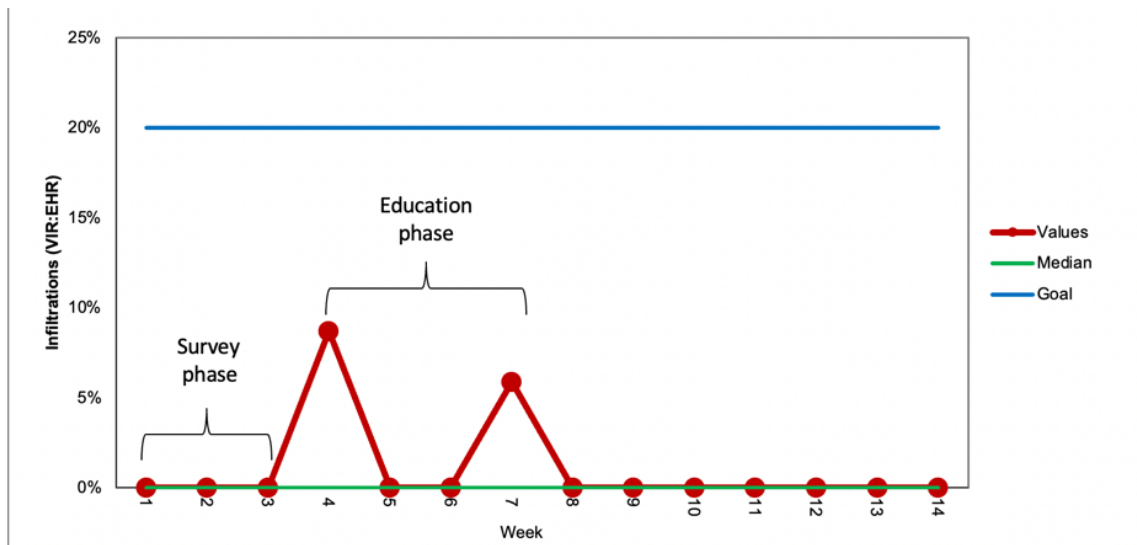


Figure 3. Total PIV Infiltrations



Notes- demonstrates the total number of PIV infiltrations identified each week. Pre-implementation data collected through VIR system. After implementation of PIV Infiltration EHR report, the EHR data was used to demonstrate the total number of infiltrations identified.

Figure 4. Percent of PIV Infiltration Reported in VIR System



Appendix A

Evidence Review

<p>Citation: Gorski, L., Hadaway, L., Hagle, M., Broadhurst, D., Clare, S., Kleidon, T., Meyer, B., Nickel, B., Rowley, S., Sharpe, E. & Alexander, M. (2021). Infusion therapy standards of practice, 8th Edition. <i>Journal of Infusion Nursing</i>, 44 (1S). https://doi.org/10.1097/NAN.0000000000000396.</p>					<p>Level and Quality IV- A</p>
Purpose/ Hypothesis	Type of Evidence	Sample	Intervention	Primary Outcome/ Measures	Conclusions
<p>To provide infusion “guidelines and clinical practice recommendations based on the most current evidence available.”</p>	<p>Practice-Clinical practice guidelines</p>	<p>N/a</p>	<p>N/a</p>	<p>Evidence was evaluated and rated using the Strength of Body of Evidence rating scale, developed in 2011 by the Standards of Practice Committee for the Infusion Nurses Society. A level I evidence is the highest-ranking and would represent a meta-analysis, whereas level V is the lowest level of evidence, such as a case report.</p>	<p>Recommendations: The safety of PIVs should be improved within an organization by standardizing and simplifying the reporting process (level IV). All PIV infiltration/extravasation incidents causing harm or injury should be reviewed using adverse event reports and health records for QI opportunities (level IV). A standardized format should be used to document initial and subsequent assessments of a PIV infiltration/extravasation site that includes all factors involved with the event (level IV). An infiltration/extravasation site should be assessed multiple times, as needed, based on the severity of the injury (level IV). Conclusions: Based on level IV evidence, it is recommended that organizations standardize and simplify the reporting process and review all PIV infiltration reports. This practice allows for QI opportunities. Additionally, infiltration/extravasation sites should be monitored consistently and repeatedly, as needed, based on injury severity. Clinical Significance: Using a standardized and simply reporting process and reviewing all PIV infiltration reports may improve patient outcomes and allow QI opportunities. Additionally, consistently, and repeatedly assessing infiltration/extravasation sites may improve patient outcomes.</p>

