The infusion pump informatics (IPI) system represents an innovative collaboration among a community of practice and researchers at Purdue University; the Rosen Center for Advanced Computing (RCAC) and the Regenstrief Center for Healthcare Engineering (RCHE). This six-year-old decision support system was started to address needs for better management of smart infusion pumps. IPI supports a systems approach to continuous improvement in the safety of medications administered with smart infusion pumps. Its design has been user driven and includes two essential components.

The first component, developed by a RCAC team led by a senior research scientist (A.C.C.), receives data uploaded from smart infusion pumps, provides secure Internet access for clinicians, and enables analyses requested by its users. Clinicians using IPI are able to navigate using intuitive, point-and-click technology to execute complex analytics and receive real-time online reports that can be configured to their specification and downloaded in a CSV file for customized analyses offline (Figure 1).

The second component of IPI is CatalyzeCare, which is a web-based hub supporting communities of practice (i.e., groups of people who share a concern, set of problems, or passion about a topic and who deepen their knowledge and expertise in this area by interacting on an ongoing basis). The IPI community shares infusion pump alert data, drug libraries, and domain knowledge to enable interhospital comparative analyses and exchange of expertise. Since its inception in 2008, the community has grown to include representatives from more than 50 hospitals.

The following cases, which were provided by community members, illustrate how IPI is being used to improve performance in areas recommended as priorities for smart infusion pump implementation and use.²,³

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About the Research Partners
The Regenstrief Center for Healthcare Engineering (RCHE) at Purdue University was established in 2005 to bring a systems analyses approach to improving healthcare delivery. With generous support from the Regenstrief Foundation, RCHE conducts basic and applied research through the application of engineering, management, and science principles.

The Rosen Center for Advanced Computing (RCAC) is the research computing arm of Information Technology at Purdue—the university's central IT organization. RCAC provides a large and diverse set of computation and data resources, high-speed networks, and science gateways to researchers on the Purdue campuses.
Case Study

Establishing Drug Libraries for Specific Clinical Requirements

Case 1

Problem statement. Hospice nurses in hospital A found that pump libraries for opioids had maximum dosing limits that were too low to effectively manage their patients’ pain. Concerned with the safe use of high-risk medications, nurses wanted to infuse opioids using pump libraries consistent with clinical evidence for continuous subcutaneous infusion.

Actions to resolve problem. Working with hospital pharmacists, the hospice clinical staff established high-dose concentration opioid profiles in drug libraries. Special consideration was given to drug choice and infusion volume for patients receiving subcutaneous infusions. These libraries were restricted to a new profile for high-dose opioid administration and eliminated workarounds required to exceed the previously established maximum infusion rates programmed in the pumps. Hospital A developed training programs to help staff with the changed practices and use of the new libraries.

In the course of reviewing opioid libraries, hospital A also found a large number of dosing guidelines for opioids being used in their pump libraries on other patient units. They were able to standardize many of these doses and thus reduce the total number of opioid guidelines.

Role of IPI. Hospital A used IPI to review the drug libraries at other hospitals and inform their library decisions. IPI analytics were used to document opioid infusion practices and design staff training for desired practice change. Hospital A is monitoring the library use with IPI using parameters that include the number of high doses administered, numbers and types of alerts, and response of nurses to the alerts.

Case 2

Problem statement. Tranexamic acid was approved by the pharmacy and therapeutics (P&T) committee in hospital B for use in trauma patients with life-threatening hemorrhagic injury. The dosing strategy recommended for this condition is considerably different from other indicated uses of tranexamic acid. Hospital B wanted to safely use different dosing of tranexamic acid based on patient conditions.

Actions to resolve problem. A library was established for tranexamic acid with guidelines specific to clinical requirements for trauma patients and restricted to the trauma service. Hospital B is conducting case reviews for each use of the trauma guidelines. The review
information has been added to the agenda of the hospital’s infusion pump safety committee and the P&T committee to assist in a structured review of these new guidelines.

**Role of IPI.** IPI provided comparison information from other hospitals that assisted in establishing the trauma guidelines for hospital B. Areas of comparison that were particularly helpful included dosing limits, intermittent and continuous infusion versus continuous infusions only, and admixture concentrations. IPI data also are being used in evaluation of the use of the trauma library by enabling easily constructed reports for safety committees.

**Case 3**

**Problem statement.** Hospital C has identified the need to customize argatroban protocols for different types of patients—one required for critically ill patients, or those with hepatic insufficiency, and one for all other patients.

**Actions to resolve problem.** Hospital C uses an infusion pump that provides a “therapies” feature within its libraries. Separate therapies have been established—“argatroban–CC/Hepatic” and “argatroban–Standard”—to differentiate among infusion guidelines for different types of patients. An education program was provided for nurses and pharmacists that introduced them to the two therapy options and explained clinical protocols. Evaluations have indicated that therapies are being used for the appropriate patients and that a reduction in overall alerts for argatroban has occurred.

**Role of IPI.** Issue identification in this situation was assisted by a review of alerts and documentation of practices for infusing argatroban. This information also was used to develop educational content for staff training. Hospital C is using IPI data to monitor appropriateness of modified argatroban protocols and staff adherence to these protocols.

**Review of Alert Data**

**Case 4**

**Problem statement.** During a review of alert volumes by medication, hospital D identified a higher-than-expected number of alerts being generated by electrolyte infusions. A review of data indicated that a high percentage of the alerts were caused by the pump being programmed at infusion rates that exceeded infusion rate limits in the library.

