Table B.58: Infusion Pumps, Staff Education and Training—Single Studies

Note: Full references are available in the [Section 12.2 reference list](#Section12point2refs).

| Author, Year | Description of Patient Safety Practice | Study Design; Sample Size; Patient Population | Setting | Outcomes: Benefits | Outcomes: Harms | Implementation Themes/Findings | Risk of Bias (High, Moderate, Low) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Carayon et al., 201014** | Nurses attended training sessions on smart intravenous (IV) pump use that occurred the week before pump implementation. Training consisted of hands-on skills training provided by nurse super-users and an optional computer-based training module. | Data were collected in three longitudinal surveys: pre-implementation of smart IV pumps and 6 weeks and 1 year post-implementation.  Sample of nurses that responded to the surveys: pre-implementation survey (n=190, response rate: 32%), 6-week-post-implementation survey (n=322, response rate: 31%), and 1-year-post-implementation survey (n=399, response rate: 38%). | Academic hospital. United States | Overall, nurses’ acceptance of the smart pump technology was positive and improved over time.  Respondents rated the information they received about pump implementation as more useful before implementation than 6 weeks after.  “Learning to operate the pump” became easier 1 year after implementation, compared to either before or 6 weeks after implementation. | Respondents reported that the training materials were more confusing in the 6-week and 1-year-post-implementation surveys. | Nurses reported more negative perceptions of the smart IV pump implementation process (e.g., usefulness of information received about pump implementation and clarity of training materials) 6 weeks after implementation, compared to what they perceived before implementation. This suggests more attention should have been devoted to the implementation process, especially regarding information and training materials. | Moderate |
| **Ferguson et al., 20104** | Hospital was following all the patient-controlled analgesia (PCA) guidelines recommended by USP except for annual retraining staff on the proper usage.  Established mandatory training by nurse educators of registered nurses (RNs) who used PCA pumps. Participants were required to return within 1 hour of the review to demonstrate proper programming of a preprinted order set into the PCA pump without any assistance from the educator. All staff members were required to complete an online module and test. | Quality improvement (QI) project. Examined PCA errors in the pre-intervention and post-intervention periods to determine effectiveness of mandatory training.  Pre-intervention data were collected from June to August 2006 and post-intervention from June to August 2007. The educational intervention occurred from January to April 2007. | Small Midwestern hospital with 22 patient care units. United States | Significant decrease from eight errors reported in the pre-intervention period to one in the post-intervention period. | Not provided | Results show that the educational intervention was effective in deceasing PCA pump errors.  Adding additional mandated education programs must be carefully considered. Combining QI data with education initiatives can help provide objective measures that resources are well spent. | Moderate |
| **Gavriloff, 20128** | Staff education focusing on correct use of the safety software and the benefits of preventing medication errors.  Super-user training for medical safety champions and education on the patient care units for nurses. | Performance improvement project using plan, do, study, act (PDSA) methodology. | 359-bed pediatric hospital. United States | Within 2 months, 100% of RN staff were educated and the content was fully incorporated into nursing orientation.  Adherence rate was 68% 1 month after staff education was completed, an increase from 28% at baseline. After the chief nursing officer sent a followup email encouraging nurses to use the medication safety software, adherence increased to 85%. In the following months, adherence continued to remain above 85%.  Education on the smart pumps allowed for any safety concerns to be easily communicated and provided closed-loop communication with the nurses. | Not provided | The combined use of staff education, improving communication, programming strategies, medication safety champions, adherence monitoring, and technology acquisition increased nursing adherence to a rate consistently above 85%.  Staff education that focuses not only on the “how” to use the smart pumps but also on the “why” it is used is important to increase medication safety software adherence. | Moderate |