<p>Citation: Miller, T. P., Li, Y., Getz, K. D., Dudley, J., Burrows, E., Pennington, J., Ibrahimova, A., Fisher, B. T., Bagatell, R., Seif, A. E., Grundmeier, R., & Aplenc, R. (2017). Using electronic medical record data to report laboratory adverse events. <i>British Journal of Haematology</i>, 177(2), 283–286. https://doi.org/10.1111/bjh.14538</p>					<p>Level and Quality III-A</p>
Purpose/ Hypothesis	Design	Sample – Population, Size, Setting	Intervention/Procedures	Primary Outcome/Measures	Results/Conclusions
<p>Purpose: “to automate EMR data extraction and grading for laboratory-based [adverse events] (AEs) at a single institution and to compare this approach to manual AE assessment.” Hypothesis: “EMR-based AE ascertainment and grading would have a higher sensitivity and PPV than manual review.”</p>	<p>Retrospective observational cohort study</p>	<p>Sampling Technique: convenience sampling through systematic chart review of all patients enrolled in two Children’s Oncology Group (COG) clinical trials at the organization between December 2006 and March 2015.</p> <p># eligible: 49 patients, 176 chemotherapy courses # accepted: 49 patients, 173 chemotherapy course</p> <p>Power analysis: not discussed</p> <p>Group Homogeneity: not discussed.</p>	<p>COG AE Reporting: COG trial AE reports initially collected at the time of the AE were received from the COG. This data was extracted from Epic, the COGs EMR, and was provided in a deidentified spreadsheet listing each reported AE.</p> <p>EMR-based report: Structured Query Language queries extracted data on nine laboratory tests for each patient and each chemotherapy course. Patient data extracted included medical record number, the ordered, collected and resulted times and dates, the test component, the name of the laboratory test, the result, and any narrative or data in a comment field.</p> <p>Manual Chart Review: A single pediatrician reviewed the charts of the patient and each chemotherapy course to manually identify laboratory AEs.</p>	<p>DV: Number of AEs detected</p> <p>State the instrument, reliability, and measurement procedure:</p> <p>Reliability of the three data collection methods was not discussed. AEs were identified using three methods: COG AE reporting, EMR data extraction, and manual chart extraction. The sensitivity, positive predictive value (PPV), specificity and negative predictive value of EMR extraction and COG AE reports, compared to manual data extraction.</p>	<p>Statistical Results: The COG AE report yielded a total of 33 reports. The EHR-based report revealed 695 AEs and manual chart review identified 754 AEs.</p> <p>The sensitivity of COG AE reporting ranged from 0% to 21.1% and the PPV ranged from 20% to 100%. The sensitivity and PPV for the EMR-based report were greater than 98% for all laboratory AEs.</p> <p>Clinical Significance: Automated data extraction from the EMR, as compared to voluntary reporting dramatically improves the accuracy of AEs reporting.</p> <p>Conclusions: The automated EMR-based report had a higher sensitivity and PPV than manual reporting through COG AE reporting</p>

