

# Improving Care through Innovations in Infusion Systems

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Infusion devices are essential to modern medical care. One or more infusion pumps are found at almost every patient's bedside, delivering fluids ranging from saline to high-risk chemotherapies. These infusions go directly into the patient and require the highest level of safety, accuracy, and reliability.

Infusion devices have advanced from basic machines that accepted any programmed dose or rate to "smart" pumps designed to help avert programming errors. However, more advanced features, such as smart pump–electronic health record (EHR) interoperability and infusion dashboards, are not part of vendors' standard offerings and therefore are not ubiquitous across all care centers. A contributing factor is that the vast majority of today's smart pumps are running on system architectures that are 20 or more years old.<sup>1</sup>

It's time to take the next step and reengineer infusion systems from the ground up using new architectures that allow for critical innovations to be built into the infusion system itself, rather than relying on other systems to make the necessary advances.

Innovative infusion systems could potentially have the ability to gather data from multiple systems, correlate near-real-time data for clinical decision making at the bedside, and analyze retrospective data for long-term quality improvement initiatives. With such systems, clinicians would no longer have to think about whether a recent laboratory result necessitates a change in dosage, and pharmacists would no longer have to wade through a flood of data to identify waste and opportunities for improvement. All of this information could be brought to their attention. Devices that support this shift could move infusion delivery from the age of interfaces and data to the age of advanced interoperability and knowledge.

This article will describe the need for improvements in infusion delivery, the limitations of legacy systems to prevent

programming errors, and advances that could be achieved through the development of innovative infusion systems that have been designed from the ground up to provide the integration and analytics needed for today's world. Finally, five essential elements of infusion-related knowledge are presented as a possible framework for considering what is needed to help optimize the discipline of informed decision making through knowledge.

## Need for Improvement in Infusion Delivery

More than 90%<sup>2</sup> of hospitalized patients receive one or more infusions to deliver fluids and medications,<sup>1</sup> ranging from saline, to high-risk-of-harm therapies (e.g., heparin, insulin, morphine, fentanyl, propofol, midazolam),<sup>3-5</sup> to high-cost regimens (e.g., chemotherapy). Errors related to the intravenous (IV) route of administration often result in the most serious outcomes for patients.<sup>6</sup> The Institute of Medicine (IOM) estimates that at least 1.5 million preventable adverse drug events (ADEs) occur within the U.S. healthcare system every year.<sup>7</sup> Data from a major teaching hospital indicate that 61% of serious and life-threatening errors are associated with IV medications.<sup>8</sup> The IOM further estimates that infusion-related ADEs add more than \$2 billion (in 2006 dollars) to U.S. healthcare costs annually.<sup>7</sup> With current technology, clinicians often cannot accurately capture the information needed to ensure reimbursement for infusion-related charges. This can cost hospitals hundreds of thousands,<sup>9</sup> if not millions, of dollars each year.

## Need for Innovation in Infusion Delivery

The vast majority of smart pumps today were developed on architectures from the previous century.<sup>1</sup> They have limited ability to collect granular infusion and alarm data over long periods of time, much less use externally

sourced patient information that might influence the delivery of the infused medications. Despite the introduction of drug libraries, these devices have limited ability to address the need to reduce infusion-related ADEs considerably.

Healthcare has become increasingly data driven, with clinicians receiving assistance from clinical decision support tools. However, little is being done to improve the real-time decision-making capabilities of medical devices themselves, though such improvements could have a substantial impact on patient care. This is particularly true in the area of infusion delivery. An innovative infusion system could exchange a wide variety of patient information with other hospital systems without the need for complicated middleware and would be able to analyze and present this information in a way that would help clinicians make more informed patient care decisions.

A major innovation would be to include a comprehensive suite of built-in, end-to-end clinical applications that would provide previously unavailable information through the infusion system itself, both remotely and at the point of care. This new world of infusion management could spark a transformation in data, interfaces, and interoperability, ushering in a new era of data-based knowledge and informed decision making.

