# The crucial link in successful smart pump adoption: The critical care nurse

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## Abstract

*Smart pumps have been designed to improve patient outcomes by reducing the number of adverse drug events related to intravenous (IV) pump medication administration. Smart pump-related technology such as two-way communication and integration with an electronic medical record system enable wireless drug library updates, automatic programming, and automatic documentation. These tools are available to critical care nurses to address problems related to manual processes while real-time dashboards and retrospective data collection allow for identification of trends to support ongoing process improvement. Adoption of smart pumps and related technologies is a major paradigm shift requiring ongoing communication, collaboration, and partnership to achieve sustainable impact on patient safety outcomes. In this paper, the authors discuss the phases of a smart pump adoption process and outline the role of the critical care nurse at each stage, from the selection of the right smart pump technology and related capabilities to drug library development, education, and continuous process improvement. The authors conclude that the critical care nurse is best positioned to take the lead in this safety initiative to achieve patient safety outcomes and zero IV pump-related errors.*

**Key words:** critical care nurse, smart pump technology, medication safety, continuous process improvement, outcomes, real-time data

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The past 15 years have seen extraordinary advancements in IV infusion pump technology, from smart pumps with dose error reduction software to those with wireless integration capabilities. These advancements were introduced to reduce the number of infusion-related adverse drug events, the frequency of which has been estimated to be between 265,000 and 500,000 annually (Trbovich, Jeon, & Easty, 2009). However, smart pumps alone do not guarantee enhanced safety, and those implementing smart pump technology have not consistently followed best practice processes for adopting and integrating this technology into practice (Karsh, 2004; Trbovich et al., 2009).

Improved patient safety outcomes are only possible when key individuals are involved in the adoption of smart pump technology. Critical care nurses are positioned to be key leaders in this safety initiative. They bring unique insight and can have the greatest impact throughout the pump adoption process because the majority of high-alert medication titrations and pump-related errors, as well as preventable IV adverse drug events, occur in critical care units (Bates et al., 1995; Goulding & Bedard, 2015; Murdoch & Cameron, 2008; Nuckols et al., 2008; Rothschild et al., 2005).

Traditionally, the critical care nurse participates, as part of an interdisciplinary team, providing input on drug library development, the implementation roll-out, and ongoing use of smart pumps (Institute for Safe Medication Practices [ISMP], 2009). However, the treatment of a smart pump implementation as a safety initiative requires a strong clinical team leader, committed to a culture of safety, with an understanding of the day-to-day workflow with smart pumps, and appreciation of the impact of change on the daily routine. Most importantly, this person must be someone who will continually advocate for the end users of smart pumps—the front-line nurses—and for their patients who will benefit from the safer medication administration practices. The critical care nurse is the ideal choice to lead the interdisciplinary team towards the goal of enhanced patient safety.

The authors in this paper describe the key components of a successful smart pump adoption process, focusing on the crucial role of the critical care nurse as a communicator, collaborator, and leader in the pursuit of improved patient safety, and outlines the role of the critical care nurse at each stage, from the selection of the right smart pump technology and related capabilities to drug library development, education, and continuous process improvement.

## Evaluation and selection

Institutions understand the need for nursing collaboration in the evaluation and eventual selection of equipment for their units (Harding, 2012; Longshore, Smith, & Weist, 2010). However, the impact of a change in both equipment and practice in the critical care is significant due to the high incidence of IV infusions and associated pump alerts and errors in the ICU (Murdoch & Cameron, 2008). Throughout the smart pump evaluation and selection process, the critical care nurse critically evaluates the core capabilities of any proposed equipment with a critical eye and determines how the practical application of smart pump technology will affect the workflow in a fast-paced, high-tech environment infusing high-alert medications. To help identify potential obstacles to successful smart pump adoption, the following questions should be asked: Is the user interface intuitive? Is there a protocol for drug library use

and when it can be bypassed? Is dual verification for specific drugs and/or soft limit overrides required? When transferring patients, what is the procedure to change the care unit library? How is feedback on drug library parameters received from end users? Is the process for making drug library changes manual or wireless? How are drug library updates communicated and how is it verified that all pumps are updated with the current drug library during active infusions? Once these questions have been addressed, the critical care nurse can help determine if the institution is ready to adopt and fully benefit from advanced smart pump capabilities, including but not limited to the following technologies.