**Actions to resolve problem.** A nursing education program was developed to target appropriate programming of electrolyte infusions. The education program was implemented with an emphasis on working with nursing staff in areas with the greatest frequency of programming above the limits and use of alert overrides.

**Role of IPI.** IPI data assisted in defining how electrolyte infusions were being programmed and defining the response of nursing to alerts. This information assisted in developing a consensus for the need for the education program and the program’s content. IPI data are being used to evaluate the effectiveness of the education program by reviewing programming practices and responses to alerts after the education program has been conducted.

**Case 5**

**Problem statement.** In an IPI community meeting, hospital D presented its work on electrolyte infusions, prompting hospital E to review its electrolyte infusion alert data. Hospital E found that magnesium sulfate was the medication most frequently infused outside programmed limits.

**Actions to resolve problem.** Hospital E compared its programmed limits for magnesium sulfate with library limits from other IPI community members. The hospital found that its infusion limits were more restrictive than those of other community members. It reviewed its alerts for magnesium sulfate infusions and found no reported adverse events. Hospital E raised its infusion limits for magnesium sulfate to reduce apparent unnecessary alert volume. A review four months after changing the limits indicated no adverse events and a 53% reduction of alerts. Hospital E
continues to have internal discussions to determine additional issues that may be contributing to alert volume and overrides for this medication.

**Role of IPI.** The interaction among IPI community members prompted hospital E to investigate alert volumes for electrolyte infusions. IPI analytics assisted in focusing interests on magnesium sulfate infusions. Comparison of infusion limits with other IPI hospitals provided valuable information to hospital E in its decision to raise infusion limits. IPI continues to be used by hospital E to monitor magnesium sulfate alert volumes and overrides.

**Evidence-Based Policy**

**Case 6**

**Problem statement.** A subgroup of the IPI community members determined that many issues emanate from fundamental practices within their hospitals and that they would increase the rate of performance improvement by having policies to cover these fundamental issues.

**Actions to resolve problem.** This subgroup has developed a list of policies that would have a broad, proactive effect on infusion pump use and safety. Subgroup members are in the final stages of drafting policies to be considered for implementation in each of their hospitals. The group will collaborate on advocacy efforts for policy adoption and plans to publish its work for general dissemination to healthcare professionals.

**Role of IPI.** IPI has supported this effort through analyses and comparison of practices across these hospitals and comparisons of pump data from two manufacturers. Virtual and online meetings of the community of practice have enabled the consideration of practices by community members who are not participating in the subgroup. Looking forward, CatalyzeCare intends to provide a forum for the dissemination of these policies to all community of practice members. IPI may further support this effort by enabling new policies to be monitored and reports developed to assist each hospital in successful policy implementation.
Case 7

Problem statement. Infusion pumps within or outside of a hospital’s wireless network (e.g., rental pumps) may not receive wireless drug library updates provided by the hospital’s pharmacy. These pumps may be used with out-of-date drug libraries if not properly processed between patients.

Actions to resolve problem. Professional groups charged with managing infusion pump inventories at hospitals have developed policies and procedures for pump maintenance prior to being used for new patients. A common practice is to ensure that pumps have been recycled within the hospital’s wireless network in order to verify that updated drug libraries are loaded on the pumps. Validation of updated drug libraries also can be confirmed with manufacturer or IPI reports.

Role of IPI. IPI has assisted hospitals in identifying outdated drug libraries through a review of alerts caused by drug limits that are no longer in practice. These alerts have been identified by the pump location in the hospital and date of alert. This information has been reported as helpful in conducting systems analyses of procedures for processing pumps and how procedures for processing pumps between patient use can be revised.

Experiential Evidence on IPI Value

IPI is being developed continually with new analytic capabilities and through an open invitation for hospitals to join the community of practice. (Note: Interested hospital representatives are invited to contact the corresponding author [S.W.].) Although not at an end state of development, evidence has indicated the value of IPI. A summary of the most frequently identified IPI values indicate a growing application of systems thinking and continuous improvement in smart pump use and safety.

Ease of access to IPI, availability of analytics requested by users, and immediate online response have increased the use of data to improve performance on a continuous basis.
manufacturers in joint problem solving. In some situations, this has enabled manufacturers to identify how the features of their pumps can be used more effectively.

The community of practice has enabled interhospital comparisons of information and sharing of expertise across hospitals (Figure 3). This feature’s importance cannot be overemphasized for improving practice and as a means of setting priorities and motivating enhanced performance.

Conclusion
Although the IPI system has only existed since 2008, the early experiences of members in the community to address issues of mutual benefit by using evidence generated through IPI are promising. The potential for practice improvement could not be practically replicated by a hospital working independently.

The principles used in developing and using IPI underline improved smart pump implementation and safety. The dual components of IPI are essential: the ability to use complex analytics and engaged communities of practice. When coupled with research, the rate of continuous improvement is increased. Examples of RCHE’s research include methods to reduce alarm fatigue among nurses and better understanding of nurses’ workarounds when using medical technologies. These principles can be generalized to the development of similar informatics systems for other medical devices and are applicable to complex adaptive systems.

Informatics systems such as IPI support systems thinking and are instrumental in the evolution toward safe healthcare.

References