### Real-Time Data for Clinical Decision Support

In a 2014 interview with *EHR Intelligence*, Nicholas Desai, chief medical information officer for the Houston Methodist Health System, said, “As a provider, having information at your fingertips is probably the most important piece, which most people take for granted.”<sup>10</sup> With more comprehensive and timely infusion information available both at the bedside and on mobile devices, care providers could make better, more informed decisions.

However, an abundance of information is not useful to clinicians if it complicates the care process. For this reason, information needs to be presented in a concise and

intuitive way that is easy to understand and respond to. Along with simplicity, solutions that are centered on patient care and get the technology out of the way are essential. For infusion pumps, this would include embracing some of the simple user interface concepts found in smartphones, such as the use of touch, color, and simple workflows. Similar to smartphones, infusion pumps could be enhanced greatly by bringing information to a user’s fingertips while presenting that information in a way that simplifies the decision-making process.

Infusion systems could go further by providing this same presentation of information when not in the patient's presence. Today, infusion systems provide only limited visibility to infusion data; therefore, clinicians need to enter the patient’s room to review the progress of an infusion or the nature of an alarm. This lack of visibility has a direct impact on clinical vigilance and nurses’ ability to make effective, timely decisions, particularly when they are caring for multiple patients. Although add-on technologies may help mitigate this problem, built-in capabilities have the potential to provide greater value at a cost point that

makes this increased visibility available to a broader number of healthcare providers. Mobile access to infusion information would improve workflow substantially, reducing disruptions for nurses and enabling some decisions to be made away from the patient's bedside.

For example, if an alarm sounds in a different room while a clinician is caring for a patient, three options are available: 1) ignore the alarm and finish caring for the patient; 2) rely on someone else to address the issue, which may or may not happen in a timely manner; or 3) interrupt the care currently being given to attend to the alarm in the other room.

None of these options is ideal. However, with a remote-viewing device in hand, the clinician could easily assess the severity of the alarm and then decide on the best response.

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### Helpful Resources

The AAMI Foundation offers several guides and white papers on infusion therapy safety.

To download your free copies, please visit [www.aami.org/infusiontherapysafety](http://www.aami.org/infusiontherapysafety).

Built-in capabilities for mobile monitoring and notification systems also could streamline other workflows. For example, the system could notify the nurse as a bag nears empty and notify the pharmacist when an expensive medication should be redispensed. Such workflow changes could make clinicians more effective and open the door to things such as just-in-time dispensing of medications.

Even simple forms of data exchange can enhance infusion systems' safety and effectiveness. For example, an infusion system that integrates with a hospital's admissions, discharge, and transfer system could provide the means to associate each infusion with a patient and his/her demographic information. This innovation would make it possible for the infusion system to send alarm data with the patient's identifying information to the EHR, as well as to clinical workflow and nurse call systems, enabling these downstream systems to make effective use of the information.

An infusion system that is aware of the patients being infused could conceivably correlate infusions being administered across multiple pumps, highlight potential issues (e.g., inadvertent double dosing of medications), and give care providers a patient-centered view of their infusions. Although enabled through integration, the value provided revolves around acquiring greater clinical knowledge and improving healthcare providers' ability to focus on the treatment of patients.