<p>Citation: Weber, E., Castrillon, K., & Ramsey-Coleman, J. (2018). Peripheral intravenous infiltrates: Engaging staff to increase reporting. <i>Journal of Nursing & Interprofessional Leadership in Quality & Safety</i>, 2(1). Retrieved April 1, 2022, from https://digitalcommons.library.tmc.edu/cgi/viewcontent.cgi?article=1026&context=uthoustonjqualsafe</p>					<p>Level and Quality V-A</p>
Purpose/ Hypothesis	Type of Evidence Research Design	Sample – Population, Size, Setting	Intervention/Procedures	Primary Outcome/Measures	Results/Conclusions
<p>“To improve patient safety and outcomes by decreasing the overall severity of peripheral intravenous infiltration and extravasations.”</p>	<p>Practice Evidence-Quality improvement</p>	<p>Setting- a large, 700-bed, free-standing children’s hospital in the United States.</p>	<p>Baseline data: Data was collected on the frequency of peripheral intravenous infiltrations and extravasations (PIVIE) through the organizations event reporting system to establish a baseline on the frequency of events.</p> <p>Engagement of frontline staff: PIVIE clinical leaders, unit-based bedside nurses, were selected to assist in the creation, dissemination and review of PIVIE quality initiative. Clinical leaders were trained on PIVIE identification and assessment, as well as the importance and seriousness of PIVIEs. Clinical leaders brought information back to their units to help with engagement and participation.</p> <p>EMR data extraction: An electronic report was created in the electronic medical record (EMR) to extract pertinent data to PIVIEs. Two additional rows were added to the EMR flowsheet to better capture assessment data required for PIVIE grading.</p>	<p>Primary outcome: Number of reported PIVIEs, measured in number of infiltrates.</p> <p>Secondary outcome: PIVIE infiltrate severity rate, as measured by rate per 1,000 patient days</p> <p>State the instrument, reliability, and measurement procedure: The organization pulled data from the EMR to identify PIVIEs based on assessment data entered in to flowsheets.</p>	<p>Statistical Results: Prior to intervention, the organization had an average of 40 PIVIE events each month. After the intervention, the average number PIVIE events reported each month increased by 82%.</p> <p>Clinical Significance: Using the EMR to collect data on PIVIE events demonstrates a better reflection of true incidence within the organization.</p> <p>Conclusions: Using the EMR to collect data on PIVIE events, as compared to relying on self-reporting, demonstrates a better reflection of true incidence within the organization.</p>