**Wireless Drug Library Updates**

The ability to update the drug library wirelessly has long been identified as an essential smart pump selection criterion (ISMP, 2009). Manually updating the drug library is both a labour- and time-intensive process and regular maintenance of the drug library is imperative for compliance and patient safety initiatives. However, additional personnel and resources are necessary to ensure ongoing success.

**Electronic Medical Record (EMR) Integration**

Two-way communication between integrated smart pumps and the EMR enables three automated processes: (a) programming, (b) documentation, and (c) notification. These processes integrate pump capabilities with computerized provider order entry (CPOE), bar code medication administration (BCMA) technology, and the institution's EMR system for a comprehensive IV medication management system. The critical care nurse is best positioned to understand the advantages and disadvantages of these automated processes and evaluate whether the institution is ready to adopt two-way communication and EMR integration into the current clinical workflow and current practice.

***Programming.*** Automatic programming allows an infusion order entered via the CPOE to be sent to the pump using BCMA technology. This avoids manual programming and helps to ensure the "right patient" receives the "right medication" and the "right dose" at the "right time" (Beattie, 2005). Automatic programming requires the nurse to use a handheld bar code scanning device to scan his or her clinician identification badge, the patient's identification bracelet, the medication label, and the smart pump itself. Following these steps the infusion order is sent to the pump. The nurse then verifies key parameters including the drug name, concentration, and dose rate, and starts the infusion. In the critical care setting, many infusions require dose and/or weight-based calculations that demand several steps in a manual programming system. Automatic programming could significantly enhance efficiency and safety. However, given the use of high-alert medications in critical care, clinical leaders will need to address potential workflow challenges with the high number of titrations to patient effect, what to do in urgent/code situations, and how to address ongoing fluctuations in a patient's weight.

***Documentation.*** Automatic documentation has the potential to save significant critical care nursing time. This feature transmits infusion data from the smart pump to the patient's electronic medical record, which is then verified by the bedside nurse. This transmitted data may include start and stop date and time, changes to dose and rate, total volume and dose infused, when the infusion was placed on hold/standby mode, bag and syringe changes and all loading doses and boluses administered.

It has been reported that as much as one hour of nursing time is spent charting for every hour of patient care (American Hospital Association, 2010). Automatic documentation offers instant and accurate charting that decreases nursing time spent manually tracking and recording infusion data. For critical care nurses, this could be a significant advantage. The automated documentation feature records all inputs from all of the continuous and intermittent infusions for shift and dose totals, allowing the nurse to verify, electronically sign and enter the data into the electronic medical record with a click of a mouse. In addition to the time that is saved, automatic documentation enables the nurse to backtrack and view accurate time records of titrations and/or boluses following an urgent or code situation. This can eliminate the need to keep error-prone, manually produced paper records that must be transcribed to charts. Automatic documentation has the added benefit of combining the infusion data with data from other integrated systems, such as vital sign monitors and lab results, to provide a fuller picture of the patient's status at any given time.

The critical care nurse leading the selection team must also consider the limitations of the technology, including whether all infusion data can be sent, if data is sent in real time or only at specific intervals, and how data is recorded if there is loss of pump-server communication, (such as during transport).

***Notification.*** Finally, automatic notification can improve alarm management and safety. The automatic notification feature remotely alerts critical care nurses of pump alarms by sending a message to the server, which then transmits the message to a mobile device or other application. This is particularly important in the critical care environment, where alarm incidence has been reported to be as high as 45 times per patient per hour (Cho, Kim, Lee, & Cho, 2016) with as many as 77% of these critical care alarms perceived as ineffective or ignored (Görges, Markewitz, & Westenskow, 2009). The types of alarms transmitted can be customized making it possible to prioritize and escalate key alarms directly to the nurse, which can help improve response time to address critical infusions.

During the implementation phase, the critical care nurse is best positioned to lead the creation of a standard decision chain for alarm prioritization and appropriate response. The critical care nurse has a unique understanding of how a smart pump and its associated capabilities of automatic programming, automatic documentation, and automatic notification might impact nursing workflow, efficiency, and safety in one of the most challenging clinical environments. This perspective makes the critical care nurse the ideal person to play a lead role in the evaluation and selection phase of smart pump adoption.