With increasing levels of integration, an innovative system could provide increasing clinical value. Information related to a patient's allergies, laboratory results, or other medical conditions could be used to highlight other potential risks related to current or planned infusions. An infusion system's ability to correlate patient information from the EHR with its own, more granular infusion information provides multiple opportunities to contribute to safe and effective delivery of infused medications. As stated by the Centers for Medicare & Medicaid Services, "When clinical decision support is applied effectively, it increases quality of care, enhances health outcomes, helps to avoid errors and adverse events, improves

efficiency, reduces costs, and boosts provider and patient satisfaction."<sup>11</sup>

### Retrospective Data for Long-Term Improvement

Looking back and making changes based on lessons learned is another way that more readily accessed clinical information could be used to improve the safety, quality, and cost of infusion systems. Using information in this way is referred to by many in the industry as clinical and business intelligence (C&BI). The Healthcare Information and Management Systems Society (HIMSS) defines C&BI as the "aggregation, analysis, and use of clinical, financial, operational, and non-traditional data captured inside and out of the healthcare setting to directly inform decision-making."<sup>12</sup> HIMSS asserts that C&BI "has the power to positively impact patient care delivery, health outcomes, and business operations."<sup>12</sup>

But as the saying goes, "The devil is in the details." To have a significant impact on infusion safety, hospitals need to better understand the details of those administrations when an ADE occurs. These details come from collecting and analyzing the way a pump was programmed, the type and amount of medication infused, if any alarms occurred, and how the care team responded. This level of detail does not make it into the patient record; however, if maintained in the right form in an infusion system, it would offer tremendous insights to care teams.

Consider the IV administration of oxytocin, a high-alert, very-short-half-life medication that causes uterine contractions. The drug is widely used to induce labor, but too much oxytocin can cause serious, unnecessary adverse effects in both the mother and baby. For example, infusing the drug too rapidly can cause much more forceful and frequent contractions. If the time for the baby to recover between contractions is insufficient, this can deprive the baby of blood and oxygen and lead to fetal distress. For the mother, too much oxytocin can increase the risk of complications, including postpartum hemorrhage and uterine rupture.

The typical recommendation is to start an oxytocin infusion at the lowest possible dose

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and then titrate upward to achieve the desired effect. Unfortunately, the pulsatile delivery of peristaltic infusion pumps sometimes creates the impression that the mother is not responding to the initial dosage, causing some healthcare providers to increase the dose. If an ADE were to occur, an infusion system that has collected all aspects of the infusion administration could be used to analyze the situation and identify possible solutions. With this knowledge in hand, clinical teams could more easily identify needed changes, such as using an infusion device with less pulsatile delivery, changing care practice, and/or offering additional staff training. Without this knowledge, needed improvements may go unnoticed for some time.

When considering C&BI solutions, it is valuable to provide information in a simple way that makes it obvious what actions are required. C&BI solutions therefore must predict the questions needed to be answered. For infusion delivery, these questions include:

- Is the root cause of an identified issue related to the drug itself, the rate at which it was delivered, an artifact of the peristaltic pumping mechanism, or some other factor that occurred during administration?
- Was the medication order administered as prescribed?
- Was the medication titrated up or down based on observation of the patient?
- Were clinicians' actions affected by advisories presented to them or by the protocols and procedures available to them?
- How many infusion-related alarms occurred and why? Were the alarms on the device in question and/or on other pumps in the room? Are an excessive number of alarms being caused by poorly defined pump settings? (For example, are overly restrictive occlusion settings triggering unnecessary alarms?) Can the pumping mechanism be changed to eliminate occlusion alarms?
- How responsive are clinical staff to alarms and alerts? Are excessive alarms causing alert fatigue, patient dissatisfaction, or an overload of distractions?
- From a forensics perspective, were alarms warning of a serious condition or creating a distraction that caused clinicians to fail to recognize that the condition existed? Did a distracting alarm generated from one patient cause the care provider to miss a more serious problem with another patient?
- How effective is the drug library? Are clinicians using the drug library or working around it? In what ways are they working around the drug library? Are the library's dosing limits too tight, resulting in frequent alerts during programming? Are clinicians frequently choosing to override the limits? Are their choices clinically valid?

These are important questions that, if answered, could lead to safer, more effective infusion delivery. However, providing answers often is not enough. Most care teams need a simple way to derive recommended improvements from the sea of available information that is presented in the context of the problem they are trying to solve.