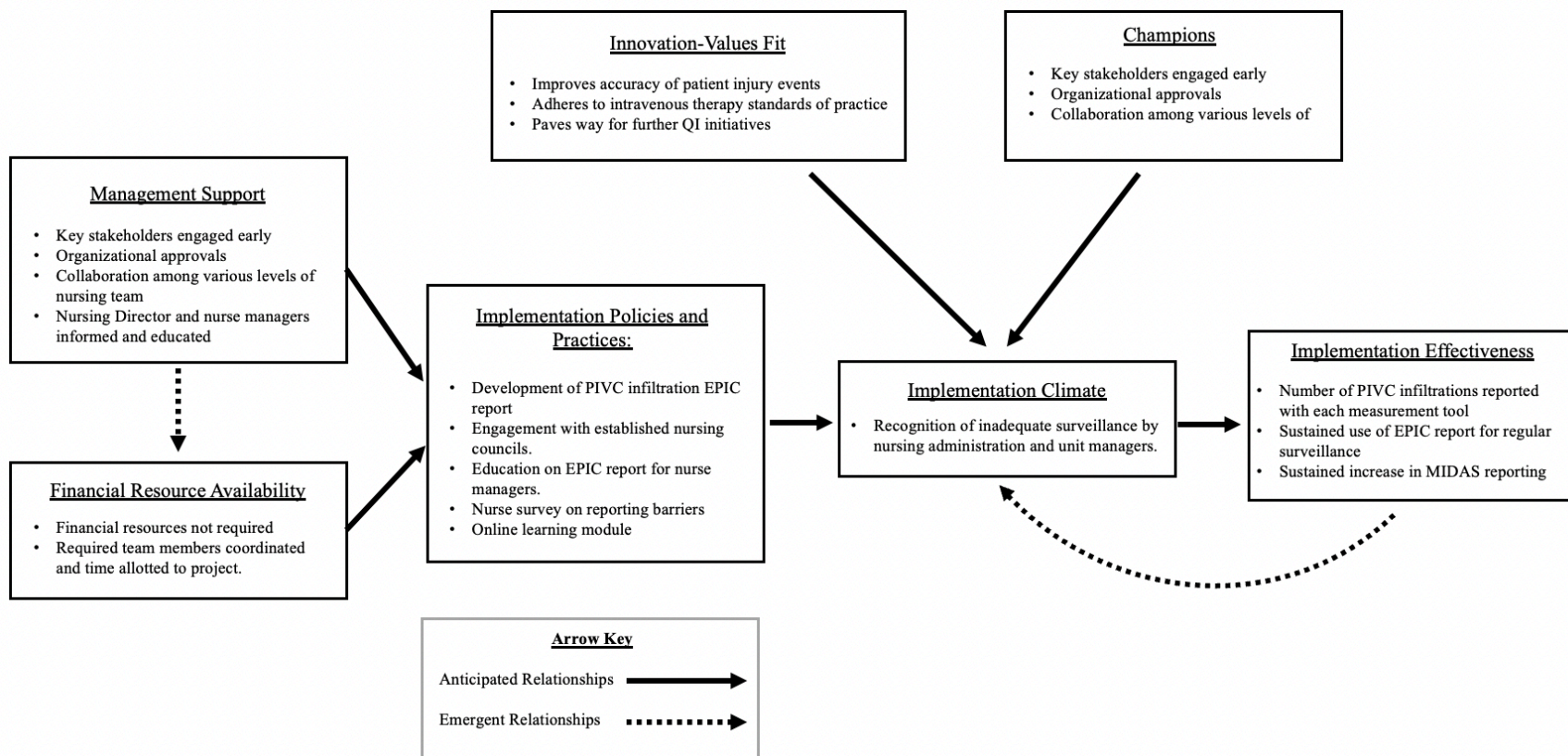
Appendix B

Evidence Synthesis

Category (Level Type)	Number of Sources	Overall Quality Rating	Synthesis of Findings
Level I	0	n/a	n/a
Level II	0	n/a	n/a
Level III	2	A- high	Miller et al. (2017) reported that automated data extraction from the EMR, as compared to voluntary reporting dramatically improves the accuracy of AEs reporting. An EMR-based data extraction tool has an increased sensitivity and PPV, as compared to AE voluntary reports, to accurately identify and capture true rates of AEs. Burlison et al. (2020) found that patient safety culture has a significant predicative effect on the likelihood of a patient event being voluntarily reported. Organizations should prioritize improving event feedback mechanisms and communication of event-related improvements to improve patient event reporting.
Level IV	1	A- high	Based on level IV evidence, Gorski et al. (2021) recommend that standardizing and simplifying the reporting process and reviewing all PIV infiltration reports should be done within an organization for quality improvement opportunities. Additionally, infiltration/extravasation sites should be monitored consistently and repeatedly, as needed, based on injury severity.
Level V	1	A- high	Weber et al. (2018) found that the use of clinical leaders in conjunction with an EMR-based PIVIE reporting tool was effective at increasing the reporting of PIVIEs and assists in providing a more accurate organization incidence. After implementation of the EMR-based tool, as compared to the event reporting system, PIV infiltrations increased by 82%, and the monthly rate of more severe PIV infiltrations increased by 32%.
Recommendations Based on Evidence Synthesis: The evidence reviewed is high quality and supports the implementation of an EHR-based tool to improve the process of PIV surveillance.			

Appendix C

Framework for Complex Innovations applied to Improve Surveillance of Intravenous Infiltrations



*Adapted from Conceptual Framework of Complex Innovation Implementation from Helfrich et al, (2007)

Appendix D

Outline of Nurse Barriers Survey

Unit Culture & PIV Infiltrations					
	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
1. Peripheral IV infiltrations are reportable patient safety incidents that should be reported in MIDAS.	1	2	3	4	5
2. Peripheral IV infiltrations are inevitable consequences of IV therapy.	1	2	3	4	5
3. Peripheral IV infiltrations are a common complication for patients on my unit.	1	2	3	4	5
4. Peripheral IV infiltrations can cause serious patient injury.	1	2	3	4	5
5. Reporting peripheral IV infiltrations in MIDAS can lead to improved patient outcomes.	1	2	3	4	5
6. MIDAS is user friendly and simple to use.	1	2	3	4	5
7. I have consistently reported PIV infiltrates in MIDAS over the past 6 months.	1	2	3	4	5