## Implementation

### Drug Library

Drug library development is one of two key processes in the implementation phase that influences whether a smart pump adoption is successful. (The second is the education plan, which will be discussed later in this paper.) "The establishment of a safe, practical, and effective customized drug library is critical to the successful utilization of smart infusion pumps" (ISMP, 2009, p. 13). The collaboration with pharmacy provided by critical care nursing throughout the development of the drug library ensures the active voice of nurses in the process and improves the likelihood of acceptance and use by end users (Karsh, 2004). Drug library use continues to be a major obstacle to achieving success after smart pump implementation, with low reported compliance rates of 8%–46% (Blum, 2015; Breland, 2010; Siv-Lee & Morgan, 2007; Trbovich et al., 2009). Involving nurses in the drug library creation process empowers staff to own the long-term success of this important infusion therapy patient safety initiative by encouraging ongoing participation in process improvements to achieve continuous improvement targets (Karsh, 2004; Vitoux, Lehr, & Chang, 2015).

The number of high-alert and high-risk IV medications administered by critical care nurses have provided them with the knowledge and expertise to contribute clinical input and leadership during the drug library development process. They work in collaboration with pharmacy to identify key areas of standardization, ensure alignment between policy and practice, establish relevant clinical advisories, set hard and soft dosing limits, and validate all aspects of the final drug library.

***Standardization***. The development of a smart pump drug library can be the impetus for the standardization of medication concentrations, dosing units/parameters, and medication administration practices. The use of standard concentrations for IV infusions simplifies and avoids dosing errors. Concentrations should be standardized across care areas as much as possible and limited to two per drug (ISMP, 2009) with exceptions made for specialty areas such as pediatrics with weight-based concentrations. This significantly impacts critical care where multiple concentrations are typically used. Dosing units should also be standardized to avoid the use of multiple dosing methods of the same drug, such as propofol in both mcg/kg/min and mg/hr. A key consideration during the standardization process is whether infusion policies and procedures reflect current clinical practices. The critical care nurse has extensive exposure to the institution's ordering and administration protocols for specialty infusion practices including loading and bolus dosing, titrating/weaning to patient effect, as well as protocols for anticoagulation, thrombolytic therapy, sedation, pain, and insulin. This experience makes the critical care nurse vital to ensure that the final drug library mirrors current practices. When accomplishing this, the critical care nurse must anticipate and minimize situations where work-arounds might occur, and create practical solutions to optimize institution-wide adoption.

***Policy and practice alignment.*** Development of a smart pump drug library can reveal incongruence between policy and clinical practice. At one hospital, an old insulin policy accounted only for insulin administered via IV push. But physicians and nurses in critical care followed a protocol for administering insulin bolus doses via the infusion pump when the patient was on insulin infusions. The critical care team leader identified this gap, revised the policy, and advised the pharmacist to activate the insulin bolus feature in the pump library, ensuring safe delivery of insulin boluses on the pump. In another hospital, the pharmacy team restricted sodium bicarbonate administration to a primary infusion only. But critical care nurses had been using the piggyback mode to deliver the sodium bicarbonate loading dose, automatically reverting to the sodium bicarbonate primary infusion. In this example, critical care nursing did not assume a collaborative role in the drug library development, so this gap was missed, resulting in nurses bypassing the library to deliver sodium bicarbonate. Open communication and collaboration between nursing and pharmacy was required to resolve the issue so that the library could be adjusted appropriately.

***Effective clinical advisories.*** During smart pump programming and use, clinical advisories provide critical medication infusion information at the time of drug selection. A pop-up advisory appears as the clinician programs the pump that must be acknowledged prior to advancing through the programming sequence. Because these advisories deliberately interrupt the sequence, they should provide new or unique practice information necessary for safe administration. Examples of effective advisories include: "This infusion requires a 0.22 micron in-line filter," "This infusion requires UV protection," and "New standard concentration for this medication." The change to a new or single preparation can be a major shift in practice, especially if the concentration is different and results in new dosing rates.

Ineffective advisories can increase programming time by forcing the nurse to acknowledge redundant and ineffective advisories every time the drug is selected. Examples of ineffective advisories include: "high-alert drug" because most drugs in the library are high alert, "verification by two RNs" for all drug entries, and "change tubing every 24 hours" because this advisory is only prompted at the initiation of therapy, not 24 hours later. Ineffective advisories can create an unnecessary burden that could lead nurses to view all advisories as non-credible and ignore them, or bypass the drug library all together. Critical care nurses can help identify where advisories will encourage best practices while eliminating those that would increase programming time.