In the case of drug library data, past systems have provided numerous reports to help care teams reduce drug library-related alerts. However, if this same information appeared within the context of the drug library tool and showed the effect of a change, care teams may be more likely to see opportunities for improvement.

### Five Essential Elements of Infusion-Related Knowledge

Similar to what HIMSS has described as the "CDS (Clinical Decision Support) Five Rights,"<sup>13</sup> the following five essential elements of infusion-related knowledge could serve as a possible framework for considering what is needed to support clinicians' ability to make better-informed patient care decisions by providing data-based knowledge when and where it's needed.

#### Right Data

Clearly, having the right data, not just a subset, is essential. In this space, the right data are granular, include all aspects of infusion delivery, and could include other data acquired from the patient record.

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### Right Time

Certain data are critically important for clinicians to have while providing care at the bedside, other data assist care providers in assessing situations while away from the patient, and still other data can provide important insights retrospectively to review care practices. An innovative infusion system could support data delivery in each of these contexts, providing information about the pump on remote dashboards or through analytic tools and scheduled reports that are sent regularly via email to those who can influence change in the care environment.

### Right People

Insights from multiple members of a care team are necessary to truly influence change. Therefore, infusion systems must be able to expose critical information to the right people in a form that makes both the challenge and opportunity for improvement clear. During the care process, getting information to the right people is equally, if not more, important. Informed professionals make better decisions, and in an area plagued by ADEs, getting the right information to the right people is key.

### Right Correlations

The infusion device industry is no longer focused on just device interfaces and data; it is concerned with safety, knowledge, and informed decision making. Once captured, the data need to be turned into actionable information through correlation technologies at the point of care and state-of-the-art data analytics in the back-end system. In either case, care providers' actions are influenced by their ability to see the association between the infusions being administered and events, anomalies, or opportunities for improvements. Was the response to oxytocin an artifact of the infusion pump or a weakness of the protocol? Should a stroke patient with a dangerously high aPTT (activated partial thromboplastin time) score still be administered heparin? Can chemotherapeutic medications be administered safely through the same line as other medications? These are important questions that could be more easily answered if the right correlations were provided to the clinical team.

### Right Presentation

As mentioned above, the right presentation of information is essential for care providers to make full use of it. Simplicity is critical at the bedside, while richness of data becomes more valuable during retrospective analysis. In either case, an innovative infusion system offering these capabilities could add tremendous value in its ability to inform clinical decisions.

### Challenges

In a 2015 article, Bresnick noted that many forward-thinking organizations "are aware that the high hospital EHR adoption rate is just the beginning of a long path towards using electronic data for improved patient care, higher quality, better outcomes, and more efficient financial gains."<sup>14</sup> Innovative infusion systems capable of turning data into knowledge could be the next step in that evolution.

To substantially improve the safety and quality of infusion delivery while reducing costs, the next generation of infusion systems needs to be more sophisticated yet present information that is simple to understand and facilitates good decision making. Pumps at the center of these systems need to be truly intelligent and capable of acquiring, correlating, and presenting information in a way that informs the care process without getting in the way of care itself. The challenge is to create an infusion system that can capture data at the necessary level of granularity, interoperate with other systems, transform multisource data into actionable information, and then present the information at the right time and in easy-to-understand formats so that stakeholders can use that knowledge to make better-informed decisions.

### Conclusion

That which cannot be measured cannot be improved. After measuring begins, the opportunities for improvement can be revealed. The right culture must exist within an organization to embrace both the opportunities and challenges that come with them. However, having a system that provides the right data from the right systems in the right way to the right people at the right time is essential.

In a world of infusion delivery that continues to be plagued by ADEs, these capabilities must exist within the infusion system itself. Most infusion systems have limited ability to support this need currently, signaling an opportunity for industry. Gaining the ability to use information in real time at the point of care and retrospectively to help streamline care delivery will be essential to advancing healthcare.

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