8. List one or two reasons for not reporting IV infiltrates in MIDAS.

- _____
- _____

9. If you would like to be entered into a raffle to win an Amazon gift card, please enter your [organization] email.

- _____

Appendix E

Outline of Online Educational Module

<i>Learning Objectives</i>	<i>Content Outline</i>	<i>Method of Instruction</i>	<i>Time Spent</i>	<i>Method of Evaluation</i>
<p><i>By the conclusion of the learning module, the learner will be able to define peripheral intravenous catheter (PIV) infiltrations and describe their causes and consequences.</i></p>	<p>a. Peripheral intravenous catheter (PIV) infiltration is defined as the escape from an intravenous (IV) solution or medication from the vein and into the surrounding tissues (Gorski et al., 2021).</p> <p>b. Causes:</p> <ul style="list-style-type: none"> i. Erosion or penetration of the catheter through the vessel wall (Helm et al., 2019). <ul style="list-style-type: none"> a. This occurs from frequent movement at the PIV site. ii. Loss of venous wall integrity (Helm et al., 2019). <ul style="list-style-type: none"> a. This can occur due to inflammatory effects on the vessel due to traumatic movements, chemical properties of the infused IV solutions or from the initial venipuncture. <p>c. Consequences of PIV Infiltrations (Helm et al., 2019; Rickard et al., 2015; Hanrahan, 2013).</p> <ul style="list-style-type: none"> i. Patient Injury ii. Patient dissatisfaction iii. Delays in patient care iv. Increased hospital length of stay v. Increased hospital costs 	<p>Asynchronous online learning module.</p>	<p>2-5 minutes</p>	<p>Pre-and post-test</p>
<p><i>By the conclusion of the learning module, the learner be able to identify risk factors that place a patient at an increased risk of PIV infiltration.</i></p>	<p>A. Risk Factors for PIV Infiltrations</p> <ul style="list-style-type: none"> i. BMI > 30 (Marsh et al., 2018) ii. 2 or more co-morbidities (Marsh et al., 2018) iii. Incapacitated or nonverbal (Kornusky & Caple, 2018) iv. Female (Marsh et al., 2018) v. Any type of infection (Marsh et al., 2018) vi. Small gauge PIV (Marsh et al., 2018) vii. Placement near joints (Hand antecubital and wrist) (Marsh et al., 2018; Helm et al., 2019) viii. Inadequate PIV securement (Helm et al., 2019) ix. Infants and children (Cline et al., 2021). 	<p>Asynchronous online learning module.</p>	<p>2-5 minutes</p>	<p>Pre-and post-test</p>

<p><i>By the conclusion of the learning module, the learner will be able to describe signs and symptoms of PIV infiltrations.</i></p>	<p>A. Signs and Symptoms</p> <ul style="list-style-type: none"> a. PIV occlusion or sluggish IV flow (Kornusky & Caple, 2018) b. Pain or tenderness at the site (Kornusky & Caple, 2018) c. Erythema (Kornusky & Caple, 2018) d. Edema (Kornusky & Caple, 2018) e. Site is cool to the touch (Kornusky & Caple, 2018) f. Leaking from the site (Kornusky & Caple, 2018) g. Paresthesia or numbness (Kornusky & Caple, 2018) 	<p>Asynchronous online learning module.</p>	<p>2-5 minutes</p>	<p>Pre-and post-test</p>
<p><i>By the conclusion of the learning module, the learner will be able to describe the assessment, grading and initial management of PIV infiltrations.</i></p>	<p>A. PIV Infiltration Assessment</p> <ul style="list-style-type: none"> i. A validated scale is used to grade the severity of infiltrations based on assessment findings (Gorski et al., 2021). This grade should be a part of the initial site assessment. ii. The Infusion Nurse Society grade the severity of infiltrations in adult patients on a scale of 0 to 4 (Kornusky & Caple, 2018) <p>B. INS Infiltration Scale (Kornusky & Caple, 2018)</p> <ul style="list-style-type: none"> i. Insert scale in a table. <p>C. Management</p> <ul style="list-style-type: none"> i. The nursing and medical management of PIV infiltrations varies depending on the severity of the injury and the involved IV solution or medication. <ul style="list-style-type: none"> a. You should not just put ice packs or heat packs on every infiltration site. The infiltrated solution drives nursing and medical management. ii. Site management may only require comfort measures and observation, or it may require injection of pharmacologic antidotes into the area or surgical intervention (Gibian et al., 2022). iii. It is important to notify providers of infiltrations in a timely manner. Pharmacy is a useful resource when determining the risk the infiltrated solution has for severe injury, as well as recommending pharmaceutical treatment. iv. Hyaluronidase is help with (Kornusky & Caple, 2018) <ul style="list-style-type: none"> a. Hyperosmotic solutions b. Penicillin, aminophylline, nafcillin v. Phentolamine is helpful with sympathomimetics (dobutamine, dopamine, epinephrine, metaraminol, norepinephrine, vasopressin) (Kornusky & Caple, 2018). 	<p>Asynchronous online learning module.</p>	<p>2-5 minutes</p>	<p>Pre-and post-test</p>
<p><i>By the conclusion of the learning module,</i></p>	<p>A. Documentation</p>	<p>Asynchronous online learning module.</p>	<p>2-5 minutes</p>	<p>Pre-and post-test</p>