| **Giuliano, 20156** | Study aimed to measure the impact of user training on programming times and use errors. User training consisted of a brief training, according to manufacturer’s instructions, on the IV medication tasks being used in the study. | Pilot study using within-subjects design. Study measured differences in programming times and frequency of programming errors for three IV smart pumps.  Fifteen critical care nurse participants completed five programming tasks in a simulation laboratory. | Study participants were recruited from Boston-area hospitals.  Data collection took place in a simulation laboratory. | Programming time for all five tasks across the three pumps was shorter after the user training. Majority of the tasks had a statistically significant time difference.  The percentage of use error decreased after user training for all three IV smart pumps: pump A, 30% to 7%; B, 17% to 3%; and C, 8% to 1%. | Not provided | Findings support the value of proper user training in helping clinicians learn to operate the IV smart pumps in a more time-efficient manner and make fewer use errors. | Moderate |
| **Herring et al., 20129** | Hospira Plum A+ smart pumps were implemented, and education about safety feature use was provided to bedside patient care nurses at program initiation through online computer modules designed by manufacturer.  The researchers surveyed nurses and identified education and training as an obstacle to smart pump utilization. Over a 6-week period, a pharmacist provided education to target identified obstacles. Active learning, practical skills lab mandated for all institutional nurses. The skills lab included hands-on scenarios for programming, troubleshooting tactics, and hypothetical situations. Cardiovascular nurses were offered an optional educational presentation on use of safety features. | QI cross-sectional study.  Rates of use of the delivery modes were captured through a wireless database.  Nurses were surveyed to identify obstacles in the cardiovascular service clinical care areas; 35 of 60 nurses (58%) responded.  Based on survey results, interventions were designed to target education and burden of use. | Academic center hospital (689 beds). United States | The majority of survey respondents agreed or strongly agreed that training and education were adequate, the drug library enhanced patient safety, and they knew how to use the drug library.  Use of “with limits” mode (when all safety features are applied) increased from 5.5% to 30.5% after educational interventions. | Of the free-text survey comments, 44% requested additional training on the safety features. | Survey results indicate that education from the manufacturer alone may be insufficient. Supplemental hands-on training significantly increased safety feature use.  Overall use was still low. One explanation may be related to the procedure for smart pump data entry. | Moderate |
| **Lee, 201013** | Audit and response to findings, including standardized settings and controls to ensure consistent operation of pumps. | Conducted an audit and then developed coordinated approach in response | Two acute hospitals within a National Health System Trust, South Wales. | A series of training days and standardized practices were developed to ensure operators had a clear understanding of the limitations and correct procedures for setting up these devices. | Audit showed staff were being deployed to other wards and exposed to new devices they had not been trained to use. | Using a coordinated approach to replace infusion pump devices and setting short and long-term goals can be an effective way to manage risks. | Moderate |
| **Luctkar-Flude et al., 201211** | Online virtual IV pump educational module for undergraduate nursing students.  Participants assigned to the experimental group were required to complete the virtual IV pump educational module. | Twenty-six nursing students in control group and 17 in the experimental group  All participants completed an IV Pump Skills Self-Confidence Survey. Experimental group completed a Virtual IV Pump Educational Module Satisfaction Survey.  Lab research assistant evaluated student performance of IV pump skills. | Academic hospital, Canada. | Majority of students felt the module enhanced their knowledge of programming the IV pump and felt the virtual IV pump module was convenient and easy to use.  Overall, students in the experimental group had higher performance scores than those in the control group; however, they took longer to perform skills. Difference was not statistically significant.  Experimental group participants scored significantly higher than control group participants in programming a continuous medication infusion. | Most students did not feel the module enhanced their ability to program a basic infusion, secondary medication bolus, or continuous medication infusion. | Findings suggest there is value in providing virtual online education module in the nursing skills lab. | Moderate |