***Soft and hard limits.*** The development of soft and hard limits for each drug entry can be very challenging and requires collaboration between critical care nursing and pharmacy. Soft limits provide a warning, but can be overridden, while hard limits cannot be bypassed. Titration and weaning practices often require doses below the low soft minimum limit or above the soft maximum limit. Soft minimum limits should be avoided for vasopressors such as dopamine or norepinephrine that are often weaned off in incrementally decreasing doses. Soft

maximum limits have been shown to be ineffective in preventing dosing errors because they can be ignored and overridden, whereas hard limits do not allow clinicians to proceed with an unsafe dose (Trbovich, Pinkney, Cafazzo, & Easty, 2010). However, many institutions are reluctant to impose hard limits for fear of limiting dosing in emergency circumstances and compromising patient care. The Institute for Safe Medication Practices (2009) suggests initially setting hard limits to avoid catastrophic events, and evaluating and adjusting those limits over time in collaboration with the critical care nurse in order to better reflect safe dosing ranges. In a number of hospitals, the authors have observed high-risk medications that are often used in critical care settings, such as fentanyl, dopamine, norepinephrine, esmolol, and diltazam, are initially set with a hard maximum limit of 9.9 times the regular dose to avoid a 10-fold programming error.

***Drug library validation.*** A drug library validation workshop provides a forum for critical review of all drug library entries and configuration settings by clinical end users that helps to ensure that any issues with the drug library parameters are identified prior to deployment of the smart pumps. During the workshop, each entry in the drug library is reviewed by selected members of front-line staff to ensure that both the drug library reflects current medication administration practice and optimizes safety and best practices. Common items for review include drug name and order in the list, concentrations, therapy modes, bolus options, soft and hard limits, and advisories. The drug selection and programming sequence on the pump can be verified by clinicians at this time to validate any care unit specific settings, default doses, and alarms. The workshop provides a forum for open communication and collaboration to evaluate and create new protocols, improve drug library workflow, and encourage standardization across care units. Adjustments are made, approved, and incorporated into the education plan.

### Education Plan

Education is the second key component of successful smart pump implementation. Documented successful outcomes have required mandatory, hands-on training for all staff—as much as two-and-one-half hours training for super-users—supplemented with continuing education to maintain competencies and optimize use (ISMP, 2009; Larsen, Parker, Cash, O'Connell, & Grant, 2005; Longshore et al., 2010; Ruhl, 2013). Examples of education plans include self-paced fundamental eLearning followed by classroom simulation-based learning lasting one to two hours.

In the role as team collaborator, the critical care nurse communicates to all staff that the new technology is not "plug and play" and that the new smart pumps signify a fundamental shift in the workflow and nursing practice of medication administration. Successful implementation requires that the entire staff be engaged in a structured learning process that ideally includes simulation-based clinical scenarios where nurses will practise each step of medication administration from verification of orders and titrations to trouble-shooting and alarm management (ISMP, 2009).

Because the extra programming steps to use the drug library have been shown to be a barrier to drug library use (Rothschild et al., 2005), training should include the importance of the new smart pump technology, as a key patient safety initiative (Edmondson, Bohmer, & Pisano, 2001; Longshore et al., 2010). Messaging and clarity of purpose for the new smart pump technology can help drive staff acceptance, positive attitudes, and accountability for success (Karsh, 2004). The critical care nurse must serve as a role model to his/her peers and patient advocate during training, promoting the safety benefits of the drug library, and warning of the consequences of not fully adopting the new patient safety technology (Harding, 2012, Longshore et al., 2010). Beyond smart pump implementation training, the critical care nurse should continue to foster organizational commitment to the routine use of the smart pump capabilities in order for the focus to shift from the initial implementation to continuous infusion therapy patient safety.

## Continuous process improvement

### Collaborative Approach

The success of the smart pump technology requires an evolving process that includes a strategic and collaborative approach by nursing, pharmacy, biomedical, and information technology to support and sustain infusion safety. The continuous process improvement team will need to identify how to measure success and establish achievable outcomes, such as drug library compliance, alert and alarm reduction, and medication error reduction. New protocols may need to be developed that take full advantage of smart pump technology with continual refinement of soft and hard limits for specified drugs and care areas. Policies must be implemented for urgent versus routine drug library updates, and a committee established to determine the frequency and responsibility for reviews of the drug library (ISMP, 2009).