<p><i>the learner will be able to describe the documentation and reporting process of PIV infiltrations</i></p>	<ul style="list-style-type: none"> i. A validated scale is used to grade the severity of infiltrations based on assessment findings (Gorski et al., 2021). This grade should be a part of the initial site assessment. ii. A site assessment should occur initially after the identification of an infiltration. The assessment should be documented in the “PIV Assessment” flowsheet. Subsequent assessments should be documented regularly and until the infiltration is completely resolved (Gorski et al., 2021). This injury should not be re-graded as it heals. iii. “Infiltration” can be added as a wound to the physical assessment flowsheets in the EHR. This allows you to continue to chart thorough site assessments, even after the PIV is removed in the “LDA” flowsheet. <p>B. Infiltration Event Reporting</p> <ul style="list-style-type: none"> i. PIV infiltrations are a cause of patient injury and should be reported as patient safety events in MIDAS, the hospitals voluntary incident reporting system. ii. Incident reporting is a term used to describe the voluntary reporting of patient safety and adverse events that occur in an organization (Patient Safety Network, 2019). iii. Incident reporting is crucial in healthcare and assists in identifying and investigating patient safety and quality issues within the organization (Patient Safety Network, 2019). iv. An incident report should be submitted for any event where harm or injury reaches or nearly reaches the patients (Patient Safety Network, 2019). 			
<p><i>By the conclusion of the learning module, the learner will understand voluntary incident reporting and the process for event reporting within the hospital.</i></p>	<p>A. Incident Reporting</p> <ul style="list-style-type: none"> i. Did you know that the majority of patient safety events are not reported? In fact, over 80% of patient safety incidents in healthcare settings go unreported (Levinson, 2012). ii. "Near misses" of patient harm or injury can provide critical surveillance of unsafe processes and allow for process improvement before patient injury occurs (Patient Safety Network, 2019). <p>B. Incident Reporting Process</p> <ul style="list-style-type: none"> i. [Organization] uses MIDAS+ (Medical Information Data Analysis System plus) for electronic incident reporting. ii. MIDAS+ can be accessed by all employees and can be accessed through [organization intranet] or through the icon on desktop home screens. iii. <i>Insert photographs demonstrating what MIDAS+ looks like and how it can be accessed.</i> 	<p>Asynchronous online learning module.</p>	<p>2-5 minutes</p>	<p>Pre-and post-test</p>

	<ul style="list-style-type: none"> iv. Initially, you will be prompted to provide information on the involved patient and the nature of the incident. v. After selecting the incident type, you will be brought to a form that prompts you to provide details on the incident's time, location, and contributing details. vi. After completing and submitting the report, the report will be sent to the involved unit manager, nursing leadership, and other pertinent departments, depending on the nature of the incident. vii. These reports are reviewed, and the incidents are investigated as appropriate. 			
<p><i>By the conclusion of the learning module, the learner will be able to describe common barriers to voluntary event reporting.</i></p>	<ul style="list-style-type: none"> A. Common Barriers to Incident Reporting <ul style="list-style-type: none"> i. Voluntary incident reporting relies on frontline staff, the ones directly involved in patient care!! ii. Incident reports drive changes and improve patient safety and organizational processes. iii. Incident reports are not used to punish or discipline staff. iv. Incident reports are not left unread and do not go unaddressed. B. What you can expect. <ul style="list-style-type: none"> i. While incident reporting relies heavily on frontline staff, nursing management and leadership are responsible for following up on patient incidents and providing timely feedback to you! 	Asynchronous online learning module.	2-5 minutes	Pre-and post-test
<p><i>By the conclusion of the learning module, the learner will be able to identify ways to prevent PIV infiltration.</i></p>	<ul style="list-style-type: none"> A. Prevention <ul style="list-style-type: none"> i. Selection of a suitable vein and catheter size for the patient and the IV solutions or medications. <ul style="list-style-type: none"> a. Avoid hard, cord-like, squiggly veins. ii. Careful selection of PIV site placement <ul style="list-style-type: none"> a. The forearms are ideal of PIV placement. vi. Adequate securement and stabilization of PIVs. vii. Frequent site assessments <ul style="list-style-type: none"> a. Assess the PIV site thoroughly before and after each infusion, and every hour while in use. In patient with risk factors for PIV infiltration or that are receiving vesicant medications, assessment should occur more frequently. viii. Immediately stop any active infusion as soon as infiltration is suspected. ix. Promptly assess the site and notify the provider if the severity is a grade 2 or higher. 	Asynchronous online learning module.	2-5 minutes	Pre-and post-test
<p><i>Quiz Questions</i></p>	<p>Quiz Question #1- Which of the following factors does NOT increase a patient's risk of having a PIV infiltration?</p> <ul style="list-style-type: none"> a. BMI >30 	Asynchronous online learning module.	5-7 minutes	Pre-and post-test