| **Nemeth et al., 201410** | Research to understand the effect of introducing a smart pump through a naturalistic look into the experience of those who use it. | Mixed-methods field study combining 9 hours of observation, formal interviews, and Cognitive Task Analyses  Sample: 9 nurses, 1 biomed engineer, 1 pharmacist. | Midwest tertiary care hospital. United States | The study found that, in the opinion of nurse study participants, the implementation of the smart pump has so far been a substantial success. | The research team found that there is a need for further investigation into system, performance, and organizational factors that affect nurses’ understanding of how the smart pumps operate. | In training, nurses should hear information about the most relevant functions and potential challenges that they may encounter, and have opportunities to apply learning through case examples. | Moderate |
| **Orto et al., 20157** | Study aims: (1) develop a nurse-led smart pump champion group and (2) revise existing protocol on IV therapy to integrate use of smart pumps.  Two nurse directors trained the champion group to educate coworkers.  Nurse champions in each unit conducted monthly education sessions.  Over the 6 months of intervention, the champion group provided education to registered nurse (RN) staff individually and in groups to ensure that all RNs were using the smart pumps and associated drug libraries. | QI project: Single cohort pre/post design.  600 direct-care RNs. | Fourteen nursing units in a southeastern community hospital. United States | Overall hospital compliance rate post-implementation was significantly improved (increase from 83.5% to 92%).  Costs avoided because severe harms were averted were $367,500 at the end of the intervention period compared with $612,500 6 months before the intervention.  Severe harms averted dropped from 0.68 to 0.44 post-implementation. | Not provided | Development of a nurse-led champion program led to a significant improvement in compliance and decrease in number of severe harms.  Nurse managers created a culture of safety and coached staff who were not compliant with smart pump drug library use. | Moderate |
| **Quattromani et al., 201812** | Study objective was to determine if the smart pump app is an effective and engaging educational tool for nursing students compared to existing traditional training methods.  Traditional training consisted of small groups of students with one faculty member going over smart infusion pump training using a single smart infusion pump device per two students.  The interventional group training consisted of small groups of students each using the mobile app smart pump training on a tablet. The smart pump app is an interactive self-contained learning encounter built on a mobile platform and designed for nurses. The app takes the students through each step of smart pump programming and allows for interactive trial and error, | Randomized controlled trial Students were randomized into either the traditional group or the intervention app group.  Eighty-seven nursing students were assigned to the traditional group and 94 to the app group. | Large urban school of nursing simulation center in the Midwest. United States | Participant feedback on the app was overall positive, and 70.2% strongly agreed or agreed the app was easy to use. | There was no significant difference in outcomes of medical knowledge, simulation performance, and learner confidence.  Students gave neutral ratings to whether they would like to use the tablet app teaching method more frequently and whether they will feel more comfortable at a patient’s bedside as a result of using the app. | Study did not find significant differences in learner-centered outcomes or performance measures between the traditional teaching methods and app group. | Moderate |
| **Subramanyam et al., 201615** | Educated anesthesiologists and certified registered nurse anesthetists (CRNAs) who regularly provided anesthesia about the importance of safety checks to reduce medication errors.  Educated stakeholders with a job aid (anesthesiologists, CRNAs, RNs) about the use of standardized pump programming, and RNs about anesthesia medications. | QI project using PDSA cycles. | Urban tertiary pediatric academic care center, anesthesia department. United States | Implementation of two- person verification resulted in >90% medication programming being double-checked prior to administration. | Cultural resistance to changing to two-person verification process. This challenge was discussed at departmental meetings. | A standardized team-based approach decreased the number of medication errors by early identification of programming errors. | Moderate |
| **Van der Sluijs et al., 20195** | Implemented standard protocols on how to change syringes and a fixed, dedicated moment to perform double-checks.  Used a Lean coach, a formally trained employee who supports Lean projects in hospitals, to support efforts. | Pre-post observational study; used Lean philosophy.  Measured impact of interventions by performing unannounced sequential audits. | Tertiary care university hospital, 32-bed mixed medical surgical intensive care unit (ICU), Netherlands. | Over 18 months, the overall percentage of errors dropped from 17.7% to 2.3%. | Not provided | Results show a Lean approach is successful in reducing the number of errors with the administration of medication with syringe infusion pumps in the ICU. | Moderate |