As new protocols are developed and the drug library is updated, the critical care nurse should play a key role in disseminating the information to front-line staff. Ongoing engagement from super-users and front-line staff is needed to avoid reverting to outdated and unsafe practices. Education for new staff and regularly scheduled review sessions for existing staff should be structured on the same principles of blended, simulation-based learning.

### New Insight Through Data Collection

Following implementation, the critical care nurse is positioned to support compliance monitoring, dosing error aversion, alarm management and infusion management efficiencies. Experience, observational skills, and good instincts are all helpful in this regard, but a system of smart pumps with two-way communication can provide the critical care nurse with new insight that can drive safer practice (ISMP, 2009). The critical care nurse can view infusions by hospital, care area, or department from workstations or monitors throughout the institution in real time. Real-time information includes dose/rate with an indicator if outside the limits, drug library compliance, infusion or alarm state, and the remaining volume or time before infusion end.

While real-time data is immediately useful to the critical care nurse, retrospective infusion data is also available with

a smart pump system with two-way communication that assists in identifying infusion management trends and practices. Historical data are collected and assembled into specific reports for viewing and distribution. Reports may include drug library utilization, pump utilization, bolus activity, dosing alerts and overrides, and top pump alarms. Most of this data can be filtered to a specific timeframe and/or by selected care units, patient, or clinician. These infusion pump data are useful in identifying trends with smart pump use, determining the need for additional pumps, quantifying averted errors, unveiling at-risk practices, reviewing pump programming history for event investigation or device performance trouble-shooting, and identifying opportunities for library adjustments to optimize use and minimize alarm fatigue. These report tools can be used by the critical care nurse to advance continuous process improvement.

**Communication**

Information gleaned and lessons learned during the implementation phase must be communicated back to the front-line staff. Errors should be analyzed and "good catches" shared, especially those associated with at-risk behaviours or specific patient populations, for the purpose of improving smart pump processes within those areas. Dedicated critical care nurses can analyze the data and identify areas for improvement, then work collaboratively with the drug library development and sustainment team to create an action plan, including any changes in protocol/practice, interventions to be implemented, and how the impact of such changes will be measured. The critical care nurse is well positioned to advocate for continuous improvement and lead the ongoing safety initiative.

## Conclusion

Smart pumps with advanced technologies such as dose error reduction software, two-way communication and EMR integration provide tremendous opportunities to improve safety and efficiency. Historically, there have been no parallel advances in patient safety that mirror the technological leap from basic IV pumps to smart IV pumps with dose error reduction software. Institutions are investing millions of dollars annually in smart pump technology, but the technology alone is not the solution to adverse drug event reduction (Trbovich et al., 2009). Communication, collaboration, and interdisciplinary teamwork are necessary to convert that investment into a sustainable improvement in patient care. Studies have demonstrated that the active participation and leadership of critical care nurses in the smart pump selection, implementation, and continuous process improvement journey leads to successful smart pump adoption outcomes, including achieving drug library compliance rates as high as 100% and averting a significant number of medication errors (Longshore et al., 2010; Raso, Velletri, & DiCrescento, 2007; Ruhl, 2013). The critical care nurse is best positioned to take the lead in this fundamental shift toward patient safety outcomes and zero IV pump-related errors.

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*CACCN calendar of events*

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**Jan. 10–Mar. 1:** Spring CNA Certification Applications opens
**January 31:** Dynamics 2018 Call for Abstracts deadline
**January 31:** Sage Poster Bursary Application deadline
**January 31:** CACCN Educational Award deadline
**February 15:** CACCN Research Grant Application Deadline
**March (tbd):** BOD F2F Meeting
**May 1–15:** CNA Certification Examination Dates
**May 31:** Chapter of the Year Award Application deadline
**June:** Dynamics 2018 Conference Brochure/Online Registration available
**June 1:** Brenda Morgan Leadership Excellence Award deadline
**June 1:** Spacelabs Healthcare Innovative Project Award deadline
**June 1:** CACCN "Chasing Excellence" Award deadline
**June 1:** BBraun "Sharing Expertise" Award deadline
**June 1–Sept. 10:** Fall CNA Certification Applications opens
**July 5:** Board of Directors Nominations deadline

## Dynamics of Critical Care Conference: Future Sites

**Dynamics 2018:** September 2018, Calgary, AB

**Dynamics 2019:** September 2019, Halifax, NS