<ul style="list-style-type: none"> b. Male <ul style="list-style-type: none"> i. <i>This is the correct answer. Females are more likely than males to have PIVs infiltrate.</i> c. Nonverbal or incapacitated patient d. 2 or more co-morbidities 			
<p>Quiz Question #2- Which of the following is NOT correct?</p> <ul style="list-style-type: none"> a. An infiltration site only needs to be assessed one time. <ul style="list-style-type: none"> i. <i>This is the correct answer. After a PIV infiltration occurs, the site should be assessed regularly until the injury is completely resolved.</i> b. PIV site assessments should occur every hour or more when the line is actively infusing. c. An infusion should be stopped immediately after any suspicion that the PIV has infiltrated. d. Infiltrations should be treated differently depending on the severity of the injury and the involved IV solution. 			
<p>Quiz Question #3- A patient receiving packed red blood cells through a PIV has acute onset of pain at the site. There is visible edema and erythema, and the site is cool to the touch. What grade of severity is this infiltration?</p> <ul style="list-style-type: none"> i. Grade I ii. Grade II iii. Grade III iv. Grade IV <ul style="list-style-type: none"> i. <i>This is the correct answer. Any infiltration of a blood product is immediately staged as a grade IV injury. The primary provider for the patient should be notified immediately.</i> 			
<p>Quiz Question 4- Which of the following is NOT a reportable patient safety incident?</p> <ul style="list-style-type: none"> a. A visitor slips and falls on a puddle in the lobby. b. While transferring a patient from the bed to stretcher, their endotracheal tube is displaced and the patient has a long, desaturation as a result of extubation. c. A patient admitted for the hospital for heart failure develops pulmonary edema, require intubation and mechanical ventilation. <ul style="list-style-type: none"> i. <i>This is not a reportable incident. Reportable events are adverse events unrelated to a patient's disease processes.</i> d. A patient's peripheral IV infiltrates while IV fluids are infusing. There is swelling and discomfort to the extremity. 			

	<p>e. A patient experiences a severe allergic reaction 5-minutes after receiving a first-time dose of IV antibiotics.</p>		
	<p>Quiz Question #5- Which of the following statements is true?</p> <p>a. Voluntary incident reporting is used to identify and investigate patient safety and quality issues within the organization.</p> <p>i. <i>This is the correct answer. Voluntary incident reporting is used to drive change and improve organization processes, patient safety and patient outcomes.</i></p> <p>b. Voluntary incident reporting is used to discipline staff and identify unsafe staff members.</p> <p>c. Most witnessed patient safety events that occur in healthcare settings are reported.</p> <p>d. Incident reports should only be submitted for incidents that cause severe injury.</p>		
	<p>Quiz Question #6- Which electronic system is used at [organization] for voluntary incident reporting?</p> <p>a. EPIC</p> <p>b. MIDAS+</p> <p>i. <i>This is the correct answer. MIDAS+ is the incident reporting system used at [organization].</i></p> <p>c. Performance Manager</p> <p>d. ADP</p>		

Appendix F

Goals and Measures

Measures		
Project Goals	Measure Pre-Implementation	Measure During Implementation
<i>Structure Goals</i>		
An EHR report will be available to identify PIV infiltrations documented in the EHR.	Unable to be assessed.	Presence of functional EHR report.
<i>Process Goals</i>		
20% of all PIV infiltrations will be reported in the VIR system.	Unable to be assessed.	Numerator: number of PIV infiltrations reported in VIR system Denominator: number of PIV infiltrations identified by EHR report
<i>Outcome Goals</i>		
A statistically significant increase in the number of PIV infiltrations identified each week will be achieved.	Aggregate number of PIV infiltration VIR submitted in VIR system.	Aggregate number of PIV infiltrations identified by the EHR system.

Appendix G
Nursing Survey Results
(n=33)

Question 1- Peripheral IV infiltrations are reportable patient safety incidents that should be reported in MIDAS.

Survey Answer	Frequency
Mother-Baby/ L&D	24.2%
NICU/ Pediatrics	18.2%
Perioperative	18.2%
Medical-Surgical	21.2%
ICU/IMC	6.1%
Oncology	3.0%
Other	9.1%

Question 2-Peripheral IV infiltrations are inevitable consequences of IV therapy.

Survey Answer	Frequency
Strongly Agree	0%
Agree	27.3%
Neither Agree nor Disagree	18.2%
Disagree	42.2%
Strongly Disagree	12.1%

Question 3- Peripheral IV infiltrations are a common complication for patients on my unit.

Survey Answer	Frequency
Strongly Agree	0%
Agree	9.1%
Neither Agree nor Disagree	21.2%
Disagree	54.5%
Strongly Disagree	15.2%

Question 4- Peripheral IV infiltrations can cause serious patient injury.

Survey Answer	Frequency
Strongly Agree	57.6%
Agree	30.3%
Neither Agree nor Disagree	9.1%
Disagree	0%
Strongly Disagree	3.0%

Question 5- Reporting peripheral IV infiltrations in MIDAS can lead to improved patient outcomes.

Survey Answer	Frequency
Strongly Agree	33.3%
Agree	33.3%
Neither Agree nor Disagree	15.2%
Disagree	15.2%
Strongly Disagree	3.0%

Question 6- MIDAS is user friendly and simple to use.

Survey Answer	Frequency
Strongly Agree	9.1%
Agree	39.4%
Neither Agree nor Disagree	9.1%
Disagree	24.2%
Strongly Disagree	18.2%

Question 7- I have consistently reported PIVC infiltrates in MIDAS over the past 6 months.

Survey Answer	Frequency
Strongly Agree	3.0%
Agree	6.1%
Neither Agree nor Disagree	27.3%
Disagree	27.3%
Strongly Disagree	36.4%

Question 8- List one or two reasons for not reporting IV infiltrates in MIDAS.

Common Themes to Open Responses	Frequency (n)
Time/Staffing Challenges	10
No Changes	1
Punishment	2
Normal Part of IV Therapy/ no harm	5
Unaware it is Reportable Event	9
MIDAS usability	4
Other	5

Appendix H Education Post-Quiz Results

Question 1- Which of the following factors does NOT increase a patient's risk of having a PIVC infiltration?

Quiz Answers	Counts
BMI	0
Male	27
Nonverbal	1
2 or more comorbidities	0

Question 2- Which of the following is NOT correct?

Quiz Answers	Counts
An infiltration site only needs to be assessed one time	27
PIVC site assessments should occur every hour or more when the line is actively infusing.	1
An infusion should be stopped immediately after any suspicion that the PIVC has infiltrated.	0
Infiltrations should be treated differently depending on the severity of the injury and the involved IV solution.	0

Question 3- A patient receiving packed red blood cells through a PIVC has acute onset of pain at the site. There is visible edema and erythema, and the site is cool to the touch. What grade of severity is this infiltration?

Quiz Answers	Counts
Grade I	8
Grade II	8
Grade III	8
Grade IV	4

Question 4- Which of the following is NOT a reportable patient safety incident?

Quiz Answers	Counts
A visitor slips and falls on a puddle in the lobby.	4
While transferring a patient from the bed to the stretcher, their endotracheal tube is displaced and the patient has a long, desaturation as a result of extubation.	1
A patient admitted to the hospital for heart failure develops pulmonary edema and requires intubation and mechanical ventilation.	22
A patient's peripheral IV infiltrates while IV fluids are infusing. There is swelling and discomfort in the extremity.	0
A patient experiences a severe allergic reaction 5-minutes after receiving the first-time dose of IV antibiotics.	1

Question 5- Which of the following statements is true?

Quiz Answers	Counts
Voluntary incident reporting is used to identify and investigate patient safety and quality issues within the organization.	28
Voluntary incident reporting is used to discipline staff and identify unsafe staff members.	0
Most witnessed patient safety events that occur in healthcare settings are reported.	0
Incident reports should only be submitted for incidents that cause severe injury.	0

Question 6- Which electronic system is used at [organization] for voluntary incident reporting?

Quiz Answers	Counts
EPIC	2
MIDAS	26
Performance Manager	0
ADP	0